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VOLUME 2 – TECHNICAL SPECIFICATIONS

RFB NO. 2023-145

**PROJECT MANUAL
FOR
GREEN BAY JAIL ROOFTOP UNITS AND SMOKE
FANS REPLACEMENTS**

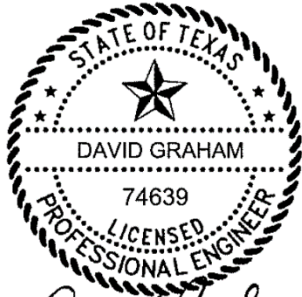
**BIDS DUE JUNE 26, 2023
2:00 P.M.**

Technical Specifications Prepared by

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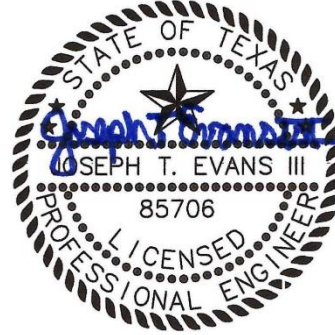
RFB NO. 2023-145

**Tarrant County Facilities
Green Bay Jail RTU Replacement**



David H. Graham

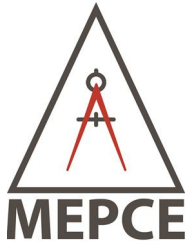
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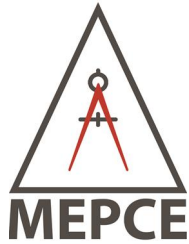


Scope Summary

Project: Tarrant County Green Bay Jail RTU and Fan Replacement

- I. Remove (39) existing Roof Top Units (RTUs) on the roof and replace them with new ones according to the Plans and Specifications. (23) of the RTUs will include internal Germicidal UVC lights and (16) RTUs will have duct mounted Germicidal UVC lights installed per the plans and specifications. (37) of the RTUs will have internal natural gas heat and the remaining (2) will have internal electric heat.**

 - II. Remove (12) Exhaust Fans and (5) Supply Fans of the Smoke Evacuation system and replace with new ones according to the Plans and Specifications. All of the fans are located on the roof.**
1. The Mechanical Contractor is the Prime Contractor on this project and will be responsible for all work on the project. The Mechanical Contractor will need to acquire ALL required subcontractors needed to complete all elements of the work. This includes, but is not limited to: Electrical work, Piping work, Controls work, General Construction work, and coordination of all related services.
 2. Perform all work in accordance with all applicable National and Local Codes and Code Authorities.
 3. Submit electronic copy of Shop Drawings and equipment submittals for all materials furnished for this work for approval.
 4. Secure and pay for all necessary permits, licenses and inspections required by Law for the completion of the work. Secure and pay for all certificates of approval that are required and deliver them to the Owner/ Engineer before final acceptance of the work.
 5. Examine the project site and make allowances in the Bid to accommodate existing conditions including, but not limited to the appropriate means to lift new and old equipment to and from the roof.
 6. All material shall be new, UL listed where applicable, and free from defects, unless existing material is specifically shown to be reused. Install all material in accordance with good workmanship standards.



7. Requests for alternates of specified material must be submitted to Tarrant County Purchasing Department as a Pre-Bid question and must be included in the bid price.
8. Provide factory finish on all material furnished to the jobsite and touch up finishes which have been damaged.
9. The schedule for removing existing units and installation of replacement units shall be carefully coordinated and scheduled with Tarrant County Facilities Management prior to any work. The County's intent is that each building remain occupied with normal weekday activity schedules.

For Base Bid anticipate that all work will be performed during regular hours, 7:00 am to 5:00 pm Monday thru Friday. Include an Alternate Bid anticipate that all work will be performed after hours, 5:01 pm to 6:59 am Monday thru Friday, or anytime Saturday, Sunday.

10. All equipment and accessories will be new.
11. Provide all electrical work required to support the new equipment in conformance with NEC requirements.
12. Any roofing alteration work will be discussed and approved by the County's Roofing Contractor, Rooftech. Contact Shawn Clark, ph 817-496-4631 x115 or 682-301-3806. The costs for all roofing work will be included in the bid.
13. All Controls work will be provided and installed by Enviromatic Systems. The costs for all Controls work will be included in the bid. Contact Sid Ellis, ph 972-206-2590.
14. All Testing and Balancing work will be provided by the County's TAB Contractor, Air Balancing Company, and will be contracted direct to the County. TAB costs should not be included in the bid.

SECTION 230500

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. General requirements for acceptance, provision, and installation of piping, mechanical, heating, ventilating and air conditioning system components, equipment, and related accessories are described in this Division and on Drawings for piping, heating, ventilating, and air conditioning. Division 23 Specifications shall be applicable to HVAC and Mechanical disciplines unless specifically noted otherwise.
- B. Provisions for the shipment, delivery, receiving, unloading, storage, on site transportation, installation, connection, support, alignment, lubrication, adjustment, securing, and grouting, for equipment are specified under this Division.
- C. On site transportation, placement, leveling, securing, support, alignment, lubrication, adjustment, connection of required piping services and grouting for process and utility equipment purchased under separate purchase order are described under this Division.
- D. Provision and installation of all other related mechanical and piping system components specified and required under this Division for proper establishment of fully operational installed process equipment.
- E. Provision and installation of all other items and equipment specified and required under this Division.

1.2 QUALITY ASSURANCE

- A. Codes and Standards: Work shall be governed by the latest edition of codes and standards in Section 23 05 01 as supplemented by specific Section references.
- B. Include start up assistance by factory trained Manufacturer's representative as defined in other sections.
- C. Guarantee in writing that Work under Division 23 will be free from defective materials and for one year after final acceptance as a minimum performance level. Some equipment may be required to have a different time span, as listed in other Sections. Submit in accordance with requirements of Owner's General Conditions.
- D. Provide equipment installation personnel having minimum of 3 years' experience in setting, installing, aligning, and adjusting equipment installed under this Division.
- E. Provide items whose design and configuration are approved by authorities having jurisdiction and that have been reviewed by Owner's Representative.
- F. Provide furnished items that are new, first grade, physically and chemically suitable for intended application unless written permission is obtained from the Owner's Representative to reuse certain materials, devices or equipment.

- G. Provide Manufacturer's standard nameplate for each item of equipment furnished under this Division. Refer to Section 23 05 58 for further identification requirements.

1.3 SUBMITTALS

- A. Shop Drawings and Manufacturer's Data: Submit in accordance with requirements of Owner's General Conditions.
 - 1. Submit complete list of proposed manufacturers of all major items of Contractor-furnished equipment within 30 days of Owner Contractor agreement.
 - 2. Submit shop drawings and operating instructions as set forth in these Contract Documents.
 - 3. Unless otherwise specified within this Division, submit shop drawings for Contractor furnished equipment, piping system and accessories (including plumbing systems), and duct system and accessories for review prior to commencement of work including, but not limited to, following:
 - a. Complete Manufacturer's descriptive data including technical data.
 - b. Pipe connection sizes and types.
 - c. Materials of construction.
 - d. Dimensions and weight.
 - e. Performance data and operating curves.
 - f. Electrical data, including wiring diagrams.
 - g. Installation recommendations.
 - h. Recommended spare parts list.
 - i. Recommended maintenance.
 - j. Drawings for fabrication and installation of piping and duct systems.
 - k. Pipe layout w/Vents and low point drains identified.
 - 4. Process shop drawing data to ensure that it conforms to the requirements of the Plans and Specifications and that there are no omissions and/or duplications.
 - 5. Each shop drawing submission shall designate the exact item offered; unidentified items on Manufacturer's data sheets are not acceptable. Each submitted for equipment such as pumps, air handlers, fans, etc. shall be accompanied by its respective performance and operating curve.
 - 6. In each case, the various material submissions of related items, procured from a single Manufacturer or Supplier, shall be assembled in brochures or in other suitable package form and shall not be submitted in a multiplicity of loose sheets.
 - 7. The shop drawings shall include room by room tabulations of air distribution devices, fire dampers, valves and similar items.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Shipment and Delivery:
 - 1. Identify equipment or shipping containers with following:
 - a. Item name
 - b. Item number, if any
 - c. Purchase order number
 - d. Manufacturer and model number
 - e. Destination
 - f. Owner's name
 - g. Contractor's name
 - 2. Receive, unload, remove from crate, and inspect all equipment and items specified and required under this Division for proper execution of this portion of Work.

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3. Protect all connections, fluid passages, working parts, and linings of items furnished under this Division from weather and physical damage during shipment.
4. Upon receipt of items at Project site, examine surfaces and working parts for defects and damage.
5. Return defective or damaged parts to Supplier for repair or replacement so that schedule of this portion of Work is not impaired.
6. Identify all documents certifying quality and compliance with Specifications and deliver to Owner's Representative.

B. Storage:

1. Store items in dry, clean areas, safe from damage.
2. Maintain security and condition of all storage areas while items are stored.
3. Store pipe and equipment off floor or off ground.
4. Store small items and loose materials in clearly labeled, neatly arranged bins.
5. Protect ends of pipe, valves, and fittings from weather and abuse; keep open ends sealed or covered until removed for installation.
6. Store equipment and motors in safe, clean, dry areas, with open ends, ventilation inlets, and pipe connection points covered until removed for installation.
7. Store nonmetallic pipe, cement, adhesives, and solvents in cool, clean areas and in accordance with Manufacturers' instructions.
8. Store all stainless steel on wood.
9. Protect equipment subject to damage from falling objects with suitable protective covers.
10. Mark with purchase order number and equipment number and deliver to storage area spare parts and small items crated with equipment but not installed by Contractor under this Division.
11. At all times take every precaution to properly protect apparatus from damage. Include erecting temporary shelters to protect apparatus stored at the site, cribbing of apparatus above the floor of the construction, and covering of apparatus in the uncompleted building with plastic sheeting or other protective coating. Failure on the part of the Contractor to comply with the above to the satisfaction of the Owner's Representative will be sufficient cause for the rejection of the pieces of apparatus in question.
12. Responsibility for the protection of apparatus shall extend to presently installed apparatus. Erect temporary sheltering structures, provide temporary bracing and supports, or cover equipment as required or directed to afford proper protection.

C. Handling:

1. Unload, unpack, and handle items with extreme care; use slings, cradles, or other appropriate appurtenances.
2. Utilize lifting points provided to move equipment.
3. Prevent contact of stainless steel and copper alloys with carbon steel.
4. Handle items in accordance with special instructions of Manufacturer or Suppliers.
5. Adequately grease all machined surfaces.
6. Move items within building such that floors are not gouged or marred.
7. Repair or replace parts damaged during handling at no additional cost to Owner so that schedule of this portion of work is not impaired.
8. If part of equipment crate serves as a skid, leave bolted to equipment until just prior to transfer of equipment to its final location.
9. Protect painted and machined surfaces where exposed; avoid denting, marring, or unduly stressing equipment parts.

1.5 SITE CONDITIONS

- A. Interferences: Examine in advance location of ducts, plumbing and electrical systems and other components to be installed, and properly coordinate installation of work to avoid interference with same.
- B. Site Visit: The accompanying drawings do not indicate exact existing mechanical and electrical installations other than to identify modifications of and extensions thereto. Visit the site, inspect the installations and ascertain the conditions to be met and the work to be accomplished in removing and modifying existing work and in installing new work. Failure to comply with this shall not constitute grounds for any additional payments in connection with removing or modifying any part of the existing installations and/or installing any new work under this Division.

1.6 SEQUENCING

- A. Coordinate installation of equipment, equipment accessories, system accessories, and piping with installation of:
 - 1. Electrical cable trays and conduit
 - 2. Ductwork
 - 3. Horizontal and vertical support systems
 - 4. Slabs and trenches
 - 5. Any items dependent on piping system for support
- B. Coordinate installation of equipment with placement of supports and foundations and placement of associated or connected systems.
- C. Progress Schedule: Contractor shall coordinate progress schedules of all other Contractors and shall work in accordance with schedules for completion of Contract.
- D. Disturbance to Occupants: Since the building will continue in use throughout the construction period, carry out the work under this Division in such a manner as to minimize disturbance to the occupants.
- E. Service Interruptions: Should the work in the designated areas affect any services to the areas remaining in use, new permanent or temporary or a combination of both shall be installed as required to enable those occupied areas to function properly. Additional valves required shall be installed without added cost to the Owner. Perform no work in the present building(s) which would interfere with its use unless special permission is granted in writing by the Owner. Included are operations which would cause objectionable noise or any service interruptions.

1.7 ENGINEERING DRAWINGS

- A. Drawings are not intended to show complete or accurate details of buildings, equipment, ductwork and piping in every respect. They indicate general layout, approximate locations, relations and arrangements and are not intended to show details of Manufacturer's equipment. Details of equipment shall be furnished by Manufacturer and Contractor for Owner's Representative approval.
- B. Contractor: Define locations and relations in the field and as satisfactory to Owner. Take all field measurements and be responsible therefor.
- C. Not all details of piping systems are shown on Drawings, nor are they specified herein. Piping shall be such as to legally pass all inspections by Inspection Department, State and Federal

Authorities and Insurance Company having jurisdiction, and any changes or additions which may be necessary to obtain such inspection and approval shall be made by the piping contractor as a part of this Contract without additional cost to Owner.

- D. Contractor shall provide three dimensional CADD (Bin) models of all mechanical work coordinated with all other trades. Submit shop drawings of mechanical piping, ductwork and equipment coordinated with other trades for review with changes from Construction Documents noted on Drawing.

1.8 SUBSTITUTIONS AND SPACE ALLOCATIONS

- A. Comply with the General Conditions.
- B. Products: Comply with requirements as indicated in the General Conditions.
- C. Space Allocations: Comply with requirements as indicated in the General Conditions.
- D. Substitutions: Comply with requirements as indicated in the General Conditions. Do not substitute items without prior approval. Bidders must submit their substitutions as a question before the question submission deadline and must include technical specifications.

1.9 SALVAGED MATERIALS

- A. Reuse no salvaged materials except as noted on the Drawings, specified herein, or directed by the Owner's Representative in writing. Remove from the premises all present materials falling under this Division which are removed from the existing building(s) and/or systems.
- B. Comply with Owners salvaged material requirements for this Project.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. In describing an item of equipment, it may be described singularly, even though there may be a multiplicity of identical items. Also, where a description is only general in nature, the exact size, duty, space arrangement, horsepower requirement and other data shall be determined by reference to plans, details and schedules. All equipment and materials shall be USA made. Provide proof of US Manufacture.
- B. Equipment called for on the plans and not listed herein shall be provided and installed as though it were fully described herein. Similarly, equipment called for herein shall be completely provided and installed, whether fully detailed or not on the plans and/or schedules.
- C. Provide pipe, pipe system accessories, duct accessories, and equipment attachments unaffected by conditions of service and adjacent atmosphere.
- D. Furnish all tools, cap screws, nuts, steel shims or shim stock, cinch anchor, anchor bolts, bolt sleeves, and proper quantities and grades of lubricant required to properly install, secure, lubricate and adjust equipment, including items purchased under separate purchase order and installed under this Division.

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- E. Provide proper quantities and grades of chemicals and appropriate media required to clean and test equipment.
- F. Erection Equipment:
 - 1. Provide and maintain equipment required to transport, erect, and install all items, including those purchased under separate purchase order.
 - 2. Equip power operated equipment with pneumatic tires or rubber treads if used within building.
 - 3. Maintain motor operated equipment such that no oil or grease is dropped on finished floors.
- G. Provide OSHA approved guards for belt drives and motor couplings. Provide ½ inch hole in guard at center of equipment drive shaft where belt drive is used.
- H. Interchangeability:
 - 1. Provide completely interchangeable components, assemblies, and parts where such items have the same part number.
 - 2. All interchangeable components shall be interchangeable without modification.
- I. No asbestos or asbestos containing products are allowed.
 - 1. Where dimensions, ratings, and characteristics are not known or specified, determine compliance using Manufacturer's design limits.

PART 3 - EXECUTION

Not Used.

END OF SECTION 230500

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 volts and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Provide a shaft grounding ring for motors used in direct-driven VFD motor applications.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 518 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Re-greaseable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F (non-inverter duty motors).
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.

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- 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION

Not Used.

END OF SECTION 230513

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Pipe stands.
 - 7. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
 - 3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
 - 4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
 - 5. Division 23 Section "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry, Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
 - 3. Powder-actuated fastener systems.
 - 4. Trapeze pipe hangers. Include Product Data for components.
 - 5. Metal framing systems. Include Product Data for components.

6. Pipe stands. Include Product Data for components.
7. Equipment supports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Available Manufacturers:
 1. AAA Technology & Specialties Co., Inc.
 2. Bergen-Power Pipe Supports.
 3. B-Line Systems, Inc.; a division of Cooper Industries.
 4. Carpenter & Paterson, Inc.
 5. Empire Industries, Inc.
 6. ERICO/Michigan Hanger Co.
 7. Globe Pipe Hanger Products, Inc.
 8. Grinnell Corp.
 9. GS Metals Corp.
 10. National Pipe Hanger Corporation.
 11. PHD Manufacturing, Inc.
 12. PHS Industries, Inc.
 13. Piping Technology & Products, Inc.
 14. Tolco Inc.
- C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Available Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
 - 3. GS Metals Corp.
 - 4. Power-Strut Div.; Tyco International, Ltd.
 - 5. Thomas & Betts Corporation.
 - 6. Tolco Inc.
 - 7. Unistrut Corp.; Tyco International, Ltd.
- C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig-minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Available Manufacturers:
 - 1. Carpenter & Paterson, Inc.
 - 2. ERICO/Michigan Hanger Co.
 - 3. PHS Industries, Inc.
 - 4. Pipe Shields, Inc.
 - 5. Rilco Manufacturing Company, Inc.
 - 6. Value Engineered Products, Inc.
- C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
- D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Available Manufacturers:
 - a. Hilti, Inc.

- b. ITW Ramset/Red Head.
 - c. Masterset Fastening Systems, Inc.
 - d. MKT Fastening, LLC.
 - e. Powers Fasteners.
- B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- 1. Available Manufacturers:
 - a. B-Line Systems, Inc.; a division of Cooper Industries.
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head.
 - e. MKT Fastening, LLC.
 - f. Powers Fasteners.

2.7 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- 1. Available Manufacturers:
 - a. RICO/Michigan Hanger Co.
 - b. MIRO Industries.
- C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
- 1. Available Manufacturers:
 - a. MIRO Industries.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
- 1. Available Manufacturers:
 - a. ERICO/Michigan Hanger Co.
 - b. MIRO Industries.
 - c. Portable Pipe Hangers.
 - 2. Base: Plastic.
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.9 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 8.
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8.
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2.

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10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8.
 11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
 17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

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5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- J. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.

- c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.
- N. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
 - 5. Pipes NPS 8 and Larger: Include wood inserts.
 - 6. Insert Material: Length greater than or equal to protective shield length.
 - 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Duct labels.
 - 4. Valve tags.
 - 5. Warning tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Anodized aluminum, 0.032-inch (0.8-mm) minimum thickness and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for

greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- B. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Per existing DFW recommendations.
- C. Background Color: Per existing DFW recommendations.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.3 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Per existing DFW recommendations.
- C. Background Color: Per existing DFW recommendations.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link or beaded chain.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

3.4 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

SECTION 230566

ANTIMICROBIAL ULTRAVIOLET LAMP SYSTEMS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Antimicrobial UV-C lamp rack systems for large air-handling units.
2. Antimicrobial UV-C lamp systems for air-handling units and packaged HVAC systems.
3. Antimicrobial UV-C lamp systems for split-system HVAC units or duct insertion.
4. Interface with building automatic controls.

1.2 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- B. UV-C: Ultraviolet-C short-wave spectrum.
- C. UV-C Lamp System: Unit including UV lamp, power supply, housing, and supports.
- D. UVGI: Ultraviolet germicidal irradiation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product description with complete technical data, performance data, and product specification sheets.
2. Maintenance and Operational Manual: Include electrical characteristics; and furnished accessories indicating process operating power, distribution range, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Installation instructions, including factors affecting performance.

B. Sustainable Design Submittals:

1. Product Data: For lamps, indicating mercury content and lamp life.

C. Shop Drawings: For each UV-C lamp system.

1. Include plans, elevations, sections, mounting, and attachment details.
2. Include details of UV-C lamp system assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include ultraviolet lamp watts for coil area in Watts (W) per sq. ft.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Elevations and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members of equipment to which lamp systems will be attached.
 - 2. Air-handling unit penetrations.
 - 3. Access points for service of lamps and power supplies.
 - 4. Power and communications connections.
- A. Qualification Data: Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Product Test Certificates:
 - 1. Perform factory test on UV lamp, fixture, and system. Submit Product Test Certificates.
 - 2. Submit report of UV-C effectiveness testing prepared by independent testing organization.
- C. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lamp systems to include in operation and maintenance manuals.
 - 1. Provide installation, operation and maintenance manual(s).
 - 2. Provide a list of all ultraviolet lamps and UV-C lamp system fixture types used on Project.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. UV-C Lamps: Furnish 10 for every 100 of each UV-C lamp type and rating installed. Furnish no fewer than one of each type.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer will repair or replace components of UV-C lamp systems that fail in materials or workmanship within specified warranty period subject to manufacturers published warranty.
 - 1. Warranty Period, Rack Mounted Stationary Air Handling System Components: Power Supply, Five years from date of purchase. For all other components, one year from date of purchase.
 - 2. Warranty Period, Exterior Mounted UV-C Lamp Systems: Three year(s) from date of purchase.
 - 3. Warranty Period, All Ultraviolet Lamps: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 ANTIMICROBIAL UV-C LAMP RACK SYSTEMS FOR LARGE AIR-HANDLING UNITS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products as listed in contract drawings, or comparable product by one of the following:
 - 1. UV Resources
 - 2. Aerapy
 - 3. Atlantic Ultraviolet Corporation
 - 4. Dust Free, LP.
 - 5. Environmental Solutions.
- B. Source Limitations: Obtain antimicrobial UV-C lamp rack systems from single source from single manufacturer.
- C. Description: UV-C lamp rack system mounted inside HVAC equipment consisting of modular racks, power supply, power supply housing, wiring, UV lamp(s), lamp plug and protector, encapsulated lamp and lamp holder..
- D. Structure: Provide rack members fabricated from aluminum formed channel.
 - 1. Form structural members into an "I" configuration, able to support 2000 psi.
 - 2. Fabricate rack assemblies in modular fashion, to allow for field assembly inside air-handling unit.
 - 3. Provide fittings to allow vertical adjustment of light racks to illuminate cooling coil with required intensity without shadows.
 - 4. Provide hardware for attachment of UV-C lamp racks to air-handling unit.
- E. Power Supply: CSA/UL/ETL listed, single phase, 120 V, 50 or 60 Hz, with programmed rapid start.
 - 1. Power Factor: high power factor, Class P, Sound Rated A, Type 1 Outdoor and with inherent thermal protection and without polychlorinated biphenyl.
 - 2. Operating Temperature: From 34 to 194 deg F.
 - 3. Wiring Harness: Plug-and-play.
 - 4. Power Consumption: Maximum of 25 Watts (W) per sq. ft..
 - 5. Electrical Connection: Single electrical connection with service disconnect.
 - a. Provide waterproof, 3-pin, push-in/screw-in, quick-connectors suitable for use with flexible conduit to interconnect fixtures and lamp bars to power source.
 - b. Connect fixtures with flexible cable in accordance with Section 260523 "Low-Voltage Electrical Power Conductors and Cables."

- 1) Lamp units having connectors rated below 120 V are not acceptable.
 - c. For multiple-lamp systems inside air-handling units, provide systems designed to mount complete UV-C system inside AHU. Connect component wiring with quick-connect couplings.
- F. UV-C Lamps: Provide lamps with FEP protective coating, with lamp wattage and model number visibly printed on each lamp, with less than 8.0 mg of mercury in each lamp, and with lamps that do not produce or release ozone.
1. Provide non-proprietary lamps manufactured to work with non-proprietary sockets and bases, and available through commercial lamp distributors.
 - a. Proprietary lamps made for use with proprietary sockets, or bases are not acceptable.
 2. Provide high-output-rated lamps suitable for application inside equipment with cold, moving airstreams, without reduction of intensity.
 3. Quantity and Type: Quantity and type as specified on construction documents with additional attic stock per specification.
 4. Output: UV-C energy, primarily at the 253.7-nm wavelength with 360[260] <Insert Number>-degree energy distribution.
 5. Operating Temperature: From 34 to 158 deg F, 100 percent relative humidity, at any velocity.
 6. Lamp Life: Minimum of 9000 hours with greater than 85 percent of initial output at end of lamp life.
- G. Power Supply Housing: Non-corrosive stainless steel, aluminum, or 20-gauge galvanized with powder coated finish, for installation inside packaged rooftop units or plenums.
1. Power Supply Capacity: [Two] [Three] [Four] [Five] [Six lamps].
 - a. Provide a suitable separate NEMA enclosure, for field installation of the power supply, on the exterior of an air-handling unit located outdoors.
- H. Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.
1. Conduit: Loom covered with UL flexible metal conduit.
- I. Lamp Plug, Holder, and Lamp Clamp: Four-pin type accommodates a single-ended high output lamp.
1. Lamp Plug and Holder Construction: UV-resistant materials designed to connect lamp to the plug.
 2. Underwriter Listing: Listed and labeled to UL Standards and requirements.
 3. Lamp Clamp Construction: Provide lamp clamp with UV-resistant materials suitable for installation in damp locations, and suitable to prevent electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing.
 4. Position: Provide fixtures with adjustable lamp-holder and lamp clamp position.

2.3 ANTIMICROBIAL UV-C LAMP SYSTEMS FOR PACKAGED ROOF TOP UNITS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products as listed in contract drawings, or comparable product by one of the following:
1. UV Resources
 2. Aerapy
 3. Atlantic Ultraviolet Corporation
 4. Dust Free, LP.
 5. Environmental Solutions.
- B. Source Limitations: Obtain antimicrobial UV lamp systems from single source from single manufacturer.
- C. Description: UV-C lamp system consisting of a NEMA 4X (IP 66) power supply housing, four each, 1/2- or 3/4-inch electrical knock-outs, power supply with integrated lamp plug, lamp compression nut, and ultraviolet lamp.
- D. Description: UV-C lamp system mounted inside HVAC equipment consisting of power supply, power supply housing, wiring, UV lamp(s), and lamp holder. Include non-corrosive aluminum housing and cover with Titanium Dioxide coated stainless steel mesh tube.
1. Provide UV-C lamp system that can be installed without cutting hole for lamp entry in HVAC unit cabinet, and without using waterproof or water tight housing.
- E. Power Supply: UL/ETL listed, single phase, 120 V, 50 or 60 Hz, with programmed rapid start.
1. For HVAC Applications, provide self-regulating fixtures for power sources between 120 V and 240 V.
 2. Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor and with inherent thermal protection and without polychlorinated biphenyl.
 3. Operating Temperature: From 34 to 194 deg F.
 4. Wiring Harness: Plug-and-play.
 5. Power Consumption: 25 Watts (W) per sq. ft.
 6. Electrical Connection: Single electrical connection with service disconnect.
 - a. Provide waterproof, 3-pin, push-in/screw-in, quick-connectors suitable for use with flexible conduit to interconnect fixtures and lamp bars to power source.
 - b. Connect fixtures with flexible cable in accordance with Section 260523 "Low-Voltage Electrical Power Conductors and Cables."
 - 1) Lamp units having connectors rated below 120 V are not acceptable.
- F. UV-C Lamps: Provide lamps with FEP protective coating, with lamp wattage and model number visibly printed on each lamp, with less than 8.0 mg of mercury in each lamp, and with lamps that do not produce or release ozone.
1. Provide non-proprietary lamps manufactured to work with non-proprietary sockets and bases, and available through commercial lamp distributors.
 - a. Proprietary lamps made for use with proprietary sockets, or bases are not acceptable.
 2. Provide high-output-rated lamps suitable for application inside equipment with cold, moving airstreams, without reduction of intensity.

3. Quantity and Type: Quantity and type as specified on construction documents with additional attic stock per specification.
 4. Output: UV-C energy, primarily at the 253.7-nm wavelength with 360-degree energy distribution.
 5. Operating Temperature: From 34 to 158 deg F, 100 percent relative humidity, at any velocity.
 6. Lamp Life: Minimum of 9000 hours with greater than 85 percent of initial output at end of lamp life.
- A. Power Supply Housing: High performance, white polycarbonate for external thermal rejection, equipped with lamp support for lamp lengths up to 61 inches and a weather tight cover with an integrated seal. Housing contains all components in one integral assembly for safety and serviceability without tools.
1. Interlock: Disrupt lever on the cover actuates the interlock switch to disconnect or restore power when removed or installed. Padlock eyelets lock the housing cover to guard against unwanted entry.
 2. Surface Installation Mounting: Four mounting holes and gasket to seal housing to the mounting surface.
- B. Lamp-Holder and Lamp clamp: Four-pin type accommodates a single-ended lamp.
1. Lamp-Holder Construction: UV resistant materials and designed to connect the lamp to the plug.
 2. Lamp clamp Construction: UV resistant materials to ensure a water-tight connection. A seal between the single ended ultraviolet lamp and the lamp plug prevents electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing.

2.4 ANTIMICROBIAL UV-C LAMP SYSTEMS FOR SPLIT-SYSTEM HVAC UNITS OR DUCT INSERTION

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products as listed in contract drawings, or comparable product by one of the following:
1. UV Resources
 2. Aerapy
 3. Atlantic Ultraviolet Corporation
 4. Dust Free, LP.
 5. Environmental Solutions.
- B. Source Limitations: Obtain antimicrobial UV lamp systems from single source from single manufacturer.
- C. Description: UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder. Include non-corrosive aluminum housing and cover with Titanium Dioxide coated stainless steel mesh tube.
- D. Power Supply: Power supply shall be UL listed, 120-277Vac – 50/60Hz, SO type. They shall be high power factor, low THD, class P, sound rated “a”, type 1 outdoor designs with inherent thermal protection, no PCB’s and labeled for field wiring. They shall be capable of operating at temperatures from 1-90°C while producing the specified output and organism destruction at no more than 10 Watts of power consumption for each square foot of treated, cross sectional plane. The power supply shall be capable of ensuring a minimum of 9000 hours of lamp life, and with greater than 80% of its initial output at end of lamp life. Power supply shall be protected against “end of lamp life” conditions and warranted for 5 years.

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- E. Plenum Wire Loom: Shall be of sufficient length to facilitate lamp connection to a remotely mounted power supply. The lamp and loom shall be capable of being mounted anywhere in the system and/or as shown on the plans. The loom shall meet UL subject 13 and UL 1581, Article 725 of the NEC and meet UL VW-1 material ratings, as plenum rated. The loom shall be constructed of ozone and UV-C resistant materials.
- F. Lamp Plug & Holder: Shall be UL listed, 4-pin SE type capable of accommodating a single-ended lamp. The holder shall be constructed of UV resistant materials and designed to connect the lamp to the plug, holder and plenum wiring loom to protect against electrical shock, moisture and separation.
- G. Lamp Clamp Construction: UV-resistant materials to ensure watertight connection. A seal between the single-ended UV lamp and the lamp plug prevents electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing. Provide lamp socket rated for application in damp locations.
- H. UV-C Lamps: Each lamp shall contain less than 8 milligrams of mercury, consistent with current environmental practices. Lamps shall include an inner layer comprising of at least one element from the series formed by magnesium, aluminum, titanium, zirconium, and rare earths to repel alkali metals (e.g. mercury) to extend lamp life. Lamp life shall be a minimum of 9,000 hours with no more than a 20% output loss at the end of the lamp's life (12 months continuous use.) Lamps shall be constructed with UV-C resistant bases and shall not produce ozone. Lamps shall produce the specified output in moving air of up to 1000 fpm and temperatures of 0-90°C. Lamps shall have an option to be hermetically sealed within a layer of UV-C transmissible FEP to provide a protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
- I. Accessories: Lamp Protection: Provide hermetically sealed lamp with thin layer of UV-C-transmissible, fluorinated ethylene propylene, to provide protection against lamp breakage and to ensure lamp contents from broken lamp are contained.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for UV-C lamp system to verify actual locations of UV lamps and electrical connections before UV-C lamp system installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install UV-C lamp systems in accordance with manufacturer's installation manual and drawings unless otherwise indicated.

- B. Install UV lamps in each UV-C lamp system.
- C. Install UV-C lamp systems in locations that are accessible and that will permit servicing and maintenance.
- D. Provide sufficient length of wiring loom to facilitate lamp connection to a remotely located power receptacle or power supply housing, such that lamp and loom can be mounted anywhere in the system.
- E. Seal HVAC system unit penetrations to maintain integrity of HVAC unit casings.
- F. Irradiation: Install quantity of UV-C lamps necessary to provide equal distribution of available UV-C energy. When installed, UV-C energy produced shall be of the lowest possible reflected and shadowed losses, distributed in 360] <Insert number>-degree pattern within cavity or plenum space.
- G. Housing Installation: Power supply housing can be installed inside or outside HVAC units or plenums.
- H. UV Lamp Installation: Mount UV lamp to irradiate surfaces, as well as the available line of sight airstream, through proper lamp placement, and incident angle reflection.
- I. Safety: Comply with requirements in UL 1995, "Standard of Safety for Heating and Cooling Equipment." Provide mechanical interlock switch on access panels and doors to UV lamp systems, or within view of UV lamp systems, to ensure that UV-C lamp systems will be de-energized when these accesses are opened. Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."
- J. Signage: Comply with requirements in UL 1995 "Heating and Cooling Equipment." Mark access panels and doors to UV-C lamp systems with warning signs stating, "WARNING: UV LIGHT SOURCE" and "DISCONNECT POWER BEFORE SERVICING." Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.3 INSTALLATION OF ANTIMICROBIAL UV-C LAMP SYSTEMS FOR AIR-HANDLING UNITS

- A. Size and rate support members for UV-C lamp system weight.
- B. Maintain UV lamp position after cleaning and relamping.
- C. Provide support for UV-C lamp system without causing deflection of air-handling unit casing.
- D. Equipment supports are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.4 ELECTRIC CONNECTIONS

- A. Provide electrical power and service disconnects to hard-wired products requiring electrical connections.
- B. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

- C. Comply with requirements for service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."
- D. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Identify UV-C lamp systems with equipment labels. Comply with requirements for equipment labels specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing UV-C lamp systems, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Safety Interlock: Confirm proper operation of safety interlock power switches on access panels and doors.
- B. UV-C lamp systems and components will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. Perform startup service.

3.9 ADJUSTING

- A. After installation, adjust UV-C lamp systems and supports to maximize exposure to surfaces, before energizing system.

3.10 CLEANING

- A. Wipe lamps clean using manufacturers' recommended cleaning methods and materials.

3.11 DEMONSTRATION

- A. Train and instruct Owner's maintenance personnel on all aspects of safety, and how to adjust, operate, and maintain UV-C lamp systems.

END OF SECTION 230566

SECTION 234100

PARTICULATE AIR FILTRATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Flat panel filters.
 - 2. Pleated panel filters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each filter, for tests performed by a qualified testing agency.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter and rack to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Provide one complete set of filters for each filter bank.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: A NRTL.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean, dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
 - 3. Replace installed products damaged during construction.

PART 2 – PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance:
 - 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 - 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- B. Comply with NFPA 90A and NFPA 90B.
- C. Comply with UL 900.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FLAT PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.
 - 1. Camfil Air Filters.
 - 2. Puralator® Air Filtration.
 - 3. AAA, All American Air Filters Inc.
 - 4. Trane.
 - 5. Carrier.
 - 6. Aeon.
 - 7. Daikin.

- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Capacities and Characteristics:
 - 1. Face Size: according to RTU manufacturer.
 - 2. Depth: 2 inches (50 mm) nominal.
 - 3. System Airflow: as per RTU schedule on plans.
 - 4. Maximum or Rated Face Velocity: 300 fpm.
 - 5. Minimum Efficiency Reporting Value: MERV 14, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
- D. Media: Interlaced glass synthetic fibers coated with nonflammable adhesive.
 - 1. Media shall be coated with an antimicrobial agent.
 - 2. Metal Retainer: Upstream side and downstream side.
- E. Filter-Media Frame: Cardboard with perforated metal retainer sealed or bonded to the media.

2.3 PLEATED PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
 - 1. Camfil Air Filters.
 - 2. Puralator® Air Filtration.
 - 3. AAA, All American Air Filters Inc.
 - 4. Trane.
 - 5. Carrier.
 - 6. Aeon.
 - 7. Daikin.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Capacities and Characteristics:
 - 1. Face Size: according to RTU manufacturer.
 - 2. Depth: 2 inches (50 mm) nominal.
 - 3. System Airflow: as per RTU schedule on plans.
 - 4. Maximum or Rated Face Velocity: 300 fpm.
 - 5. Minimum Efficiency Reporting Value: MERV 14, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
- D. Media: Interlaced glass synthetic fibers coated with nonflammable adhesive.
 - 1. Separators shall be bonded to the media to maintain pleat configuration.
 - 2. Welded-wire grid shall be on downstream side to maintain pleat.
 - 3. Media shall be bonded to frame to prevent air bypass.
 - 4. Support members on upstream and downstream sides to maintain pleat spacing.
- E. Filter-Media Frame: Cardboard frame with perforated metal retainer.

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FILTERS

- A. Install filters in position to prevent passage of unfiltered air.
- B. Do not operate fan system until filters (temporary or permanent) are in place.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test for leakage of unfiltered air while system is operating.
- C. Air filter will be considered defective if it does not pass tests and inspections.

3.4 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100

SECTION 237416.11

PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:
 - 1. Casings.
 - 2. Fans, drives, and motors.
 - 3. Rotary heat exchangers.
 - 4. Coils.
 - 5. Refrigerant circuit components.
 - 6. Air filtration.
 - 7. Gas furnaces.
 - 8. Dampers.
 - 9. Electrical power connections.
 - 10. Controls.
 - 11. Roof curbs.
 - 12. Accessories.

1.3 DEFINITIONS

- A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.4 ACTION SUBMITTALS

- A. Product Data: For each RTU.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.

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- b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
 7. Include filters with performance characteristics.
 8. Include gas furnaces with performance characteristics.
 9. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each packaged, small-capacity, rooftop air-conditioning unit.
1. Include plans, elevations, sections, and **[mounting] [attachment]** details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 3. Wind-Restraint Details: Detail fabrication and attachment of wind restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Source quality-control reports.
- D. System startup reports.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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1. Filters: **One** set of filters for each unit.
2. Gaskets: **One** set for each access door.
3. Fan Belts: **One** set for each belt-driven fan.

1.8 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
1. Warranty Period: 1 year(s) from date of Substantial Completion.
 2. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 3. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than fifteen years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE 15 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. UL Compliance: Comply with UL 1995.
- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
1. Design RTU supports to comply with wind performance requirements.
- H. Wind-Restraint Performance:
1. Basic Wind Speed: 60 mph
 2. Building Classification Category: I.
 3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

2.2 CAPACITIES AND CHARACTERISTICS

A. Supply-Air Fan:

1. Fan Type: Belt driven, double width, **forward curved**, centrifugal.
2. Fan Type: Double width, forward curved, centrifugal.
3. Airflow: as scheduled.
4. External Static Pressure: as scheduled.
5. Fan Speed: as scheduled.
6. Enclosure Type: as scheduled.
7. Enclosure Materials: **Rolled steel**.
8. Motor Characteristics:
 - a. Horsepower: as scheduled.
 - b. Motor Speed: **Multispeed or ECM**.
 - c. Volts: as scheduled.
 - d. Phase: as scheduled].
 - e. Hertz: 60.
 - f. Full-Load Amperes: as scheduled.
 - g. Minimum Circuit Ampacity: as scheduled.
 - h. Maximum Overcurrent Protection: as scheduled.

B. Rotary Heat Exchanger:

1. Intake Airflow as scheduled.
2. Pressure Differential: as scheduled.
3. Entering Supply-Air Dry-Bulb Temperature: as scheduled.
4. Entering Supply-Air Wet-Bulb Temperature: as scheduled.
5. Leaving-Air Dry-Bulb Temperature: as scheduled.
6. Leaving-Air Wet-Bulb Temperature: as scheduled.
7. Exhaust Airflow: as scheduled.
8. Pressure Differential: as scheduled.
9. Entering Exhaust-Air Dry-Bulb Temperature: as scheduled.
10. Entering Exhaust-Air Wet-Bulb Temperature: as scheduled.
11. Leaving Exhaust-Air Dry-Bulb Temperature: as scheduled.
12. Leaving Exhaust-Air Wet-Bulb Temperature: as scheduled.

C. Supply-Air Refrigerant Coil:

1. Total Cooling Capacity: as scheduled.
2. Sensible Cooling Capacity: as scheduled.
3. Entering-Air Dry-Bulb Temperature: as scheduled.
4. Entering-Air Wet-Bulb Temperature: as scheduled.
5. Refrigerant Type: R410A.

D. Outdoor-Air Refrigerant Coil:

1. Ambient-Air Temperature: as scheduled.
2. Fan Motor: as scheduled.
3. Number of Fans: as scheduled.
4. Refrigerant Type: R410A.

E. Hot-Gas Reheat Coil:

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1. Heating Capacity: as scheduled.
2. Entering-Air Temperature: as scheduled.
3. Air-Temperature Rise: as scheduled.
4. Refrigerant Type: R410A.

F. Electric-Resistance Heating Coil:

1. Capacity: as scheduled.
2. Number of Steps: as scheduled.

G. Compressors:

1. Number of Refrigerant Circuits: as scheduled.
2. Power Input: as scheduled.
3. Seasonal Energy-Efficiency Ratio EER: as scheduled.

H. Dampers:

1. Outdoor-Air Damper: Linked damper blades, for zero to **25** percent outdoor air, with damper filter.
2. Outdoor- and Return-Air Mixing Dampers: blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect so dampers operate simultaneously.
3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1.
4. Barometric relief dampers.

I. Electrical Characteristics for Single-Point Connection:

1. Voltage: as scheduled.
2. Phase: as scheduled.
3. Hertz: 60.
4. Full-Load Amperes: as scheduled.
5. Minimum Circuit Ampacity: as scheduled.
6. Maximum Overcurrent Protection: as scheduled.

2.3 MANUFACTURERS

- A. AAON, Trane, Carrier, Lennox, and Daiken.

2.4 UNIT CASINGS

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- C. Panels and Doors:
1. Panels:

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- a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
2. Access Doors:
- a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
- D. Condensate Drain Pans:
1. Location: Each type of **cooling coil**.
 2. Construction:
 - a. Single-wall, **galvanized-steel** sheet.
 3. Drain Connection:
 - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **one end** of pan.
 4. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
 5. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- 2.5 FANS, DRIVES, AND MOTORS
- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.
1. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway.
 2. Shaft Bearings:
 - a. Heavy-duty, self-aligning, pillow-block type with an **L-50** rated life of minimum **100,000** hours according to ABMA 9.
 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

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- a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard[**restrained**] vibration isolation mounting devices having a minimum static deflection of [**one-inch**] <Insert dimension>.
 6. Shaft Lubrication Lines: Extended to a location outside the casing.
 7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.
 - a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
- C. Drives, Direct: Factory-mounted, direct drive.
- D. Condenser-Coil Fan: propeller, mounted on shaft of permanently lubricated **multispeed or ECM** motors.
- E. Motors:
1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Enclosure Type: **Open, drip proof or Totally enclosed, fan cooled.**
 4. Efficiency: Premium efficient as defined in NEMA MG 1.
 5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.6 COILS

- A. General Requirements for Coils:
1. Comply with AHRI 410.
 2. Fabricate coils section to allow for removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 3. Coils shall not act as structural component of unit.
- B. Supply-Air Refrigerant Coil:
1. Tubes: **Copper.**
 2. Fins:
 - a. Material: **Aluminum or Copper.**
 3. Fin and Tube Joints: Mechanical bond.
 4. Frames: **Galvanized steel.**
 5. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

- a. Working Pressure: Minimum 300 psig (2070 kPa).
- C. Outdoor-Air Refrigerant Coil:
- 1. Tubes: **Copper**.
 - 2. Fins:
 - a. Material: **Aluminum or Copper**.
 - 3. Fin and Tube Joints: Mechanical bond.
 - 4. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 - a. Working Pressure: Minimum 300 psig (2070 kPa).
- D. Hot-Gas Reheat Refrigerant Coil:
- 1. Tubes: **Copper**.
 - 2. Fins:
 - a. Material: **Aluminum or Copper**.
 - 3. Fin and Tube Joints: Mechanical bond.
 - 4. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 - a. Working Pressure: Minimum 300 psig (2070 kPa).
 - 5. Suction-discharge bypass valve.
- E. Electric-Resistance Heating Coils: Comply with UL 1995.
- 1. Casing Assembly: **Slip-in or Flanged** type with galvanized-steel frame.
 - 2. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 5. Control Panel: **Unit** mounted with disconnecting means and overcurrent protection.
 - a. **Magnetic** contactor.
 - b. Solid-state, stepless pulse controller.
 - c. Toggle switches, one per step.
 - d. Step controller.
 - e. Time-delay relay.
 - f. Pilot lights, one per step.
 - g. Airflow proving switch.

2.7 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Hermetic, [**variable-speed**] scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, **and crankcase heater**].
- B. Refrigeration Specialties:

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1. Refrigerant: **R-410A**.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.
9. Low-ambient kit high-pressure sensor.
10. Hot-gas reheat solenoid valve with a replaceable magnetic coil.
11. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
12. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

2.8 AIR FILTRATION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
 1. Description: **Pleated** factory-fabricated, self-supported, disposable air filters with holding frames.
 2. Filter Unit Class: UL 900.
 3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 4. Filter-Media Frame: **Beverage board** with perforated metal retainer, or metal grid, on outlet side.
- C. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
- D. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.9 GAS FURNACES

- A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
- B. CSA Approval: Designed and certified by and bearing label of CSA.
- C. Burners: Stainless steel.
 1. Rated Minimum Turndown Ratio: **14 to 1**.
 2. Fuel: **Natural** gas.
 3. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
 4. Gas Control Valve: **Two stage or Modulating**.
 5. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
 6. High-Altitude **[Model]** **[Kit]**: For Project elevations more than 2000 feet (610 m) above sea level.

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- D. Heat-Exchanger and Drain Pan: Stainless steel.
- E. Venting, Gravity: Gravity vented[**with vertical extension**].
- F. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve[**with vertical extension**].
- G. Safety Controls:
 - 1. Gas Manifold: Safety switches and controls complying with ANSI standards [**and**] [**FM Global**] <Insert insurer>.

2.10 DAMPERS

- A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."
- B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **galvanized-steel** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **opposed-blade** arrangement with **zinc-plated** steel operating rods rotating in **sintered bronze or nylon** bearings mounted in a single **galvanized-steel** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa) rated in accordance with AMCA 500D).
- C. Barometric relief dampers.
- D. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
- E. Electronic Damper Operators:
 - 1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - 3. Operator Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - 4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 - 5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 - 6. Size dampers for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.

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- b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
7. Coupling: V-bolt and V-shaped, toothed cradle.
 8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
 10. Power Requirements (Two-Position Spring Return): **24 V dc**.
 11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 13. Temperature Rating: **Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)**.

2.11 ELECTRICAL POWER CONNECTIONS

- A. RTU shall have a single connection of power to unit with **unit-mounted disconnect switch accessible from outside unit and** control-circuit transformer with built-in overcurrent protection.

2.12 CONTROLS

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- B. Basic Unit Controls:
 1. Control-voltage transformer.
 2. Wall-mounted thermostat with the following features:
 - a. Heat-cool-off switch.
 - b. Fan on-auto switch.
 - c. Fan-speed switch.
 - d. **[Manual] [Automatic]** changeover.
 - e. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
- C. **Electronic Controller:**
 1. Controller shall have volatile-memory backup.
 2. Safety Control Operation:
 - a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.

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- b. Firestats: Stop fan and close outdoor-air damper if air greater than **130 deg F (54 deg C)** enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
 - c. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than **40 deg F (4 deg C)**.
 - d. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
3. Supply Fan Operation:
- a. Occupied Periods: Run fan continuously.
 - b. Unoccupied Periods: Cycle fan to maintain setback temperature.
4. Refrigerant Circuit Operation:
- a. Occupied Periods: Cycle or stage compressors[, **and operate hot-gas bypass**] to match compressor output to cooling load to maintain **room** temperature **and humidity**. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
5. Hot-Gas Reheat-Coil Operation:
- a. Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles the compressor.
 - b. Unoccupied Periods: Reheat not required.
6. Gas Furnace Operation:
- a. Occupied Periods: **Stage** burner to maintain **room** temperature.
7. Electric-Heating-Coil Operation:
- a. Occupied Periods: **Stage** coil to maintain **room** temperature.
 - b. Unoccupied Periods: Energize coil to maintain setback temperature.
8. Fixed Minimum Outdoor-Air Damper Operation:
- a. Occupied Periods: Open to **15**.
 - b. Unoccupied Periods: Close the outdoor-air damper.
- D. Interface Requirements for HVAC Instrumentation and Control System:
- 1. Interface relay for scheduled operation.
 - 2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
- 2.13 ROOF CURBS
- A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
- 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C1071, Type I or II.

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C916, Type I.
- B. Curb Dimensions: Height of **14 inches (355 mm)**. **Adaptable horizontal dimensions as required for existing roof openings.**

2.14 ACCESSORIES

- A. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.
- B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.
- C. Low-ambient kit using **staged** condenser fans for operation down to **35 deg F (1.7 deg C)**.
- D. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- E. Remote potentiometer to adjust minimum economizer damper position.
- F. Return-air bypass damper.
- G. Factory- or field-installed, demand-controlled ventilation.
- H. Safeties:
 1. Condensate overflow switch.
 2. Phase-loss protection.
 3. High **and low** pressure control.
 4. airflow-proving switch.
- I. Coil guards of painted, galvanized-steel wire.
- J. Hail guards of galvanized steel, painted to match casing.
- K. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
- L. Door switches to disable heating or reset set point when open.
- M. Outdoor-air intake weather hood.
- N. Oil separator.

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- O. Service Lights and Switch: Factory installed in **[fan section] [fan and coil sections] [each accessible section]** <Insert locations> with weatherproof cover. Factory wire lights to a single-point field connection.

2.15 MATERIALS

A. Steel:

- 1. ASTM A36/A36M for carbon structural steel.
- 2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

- 1. Manufacturer's standard grade for casing.
- 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209 (ASTM B209M).

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **2500**-hour salt-spray test according to ASTM B117.

1. Standards:

- a. ASTM B117 for salt spray.
- b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
- c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Thickness: **1 mil (0.025 mm)**.

3. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.16 SOURCE QUALITY CONTROL

A. AHRI Compliance:

- 1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
- 2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
- 3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
- 4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

- 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
- 2. Damper leakage tested according to AMCA 500-D.
- 3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- 1. Roof Curb: Install on roof structure or concrete base, level and secure, according to **AHRI Guideline B**. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- 2. Install normal-weight, 3000-psi (20.7-MPa), compressive strength (28-day) concrete mix inside roof curb, [**4 inches (100 mm)**] <Insert dimension> thick. Concrete, formwork, and reinforcement are specified with concrete.
- B. Unit Support: Install unit level on structural [**curbs**] [**steel supports**]. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Equipment Mounting:
 - 1. Install RTUs on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to RTU, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using unit connection size, ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

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- E. Gas Piping: Comply with applicable requirements in **Section 231123 "Facility Natural-Gas Piping."** on connecting gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- F. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- G. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- H. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination at top of roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
 - 4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch (13 mm) high.
 - 3. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- C. Tests and Inspections:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. RTU will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A. **Perform** startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Inspect for visible damage to unit casing.
 - 3. Inspect for visible damage to furnace combustion chamber.
 - 4. Inspect for visible damage to compressor, coils, and fans.
 - 5. Inspect internal insulation.
 - 6. Verify that labels are clearly visible.
 - 7. Verify that clearances have been provided for servicing.
 - 8. Verify that controls are connected and operable.
 - 9. Verify that filters are installed.
 - 10. Clean condenser coil and inspect for construction debris.
 - 11. Clean furnace flue and inspect for construction debris.
 - 12. Connect and purge gas line.
 - 13. Remove packing from vibration isolators.
 - 14. Inspect operation of barometric relief dampers.
 - 15. Verify lubrication on fan and motor bearings.
 - 16. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 17. Adjust fan belts to proper alignment and tension.
 - 18. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.

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- c. Complete startup sheets and attach copy with Contractor's startup report.
19. Inspect and record performance of interlocks and protective devices; verify sequences.
20. Operate unit for an initial period as recommended or required by manufacturer.
21. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency:
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.
 - c. Measure combustion-air temperature at inlet to combustion chamber.
 - d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
22. Calibrate thermostats.
23. Adjust and inspect high-temperature limits.
24. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
25. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
26. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
27. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
28. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
29. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.
30. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

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3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

3.10 CLEANING

- A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
- E. Tests and Inspections:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. RTU will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

3.12 DEMONSTRATION

- A. **Train** Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.11

SECTION 237416.13

PACKAGE, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes packaged, large-capacity, rooftop air conditioning units with following components:
 1. Casings.
 2. Fans, drives, and motors.
 3. Rotary heat exchanger.
 4. Coils.
 5. Refrigerant circuit components.
 6. Air filtration.
 7. UV germicidal irradiation section.
 8. Sound-attenuator section.
 9. Dampers.
 10. Electrical power connections.
 11. Controls.
 12. Roof curbs.
 13. Accessories.

1.3 DEFINITIONS

- A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.4 ACTION SUBMITTALS

- A. Product Data: For each RTU.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
 3. Include unit dimensions and weight.
 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.

- d. Include motor ratings, electrical characteristics, and motor accessories.
 6. Include certified coil-performance ratings with system operating conditions indicated.
 7. Include filters with performance characteristics.
 8. Include gas furnaces with performance characteristics.
 9. Include factory selection calculations for each antimicrobial ultraviolet lamp installation.
 10. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning units.
1. Include plans, elevations, sections, and mounting details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Source quality-control reports.
- D. System startup reports.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One set of filters for each unit.
 2. Gaskets: One set for each access door.

1.8 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 1 year(s) from date of Substantial Completion.
 - 2. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 - 3. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than fifteen years from date of Substantial Completion

PRODUCTS

1.9 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE 15 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. UL Compliance: Comply with UL 1995.
- G. Wind-Restraint Performance:
 - 1. Basic Wind Speed: 105.
 - 2. Building Classification Category: [II]
 - 3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.10 MANUFACTURERS

- A. Manufacturers:
 - 1. Aeon.
 - 2. Carrier.
 - 3. Daikan.
 - 4. Trane.

1.11 UNIT CASINGS

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

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- B. Double-Wall Construction:
 - 1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - 2. Inside Casing Wall: G90 (Z275)-coated galvanized steel, 0.034 inch thick, perforated 40 percent free area.
 - 3. Floor Plate: G90 galvanized steel treadplate, minimum 18 gauge thick.
 - 4. Casing Insulation:
 - a. Materials: Injected polyurethane foam insulation.
 - b. Insulation Thickness: 2 inches.
 - c. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
- C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. Static-Pressure Classifications:
 - 1. For Unit Sections Upstream of Fans: Minus 3-inch wg.
 - 2. For Unit Sections Downstream and Including Fans: 3-inch wg.
- E. Panels and Doors:
 - 1. Panels:
 - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components. Dimensions to be at least 18 inches wide by full height of unit casing up to a maximum height of 72 inches.
 - 2. Access Doors:
 - a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components. Dimensions to be at least 18 inches wide by full height of unit casing up to a maximum height of 72 inches.
 - 3. Locations and Applications:
 - a. Fan Section: Doors and inspection and access panels.
 - b. Access Section: Doors.
 - c. Coil Section: Inspection and access panels.
 - d. Damper Section: Inspection and access panels.
 - e. Filter Section: Inspection and access panels large enough to allow periodic removal and installation of filters.
 - f. Mixing Section: Doors.
 - 4. Service Light: 100-W vaporproof fixture with switched junction box located outside or inside adjacent to door.
 - a. Locations: Each section accessed with door.

F. Condensate Drain Pans:

1. Location: Each type of cooling coil.
2. Construction:
 - a. Single-wall, galvanized-steel or noncorrosive polymer sheet.
 - b. Double-wall, galvanized-steel or noncorrosive polymer sheet with space between walls filled with foam insulation and moisture-tight seal.
3. Drain Connection:
 - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - b. Minimum Connection Size: NPS 1.
4. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

1.12 FANS, DRIVES, AND MOTORS

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.
 1. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway.
 2. Shaft Bearings:
 - a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.
 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
 6. Shaft Lubrication Lines: Extended to a location outside the casing.
 7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches (89 mm) wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

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- a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
- C. Drives, Direct: Factory-mounted, direct drive.
- D. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.
- E. Relief-Air Fan: Propeller, Forward curved or Backward inclined, shaft mounted on permanently lubricated motor.
- F. Motors:
 - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 3. Enclosure Type: Open, dripproof
 - 4. Enclosure Materials: Cast iron.
 - 5. Motor Bearings:
 - 6. Unusual Service Conditions:
 - a. Ambient Temperature: 115F.
 - b. Altitude: 500 feet above sea level.
 - c. High humidity.
 - 7. Efficiency: Premium efficient as defined in NEMA MG 1.
 - 8. NEMA Design: TBD
 - 9. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 10. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

1.13 ROTARY HEAT EXCHANGERS

- A. Casing:
 - 1. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory finish.
 - 2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch differential pressure.
 - 3. Casing seals on periphery of rotor, on duct divider, and on purge section.
 - 4. Support vertical rotors on grease-lubricated ball bearings with extended grease fittings. Mount horizontal rotors on tapered roller bearing.
- B. Rotor - Aluminum or Polymer: Segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.
- C. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
- D. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10 rating, or 400,000 hours.

E. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. Retain one of first three subparagraphs below.
3. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
4. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
5. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
6. Control energy recovery to permit air economizer operation.
 - a. Bypass dampers to assist energy recovery control.
7. Pilot-Light Indicator: Display rotor rotation and speed.
8. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
9. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch differential pressure.

1.14 COILS

A. General Requirements for Coils:

1. Comply with AHRI 410.
2. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Supply-Air Refrigerant Coil:

1. Tubes: Copper.
2. Fins:
 - a. Material: Aluminum or Copper .
 - b. Fin Spacing: Maximum 8 fins per inch.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel
6. Coatings: Corrosion-resistant coating
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 - a. Working Pressure: Minimum 300 psig (2070 kPa).

C. Hot-Gas Reheat Refrigerant Coil:

1. Tubes: Copper .
2. Fins:
 - a. Material: Aluminum or Copper.
 - b. Fin Spacing: Maximum 8 fins per inch.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Galvanized steel
6. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

- a. Working Pressure: Minimum 300 psig.
- 7. Suction-discharge bypass valve.
- D. Electric-Resistance Heating Coils: Comply with UL 1995.
 - 1. Casing Assembly: Flanged type with galvanized-steel frame.
 - 2. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
 - 3. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
 - 4. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
 - 5. Control Panel: Unit mounted with disconnecting means and overcurrent protection.
 - a. Magnetic contactor.
 - b. Solid-state, stepless pulse controller.
 - c. Toggle switches, one per step.
 - d. Step controller.
 - e. Time-delay relay.
 - f. Pilot lights, one per step.
 - g. Airflow proving switch.

1.15 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- B. Refrigeration Specialties:
 - 1. Refrigerant: R-410A.
 - 2. Expansion valve with replaceable thermostatic element.
 - 3. Refrigerant filter/dryer.
 - 4. Manual-reset high-pressure safety switch.
 - 5. Automatic-reset low-pressure safety switch.
 - 6. Minimum off-time relay.
 - 7. Automatic-reset compressor motor thermal overload.
 - 8. Brass service valves installed in compressor suction and liquid lines.
 - 9. Low-ambient kit high-pressure sensor.
 - 10. Hot-gas reheat solenoid valve modulating with a replaceable magnetic coil.
 - 11. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
 - 12. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

1.16 AIR FILTRATION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
 - 1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
 - 2. Filter Unit Class: UL 900.
 - 3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.

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4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.
- C. Bag Filter:
1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
 2. Filter Unit Class: UL 900.
 3. Media: Fibrous material, with antimicrobial coating, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
 4. Filter-Media Frame: Galvanized steel.
- D. Cartridge Filters:
1. Description: Factory-fabricated, adhesive-coated disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
 2. Filter Unit Class: UL 900.
 3. Media: Fibrous material, with antimicrobial coating, constructed so individual pleats are maintained in pleated form under rated-airflow conditions by corrugated aluminum separators.
 4. Filter Media Frame: Galvanized steel.
- E. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
1. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

1.17 ANTIMICROBIAL ULTRAVIOLET LAMP SYSTEM

- A. Description:
1. UV-C lamp system consisting of power supply, power supply housing, wiring, UV lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
 2. Factory installed and preengineered.
- B. Standard: UL Category Code ABQK, HVAC accessories, air-duct mounted.
- C. Lamps: High output, hot cathode.
- D. Lamp-Holder Construction:
1. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
 2. Adjustable positioning.
- E. Lamp-Clamp Construction:
1. UV- and moisture-resistant materials, water-tight connection.
 2. Adjustable positioning.
- F. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.

- G. Lamp Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.
- H. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.
- I. Power Supply: UL-listed, single-point electrical connection with service disconnect.
- J. Power Consumption: Maximum of 24 W/sq. ft.

1.18 DAMPERS

- A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."
- B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg rated in accordance with AMCA 500D.
- C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
- D. Electronic Damper Operators:
 - 1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - 3. Operator Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - 4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 - 5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 - 6. Size dampers for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.

- f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Temperature Rating: Minus 22 to plus 122 deg F.
11. Run Time: 30 seconds.

1.19 ELECTRICAL POWER CONNECTIONS

- A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

1.20 CONTROLS

- A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:
 - a. Heat-cool-off switch.
 - b. Fan on-auto switch.
 - c. Fan-speed switch.
 - d. Automatic changeover.
 - e. Adjustable deadband.
 - f. Exposed set point.
 - g. Exposed indication.
 - h. Degree F indication.
 - i. Unoccupied-period-override push button.
 - j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.
3. Wall-mounted humidistat or sensor with the following features:
 - a. Concealed set point.
 - b. Exposed indication.
4. Unit-Mounted Annunciator Panel for Each Unit:
 - a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
 - b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
 - c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

- B. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:
 - a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.

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- b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
 - c. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 284621.13 "Conventional Fire-Alarm Systems."
 - d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.
 - e. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
3. Scheduled Operation: Occupied and unoccupied periods on 365-day clock with a minimum of two programmable periods per day.
4. Unoccupied Period:
 - a. Heating Setback: Plus 10 deg F.
 - b. Cooling Setback: System off.
 - c. Override Operation: Two hours.
5. Supply Fan Operation:
 - a. Occupied Periods: Run fan continuously.
 - b. Unoccupied Periods: Cycle fan to maintain setback temperature.
6. Refrigerant Circuit Operation:
 - a. Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass to match compressor output to cooling load to maintain discharge temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
 - b. Unoccupied Periods: Cycle compressors and condenser fans for heating to maintain setback temperature.
 - c. Switch reversing valve for heating or cooling mode on air-to-air heat pump.
7. Electric-Heating-Coil Operation:
 - a. Occupied Periods: Modulate coil to maintain discharge temperature.
 - b. Unoccupied Periods: Energize coil to maintain setback temperature.
 - c. Operate supplemental electric heating coil with compressor for heating with outdoor temperature below 25 deg F.
8. Economizer Outdoor-Air Damper Operation:
 - a. Morning warm up cycles.
 - b. Occupied Periods: Open to 10 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F. Use mixed-air temperature and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
 - c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
 - d. Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc.
9. Carbon Dioxide Sensor Operation:
 - a. Occupied Periods: Reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 1000-ppm concentration.
 - b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.
10. Terminal-Unit Relays:

- a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."
- C. Interface Requirements for HVAC Instrumentation and Control System:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
 3. Provide BACnet compatible interface for central HVAC control workstation for the following:
 - a. Adjusting set points.
 - b. Monitoring supply fan start, stop, and operation.
 - c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
 - d. Monitoring occupied and unoccupied operations.
 - e. Monitoring constant and variable motor loads.
 - f. Monitoring variable-frequency drive operation.
 - g. Monitoring cooling load.
 - h. Monitoring economizer cycles.
 - i. Monitoring air-distribution static pressure and ventilation air volume.

1.21 ROOF CURBS

- A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C1071, Type I or II.
 - b. Thickness: 2 inches.
 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C916, Type I.
- B. Curb Dimensions: Height of 14 inches.

1.22 ACCESSORIES

- A. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.
- B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
- C. Low-ambient kit using variable-speed condenser fans for operation down to 35 deg F.

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- D. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- E. Remote potentiometer to adjust minimum economizer damper position.
- F. Return-air bypass damper.
- G. Factory- or field-installed demand-controlled ventilation.
- H. Safeties:
 - 1. Smoke detector.
 - 2. Condensate overflow switch.
 - 3. Phase-loss reversal protection.
 - 4. High and low pressure control.
 - 5. Electric coil airflow-proving switch.
- I. Coil guards of painted, galvanized-steel wire.
- J. Hail guards of galvanized steel, painted to match casing.
- K. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
- L. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.
- M. Door switches to disable heating or reset set point when open.
- N. Outdoor air intake weather hood with moisture eliminator.
- O. Service Lights and Switch: Factory installed in each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

1.23 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Galvanized Steel: ASTM A653/A653M.
- C. Aluminum: ASTM B209 (ASTM B209M).
- D. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
- E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
 - c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

1.24 SOURCE QUALITY CONTROL

- A. AHRI Compliance:
1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
 2. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs
 3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
 4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
- B. AMCA Compliance:
1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
 2. Damper leakage tested in accordance with AMCA 500-D.
 3. Operating Limits: Classify according to AMCA 99.

EXECUTION

1.25 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
- B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
- C. Examine roofs for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

1.26 INSTALLATION

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to AHRI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
1. Install normal-weight, 3000-psi, compressive strength (28-day) concrete mix inside roof curb, 4 inches thick. Concrete, formwork, and reinforcement are specified with concrete.
- B. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
- C. Equipment Mounting: Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

1.27 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to RTU, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 2, ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

1.28 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination at top of roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
 - 4. Install return-air duct continuously through roof structure.

1.29 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch (13 mm) high.
 - 3. Locate nameplate where easily visible.

1.30 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

1.31 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to furnace combustion chamber.
 - 3. Inspect for visible damage to compressor, coils, and fans.
 - 4. Inspect internal insulation.
 - 5. Verify that labels are clearly visible.
 - 6. Verify that clearances have been provided for servicing.
 - 7. Verify that controls are connected and operable.
 - 8. Verify that filters are installed.
 - 9. Clean condenser coil and inspect for construction debris.
 - 10. Clean furnace flue and inspect for construction debris.
 - 11. Connect and purge gas line.
 - 12. Remove packing from vibration isolators.
 - 13. Inspect operation of barometric relief dampers.
 - 14. Verify lubrication on fan and motor bearings.
 - 15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 16. Adjust fan belts to proper alignment and tension.
 - 17. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.
 - 18. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 19. Operate unit for an initial period as recommended or required by manufacturer.
 - 20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.
 - c. Measure combustion-air temperature at inlet to combustion chamber.
 - d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - 21. Calibrate thermostats.
 - 22. Adjust and inspect high-temperature limits.
 - 23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
 - 24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
 - 25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - 26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.

- c. Relief-air volume.
 - d. Outdoor-air intake volume.
27. Simulate maximum cooling demand and inspect the following:
- a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
- a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.
29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

1.32 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

1.33 CLEANING

- A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems and after completing startup service, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

1.34 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. RTU will be considered defective if it does not pass tests and inspections.

- F. Prepare test and inspection reports.

1.35 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.13

SECTION 260500

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Related documents that govern work specified in this section.

1. Conditions of Contract.
2. Other applicable sections of specifications.

1.2 BASIC REQUIREMENTS

- A. Per Conditions of Contract, each Electrical Contractor executing work in Divisions 26 is acting in capacity of sub-contractor. However, throughout Divisions 26 Electrical Contractor is hereinafter referred to as Contractor.
- B. Contractor is duly bound to applicable requirements of prime contractor as stipulated in Conditions of Contract.
- C. Execute work hereinafter specified or indicated on accompanying drawings and provide equipment and labor as required in connection with work and systems.

1.3 SITE INSPECTION

A. Visit site and verify following.

1. Items shown or indicated as "existing" on drawings, including structures, trees, utilities, obstructions, etc.
2. Work conditions.
3. Hazards.
4. Soil grades and conditions.

B. Acceptance of contract shall be deemed as evidence that site visit has been made and that Contractor has become familiar with conditions noted above.

1.4 PERMITS, UTILITY CONNECTIONS AND INSPECTIONS

A. Obtain and pay for required utility connections, meters and meter boxes, utility extensions and/or relocations and shall pay all costs and inspection fees for all work included therein. Include applicable taxes.

B. Other miscellaneous fees related to permits and utilities shall be paid by Contractor and shall be included in Bid.

1.5 APPLICABLE CODES AND STANDARDS

- A. Except as hereinafter modified in individual sections of Divisions 26 and contract drawings, materials and installation shall meet requirements prescribed in latest editions of applicable manuals and standards of following codes and standards:
1. National Fire Protection Association Standards (NFPA):
 - a. NFPA No. 70 - National Electrical Code
 - b. NFPA No. 101 - Life Safety Code
 - c. NFPA No. 200 Series - Building Construction
 2. United States of American National Standards Institute (ANSI) Standards
 3. American Society of Testing and Materials (ASTM).
 4. American National Standards Institute (ANSI).
 5. National Electrical Manufacturers' Association (NEMA).
 6. Occupational Safety and Health Act (OSHA).
 7. State and Local safety and health standards.
 8. Work shall be per regulations and requirements of Standards and Specifications for Handicapped and Disabled for Construction of Public Buildings and Facilities in State of Texas Usable by Physically Handicapped and Disabled Persons. Reference 028.13.03.579 of Section 7, Article 601b, V.T.C.S.
 9. See individual sections for additional codes, standards, and special requirements.
- B. It is intent of Divisions 26 and related drawings to comply with above mentioned requirements, standards, and codes. However, some discrepancies may occur. Where discrepancies occur, Owner in writing of discrepancies and request interpretation.
1. Request for interpretation shall be made before work is performed or material is fabricated.
 2. Should Contractor fabricate and/or install materials and/or workmanship in such manner that does not comply with applicable codes, standards, and/or regulations, Contractor shall bear costs arising in correcting deficiencies to comply with codes, standards, and/or regulations.
 3. Should conflict or discrepancy occur between codes, standards, and/or regulations, comply with most stringent, at no additional cost to Owner.

1.6 CONTRACT DOCUMENTS

- A. Specifications and accompanying drawings of building indicate plans and details showing installations and locations of equipment, piping, ductwork, outlets, controls, etc., based on product or group of products, from identified manufacturer or manufacturers, layout of equipment and installation drawing are based on identified equipment, materials, etc.
- B. Alternates (equipment, materials, systems, etc.) are named, or listed equal products, or manufacturers included in documents and that comply with performance and quality provisions of specifications. Alternates shall be as proposed for use by the Contractor and subject to acceptance by Owner, and in compliance with following specifications. Any alternate presented must be included in bid pricing.
- C. Installation drawings of systems are based on identified vendors and products, and these items are used for dimensions, utility connections, service clearances, etc. These drawings, even when dimensioned, are schematic in nature and are subject to field coordination to reflect actual conditions, final equipment shop drawings, construction means and methods, and coordination between trades.
- D. Coordinate final installation of equipment and systems where named manufacturers are incorporated into work. Architectural or engineering design required to incorporate that work shall be responsibility of Contractor. Cost resulting from changes in layout, increase sizes or length of run, ductwork

revisions, and/or services for additional utilities that may be required shall be the responsibility of Contractor and provided at no additional cost.

- E. Changes in the project required to support alternates shall be fully identified and submitted as attachment to shop drawing for alternate product. Such changes shall be reflected in coordination drawings and be approved by affected trades. Any alternate must be included in bid pricing.
- F. Due to intricacies of construction, it is impractical to specify or indicate every detail; in such cases, current rules of good construction practices and applicable specifications shall govern. If departures from drawings are deemed necessary by Contractor, details of such proposed departures shall be made to Owner in writing. Each request shall state reasons and recommended correction for proposed departure. No departure shall be made without prior written approval of Owner.
- G. Become familiar with drawings and specifications and properly use information found on Architectural, Structural, Mechanical, and Electrical drawings and specifications affecting work.
- H. Electrical power circuits shown on drawings to items of mechanical equipment may or may not be correct size to serve equipment to be installed by HVAC and/or Plumbing Contractors. Obtain from HVAC and Plumbing Contractors exact power requirements for each item of mechanical equipment before circuit breakers, disconnects, power wiring, conduit, etc., have been purchased or installed. Correct power wiring to feed installed mechanical equipment items shall be provided at no additional cost to Owner.
- I. Dimensional information pertaining to new work in structure shall be taken from appropriate drawings. Dimensional information pertaining to existing conditions and outside structure shall be made by Contractor on site.
- J. Should drawings or specifications disagree within themselves, or with each other, better quality or greater quantity of work or materials shall be performed or furnished at no additional cost to Owner.
- K. Interrelation of specifications and drawings and schedules is as follows:
 - 1. Specifications determine type and installation of material.
 - 2. Drawings establish location, quantities, dimensions, and details.
 - 3. Schedules establish performance characteristics of equipment.
- L. Dimensions indicated on drawings govern scaled measurements. Large scale details govern small scale drawings.

1.7 SPACE AND EQUIPMENT

- A. Size of electrical equipment indicated on drawings is based on dimensions of equipment by manufacturer indicated on drawings, in specifications and/or as listed in equipment schedules. Other manufacturers may be acceptable if equal in design and function.
- B. Determine if equipment proposed to be furnished will fit in allotted space.
- C. Space is critical; therefore, equipment of larger sizes than shown, even though of specified manufacturer, will not be acceptable unless Contractor can demonstrate that ample space exists for proper installation, operation, and maintenance.
- D. If requested by Owner, Contractor shall prepare and furnish detailed installation drawings indicating arrangement and installation of proposed equipment and submit to Owner for approval. Approval, in writing, shall be obtained before ordering equipment.

1.8 SUPERINTENDENT

- A. Study Contract Documents and become familiar with work to be done by other trades. Coordinate work with other trades and before material is fabricated or installed, make sure that work will not cause interferences that cannot be resolved without major changes to Contract Documents.

1.9 GUARANTEE/WARRANTY

- A. Guarantee work, labor, and materials, for one year from date of substantial completion per Conditions of Contract.
- B. Refer to individual sections of specifications for guarantees which may be required in addition to above-specified one-year guarantee.

1.10 MANUFACTURER'S CERTIFICATION OF MATERIALS AND EQUIPMENT

- A. Before shop drawings or manufacturer's data are submitted for approval, duly authorized manufacturer's representative of proposed equipment shall review design of system relative to proper operation of their equipment and material. Shop drawings and/or manufacturer's data submitted shall include letter from manufacturer's representative certifying that equipment and materials will operate and function satisfactorily under design conditions.
- B. Before work is accepted, duly authorized manufacturer's representative of installed equipment shall inspect installation and operation of their equipment and materials to determine that they are properly installed and properly operating per manufacturer's recommendations.
 - 1. Testing and checking required due to work being concealed shall be accomplished during work. Otherwise, checking and testing will be done at completion of Work.
 - 2. Upon completion of inspection, submit letter from manufacturer's representative making inspection stating following:
 - a. "I, _____, (duly authorized manufacturer's representative), certify that the equipment and materials listed below have been personally inspected and are properly installed and operating per manufacturer's recommendations."
- C. Following equipment and materials require manufacturer's certification as stipulated above:
 - 1. Low Voltage Switchgear
 - 2. Power Factor Correction Equipment
 - 3. Lightning Protection Systems
 - 4. Lighting Control System

1.11 General Requirements for Electrical Work

- A. Unless otherwise specified, materials shall be new and of current U.S. manufacture, free from defects, and of best quality of their respective kinds.
- B. Equipment and/or materials damaged in shipment or handling, or otherwise damaged before installation, shall be replaced with new equipment and/or materials. Damaged equipment and/or materials shall not be repaired at jobsite.
- C. Furnish proper equipment and/or materials and see that it is installed as recommended by manufacturer. If required for proper installation, obtain advice and supervisory assistance from representative of specific manufacturer of equipment being installed.

- D. Materials and adhesives shall conform to Federal Standard Flame-Spread Properties, Inc., with composite fire and smoke hazard ratings, maximum 25 for flame spread and 50 for smoke developed. Adhesives shall be waterproof.
- E. Promptly notify Owner in writing of conflict between requirements of Contract Documents and manufacturer's directions and obtain Owner's instructions before proceeding with work. Should If such work is performed and does not comply with manufacturer's directions or such instructions from Owner, bear costs arising in connection with deficiencies.

1.12 CONSTRUCTION REQUIREMENTS

- A. It is intent of Contract Documents that installation be provided, complete in every respect. If additional work is required for Work indicated or specified, provide same and provide material and equipment usually furnished with such systems or as required to complete installation.
- B. Place material and equipment into building and carefully lay out work in project to conform to structural conditions, to avoid obstructions, to conform to details of installation supplied by manufacturer of equipment to be installed and thereby provide integrated, satisfactorily operating installation.
- C. Investigate structural and finish conditions and coordinate work with various trades to avoid interferences between different phases of Work. Harmonize work so that it may be installed in most direct and workmanlike manner without hindering or handicapping each other.
- D. Unless specifically noted to be exposed, lay out work in finished portions of building so that it will be concealed.
- E. Lay out work as required to avoid impairment or weakening of structural members. Inserts for pipe hangers shall be set before concrete is poured. Provide and properly lay out sleeves in concrete for penetrating conduits. Hold conduits as tight to structure as possible.
- F. Lay out and install equipment as required to provide convenient and safe maintenance and access for future replacement as well as providing easy access to removable access panels and junction boxes.

1.13 STORAGE AND PROTECTION

- A. Provide required protection of equipment and materials from time of delivery until completion of Work. Protect from damage, rust, rain, humidity and dust.
- B. Do not receive equipment or materials on job site until adequate space has been provided for storage.
- C. Provide adequate supports for protection from ground and erect required shelters for items stored in open.
- D. Items stored within building shall be adequately protected and covered with tarpaulins or other protective covering.
- E. Always protect building during construction from damage by workmen, tools and/or equipment. Protect floors, steps, wall, ceilings, doors, windows and other finished surfaces.
- F. Equipment and materials found in rusty condition at completion of work shall be thoroughly cleaned of rust and refinished as required to its original condition.

- G. Provide laminated copy of schematic electrical diagram on wall of each electrical room. Schematic electrical diagram used shall be one serving electric room.

1.14 PRECEDENCE OF MATERIALS

- A. Install equipment and material into allotted spaces in structure to provide complete and acceptable systems.
- B. To prevent conflict in space requirements, following order of precedence, in general, shall be observed.
 - 1. Building lines
 - 2. Structural members
 - 3. Soil and drain piping
 - 4. Vent piping
 - 5. Refrigerant piping
 - 6. Steam piping
 - 7. Condensate piping
 - 8. Electrical bus duct
 - 9. Supply ductwork
 - 10. Return air ductwork
 - 11. Exhaust ductwork
 - 12. Circulating chilled and heating water piping
 - 13. Domestic hot and cold water piping
 - 14. Electrical conduit

1.15 LOCATION OF OUTLETS AND EQUIPMENT

- A. Drawings show locations of various outlets and equipment. Exact locations of these outlets and equipment shall be determined by reference to general construction plans and to detail drawings, equipment drawings, roughing-in drawings, etc., by measurements at building, and in cooperation with other trades.
- B. At Owner's option, devices and outlets as listed below may be relocated at no additional cost to Owner.
- C. Lighting fixtures, convenience outlets, and floor outlets, may, at Owner's option, be relocated to point within 10 feet of location indicated on drawings, at no additional cost to Owner, provided Contractor is advised of this relocation before roughing-in begins.
- D. Install work complete and in good working order. If requirements of drawings and specifications are impossible to perform, or if installation when made per such requirements will not perform satisfactorily, report same to Owner for correction.
- E. No extra compensation will be allowed for extra work or change caused by failure to comply with above requirements.

1.16 CUTTING AND PATCHING IN EXISTING CONSTRUCTION

- A. Cut and patch walls, floors, etc., resulting from work in existing construction. If cutting and patching is required, it shall be performed by trades specializing in that work.

- B. Openings cut through concrete and masonry shall be made with masonry saws and/or core drills and at such locations acceptable to Owner. Impact-type equipment shall not be used except where specifically acceptable to Owner.
- C. Openings in existing precast concrete slabs or existing walls for conduit, etc., shall be core drilled to exact size.
- D. Where openings are cut through existing masonry walls, provide lintels or other structural supports to protect remaining masonry. Adequate supports shall be provided during cutting operation to prevent damage to masonry occasioned by operation. Structural members, supports, etc., shall be of proper size and shape, and shall be installed in manner acceptable to Owner.
- E. No cutting, boring, or excavating that will weaken existing structure will be permitted.

1.17 ROOF PENETRATIONS

- A. Conduit penetrating roof shall be installed as directed by roofing supplier/installer and shall be compatible with roofing system.

1.18 ELECTRICAL WORK IN EXISTING FACILITIES

- A. Existing Conditions: In addition to Contract Documents, obtain data related to existing facilities from existing measurements, conditions, notations, and other observations at site.
- B. Work Included
 - 1. Remove existing conduit, equipment, and other items as required to provide access for new Work.
 - 2. Reinstall conduit, equipment, etc., where indicated.
 - 3. Repair and/or refinish damaged surfaces upon completion of work.
- C. Disruption of Existing Functions
 - 1. Access to and use of existing building and site, except as otherwise indicated, will be restricted and under direction and control of Owner.
 - 2. Maintain existing electric service except for scheduled disruptions.
 - 3. Obtain approval 2 weeks in advance of schedule for date, time and duration of required disruptions.
 - 4. Other disruptions:
 - a. Make request immediately on knowledge of requirement.
 - b. Perform Work to cause minimum disruption.
 - 5. Notify Owner immediately by telephone and then in writing as changes and additions to scheduled disruption requirements become known.
 - 6. Duration:
 - a. Complete as large portion of Work as possible before disruption.
 - b. Maintain on hand adequate supplies, materials, equipment, workers, and other items during disruption.
 - c. Duration of disruption shall be kept to minimum.
 - d. During disruption, perform only amount of work that requires disruption.
- D. Salvage, Demolition and Relocation
 - 1. General:

- a. Modify, remove, or relocate materials and items indicated on Drawings or required by installation of new facilities.
 - b. Electrical items not required to be turned over to Owner for salvage shall be removed from site.
2. Relocations:
- a. Materials and items scheduled for relocation that are damaged during dismantling or reassembly operations shall be repaired and restored to good operational and functional condition.
 - b. If materials are damaged and cannot be repaired, new materials and items of like design and quality shall be substituted upon approval of Shop Drawings, Product Data, and Samples.
 - c. Remove carefully, in reverse to original assembly or placement, items that are to be relocated.
 - d. Store and protect items until relocation is complete.
 - e. Clean, repair, and/or provide new materials, fittings, and appurtenances as required to complete relocations and to restore to good operative order.
 - f. Perform relocation work per pertinent sections of specifications, using skilled workers.
3. Before work has been started on dismantling, report to Owner items that are scheduled for relocation, reinstallation, or reuse and are found to be in damaged condition.

1.19 ELECTRICAL CONNECTIONS TO EQUIPMENT

A. Description of Work

1. Extent of electrical connections to equipment is indicated on drawings and in schedules, in other Divisions of specifications, and by requirements of this section, and is hereby defined to include (but not necessarily limited to) connections for providing electrical power to equipment.
2. Types of electrical connections specified in this section include, but are not necessarily limited to, following.
 - a. To motors
 - b. To electric heaters
 - c. To motor starters
 - d. From motor starters to motors
 - e. To HVAC control and other control devices
 - f. To elevators

B. Materials and Components

1. For each indicated electrical connection, provide complete assembly of materials, including but not necessarily limited to following.
 - a. Pressure connectors
 - b. Terminals (lugs)
 - c. Electrical insulating tape
 - d. Heat shrinkable tubing
 - e. Cable ties
 - f. Solderless wire nuts
 - g. Conductors
2. Furnish materials and components per equipment manufacturer's recommendations for intended application.

C. Installation of Electrical Connections

1. Install electrical connections as indicated, per recognized industry practices to ensure that products serve intended functions.
 2. Connect electrical power supply conductors to equipment conductors per other sections of specifications and per equipment manufacturer's written instructions and wiring diagrams. Wherever possible, match conductors of electrical connection for proper interface between electrical supply and installed equipment.
 - a. Cover splices with electrical insulation equivalent to, or of higher rating, than insulation on conductors being spliced.
 - b. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated.
 - c. Trim cables and wires to be as short as practical and arrange routing to facilitate inspection, testing, and maintenance.
 3. Provide conduit for connections per other sections of specifications.
 4. Coordinate installation of electrical connections to equipment with equipment installation work and as follows.
 - a. Make electrical connections to equipment furnished under other sections of Contract Documents.
 - b. Furnish wiring, conduit, outlet boxes, disconnect switches, etc., as required for same throughout project.
 - c. Check General Construction, Plumbing, Heating and Air Conditioning plans and specifications and determine amount of required wiring for final connections.
 - d. Verify locations, horsepower, voltages, etc., of such equipment as work progresses.
 - e. Advise Owner immediately, for clarification, if apparent conflict arises in control wiring, power wiring, etc.
 5. Due to manufacturer's changes equipment furnished under mechanical and other sections of specifications may require different rough-in requirements than indicated on plans. Secure detailed drawings from Contractor furnishing equipment, to determine actual rough-in locations, and conduit and conductor requirements to ensure proper and workmanlike installation.
 6. Install motor controls, safety switches, etc., for equipment on new 3/4-inch-thick plywood (with 2 coats of paint) to match surrounding area. Arrange equipment in each area to mount on one piece of plywood where possible.
 7. Provide fusible or non-fusible disconnecting switches or NEC-approved disconnecting means for motors and equipment that are not otherwise provided with same.
- D. Final Connections from Motor Starters to Motors: Provide conduit, wiring, disconnects, etc., as required to install final connections from motor starters to motors. Verify number and size of conductors and disconnecting means requirements. Part-winding and wye-delta starting and multi-speed motors may require multiple or 6-pole disconnects that shall be provided under this section of Contract Documents.
- E. Final Connections for Equipment Furnished by Owner or Under Other Sections of Contract Documents.
1. HVAC AND MECHANICAL EQUIPMENT: Obtain submittal data from Owner or other parties furnishing HVAC and mechanical equipment, check data, and provide required electrical, including conduit and conductors, circuit breakers, fuses, disconnects, etc., to accommodate changes or variations in drawings and/or specifications.
 2. ELEVATORS: Provide disconnect switches for elevators as indicated on plans. Wiring under this contract includes feeders and branch circuits (including control circuits) from load side of disconnect to line side of elevator controllers. Provide wiring for elevator lights as indicated on plans and as required by elevator Installer.

1.20 REQUIRED SUBMITTAL DATA FOR ELECTRICAL WORK

A. General

1. As soon as practical after date of award of contract and before purchasing or starting installation of materials or equipment, submit complete shop drawings and/or manufacturer's data of materials and equipment to be incorporated in work.
2. Materials and equipment requiring detailed submittal data shall be submitted with sufficient data to indicate that requirements of specifications have been met. Where products are noted or specified by brand names, it is for purpose of establishing standards of quality, style and size.
3. Manufacturer's data shall have non-applicable features crossed out or deleted in manner that will clearly indicate exactly what is to be furnished.
4. Samples shall be furnished when requested.

B. Review of Submittals

1. Allow minimum of 2 weeks for review of each submission by office of design discipline involved after receipt of such submissions by that design discipline.
2. Allow sufficient time in construction schedule to cover 2-week cycles of data processing, including time for resubmission cycles on non-acceptable materials, equipment, etc., covered by data submitted.
3. Construction delays and/or lack of timeliness in above regards are responsibility of Contractor and will not be considered in request for scheduled construction time extensions.

C. Acceptance of Materials and Equipment

1. Acceptance of materials and equipment will be based on manufacturer's published data and will be tentative subject to submission of complete shop drawings and/or manufacturer's data indicating compliance with contract documents and that adequate and acceptable clearance for entry, servicing, and maintenance will exist.
2. Acceptance of materials and equipment under this provision shall not be construed as authorizing deviations from contract documents, unless attention of Owner has been directed in writing to specific deviation.
3. Data submitted shall not contain unrelated information unless pertinent information is properly identified.

D. Certification: Furnish manufacturer's certification where required.

E. Equipment Service: Equipment installed on project shall have representation; factory authorized service, and stock of repair parts within 200-mile radius.

F. Submittal Requirements

1. Check items of submittal data and verify by statement and initial that each item has been checked for following conditions.
 - a. Item is equal to specified item in construction, quality, and function.
 - b. Item is of same physical size. If not of same physical size, dimensions have been checked and item will fit within allocated space shown on plans.
 - c. System connections to item can be made as shown on plans.
 - d. Shop drawings show in detail connections, etc., required to meet overall specifications.

- e. Statement of guarantee that proposed equipment shall operate properly as applied to project and will not require additional device or changes in installation shown on plans.
 2. Submit letter stating that equipment specified in Division 23 or furnished by others has been verified for proper overcurrent protection, branch circuit size, disconnect requirements and number of required service points. Check mechanical equipment drawings and submittals and provide required electrical including wiring, breakers, fuses, disconnects, etc. Conductor sizes shall not be decreased from sizes indicated on electrical drawings.
- G. Complete specification data shall be submitted for electrical items including list below.
1. Low voltage conductor (600V and less)
 2. Conduit
 3. Wiring devices
 4. Relays/contactors
 5. Surface metal raceway
 6. Lighting fixtures
 7. Dry type transformers
 8. Transformer vibration isolators
 9. Photocells
 10. Time clock
 11. Disconnect switches
 12. Fuses
 13. Ground fault protection systems
- H. Complete scaled shop drawings and specification data shall be submitted for following.
1. Switchboards ,600V
 2. Distribution Switchboards, 600V
 3. Distribution panelboards
 4. Panelboards with completed schedule and dimensions
 5. Switchgear
- I. Complete system one-line schematic and specification data shall be submitted for following.
1. Dimming systems
 2. Lightning protection system
 3. Lighting control system

1.21 CLEANING REQUIRED UNDER ELECTRICAL WORK

A. Materials

1. Use only cleaning materials recommended by manufacturer of surface to be cleaned.
2. Use cleaning materials only on surfaces recommended by cleaning material manufacturer.

B. During Construction

1. Clean up and remove litter and construction debris that results from work under Divisions 26 in construction areas on as-needed and as-directed basis.
2. Schedule cleaning operations so that dust and other contaminants resulting from cleaning process will not fall on wet, newly painted surfaces.

C. Final Cleaning: Refer to "Project Closeout" within this section.

D. Housekeeping Pads

1. Install steel reinforced concrete housekeeping pad under floor-mounted electrical equipment such as switchgear, switchboards, transformers and capacitor banks. Indoor pads shall be minimum of 4-inch-thick. Outdoor pads shall be minimum of 8-inch-thick. Reinforce pads with No. 4 rebar, 6 inches on center unless noted or detailed otherwise.
2. Install pad 6 inches larger (in all dimensions) than equipment supported, installed to walls, etc., to prevent dirt traps.
3. Pour as integral part of floor slab whenever possible. Trowel finish and chamfer edges 1/2-inch.

E. Locking of Electrical Facilities

1. Provide padlocks or lockable latches for electrical facilities subject to unauthorized entry, such as panelboards, switchboards, transformers, generators, etc.
2. Furnish locks to match existing locking system. Key locks alike.
3. Furnish Owner with 2 keys per lock up to quantity of 10 keys.
4. Install locks immediately upon installation of electrical facility.

F. Electric Utility

1. Verify standard practices of electric utility company and requirements for electric metering and provide metering to conform to requirements.
2. Furnish necessary labor to install equipment supplied by electric utility company and provide other materials and equipment as required.

G. Electric Service for Testing: Install sufficient temporary electric service to related pumps, fans, and fan coil units so that HVAC system may begin testing 30 working days before job completion date.

H. Cleaning and Preparation of Items for Painting

1. Refer to Division 9 Sections for painting requirements.
2. Thoroughly clean parts of materials and equipment of cement, plaster, and other materials. Oil and grease spots shall be removed.
3. Thoroughly clean finish on parts of materials and equipment with factory applied finishes. If factory finish or job applied painted finished surface has been damaged, surfaces shall be repainted to satisfaction of Owner.
4. No nameplates on equipment shall be painted and suitable protection shall be afforded to plates to prevent being rendered illegible during painting operation.

1.22 ELECTRICAL TESTING AND LOAD BALANCING

- A. Work Included: Perform test, balance, final adjustment, etc., and record data for electrical work as described herein.
- B. Submittals: Submit data record forms for approval before conducting all tests or making final adjustments, torquing, balancing, etc.

C. Testing

1. 600V Conductors:
 - a. Megger test feeder conductors at 600V DC. Record value for each feeder conductor. Conductors that test below 30 megohms shall be replaced. Retest new conductors and record data.
 - b. Perform continuity test on feeder and branch circuit conductors.
 - c. Torque feeder and branch circuit connections and terminations to manufacturer's recommended values.
2. Grounding:
 - a. Measure and record ground resistance from system neutral connection at service entrance to ground reference point using suitable ground testing equipment. Resistance shall not exceed 3 ohms.
 - b. Test continuity and bonding of cable trays, wireways, etc.
 - c. Record data for each test.
3. Metering and Control Wiring: Test for proper connection before energization of equipment. System shall be completely tested to verify proper operation and multipliers.
4. Transformers, Dry Type:
 - a. Check for damage and tight connections before energizing transformer.
 - b. Measure and record primary and secondary voltages and make appropriate tap adjustments.
 - c. Before energization, check transformer for conductivity of circuits and short circuits.

D. Device Trip Settings: Equipment manufacturer field service personnel shall adjust and set devices per approved results of "System Coordination and Analysis" as defined in section 26 05 73 Overcurrent Protective Device Coordination Study

E. Bus Torquing

1. Bolted bus connections shall be made using torque wrench.
2. Bus and lug connections in panelboards and switchboards shall be per manufacturer's specifications.
3. Busway connections shall be torqued per manufacturer's specifications. Record value for each bolted connection. Retorque busway joint bolts after energizing busway and shutting down to ensure joints are secure.

F. Load/Voltage Data

1. Record amperage of each phase and neutral in each panelboard and switchboard.
2. Record voltage line-to-neutral and line-to-line of phases in each switchgear, panelboard, and switchboard. Record each reading.
3. Lighting only panelboards shall be arranged so that, under full load, phases carry same load as near as possible.

G. Phase Rotation

1. Connect phases of panelboards, disconnects, controllers A, B, C to Bus and 1, 2, 3 from left to right.
2. Verify and make final connection to motor loads to provide proper rotations.
3. For existing installations, maintain existing phase rotation.

H. Mechanical Adjustment: Adjust operating mechanisms of electrical equipment for free mechanical movement.

1.23 ELECTRICAL STANDARDS AND SYMBOLS

A. Quality Assurance

1. Codes, Associations, and Standards: Local governing codes and authorities, trade association standards and publications are extension of contract documents and are hereby imposed as applicable to work in each instance. In general, each manufacturer, fabricator, supplier, and installer of electrical work is recognized as expert to be completely familiar with standards and publications applicable to their portion of work. Therefore, copies have not been bound with these specifications.
 - a. Where local codes, ordinances, rules, or authorities conflict with associations and standards listed hereinafter, local ordinances, codes, rules or authorities take precedence.
 - b. Obtain copies of trade association standards and publications, wherever needed for proper execution of work.
 - c. Comply with issue of applicable standard or publication that is in effect at date shown on these contract documents.
 - d. Where application of trade association standard or publication appears to conflict with requirements of contract documents, Owner will determine which must be complied with and, in general, more stringent will be required for performance of work.

B. Listing of Associations and Standards

1. AASHTO: American Association of State Highway and Transportation Officials, 444 N. Capitol; Washington, DC 20001
2. AISC: American Institute of Steel Construction, One East Wacker Drive, Suite 3100; Chicago, IL 60601
3. AISI: American Iron and Steel Institute, 1101 17th Street N.W., Suite 1300; Washington, DC 20036
4. ANSI: American National Standards Institute (Successor to USASI and ASA), 11 West 42nd Street; New York, NY 10036
5. ASTM: American Society for Testing and Materials, 100 Barr Harbor Drive; West Conshohocken, PA 19428
6. AWWA: American Wood Preservers Institute, 2750 Prosperity Avenue, Suite 550; Fairfax, VA 22031-4312
7. AWS: American Welding Society, 550 N.W. LeJeune Road; Miami, FL 33126
8. BOCA: Building Officials and Code Administrators
9. CBM: Certified Ballast Manufacturers Association, 355 Lexington Avenue, 17th Floor; New York, NY 10017-6603
10. COE: Corps of Engineers (Army)
11. ETL: Electrical Testing Laboratories
12. FM: Factory Mutual System, 1151 Boston-Providence Turnpike; Norwood, MA 02062-9102
13. FS: Federal Specifications
14. ICEA: Insulated Cable Engineers Association, P. O. Box 440; South Yarmouth, MA 02664
15. IECC: International Energy Conservation Code, International Code Council, 5203 Leesburg Pike, Suite 600, Falls Church, VA 22041-3401
16. IEEE: Institute of Electrical & Electronics Engineers, 445 Hoes Lane, P. O. Box 1331; Piscataway, NJ 08855-1331
17. MIL: Military Specifications
18. NEC: National Electrical Code (NFPA No. 70), 1 Batterymarch Park, P. O. Box 9101; Quincy, MA 02269-9101
19. NECA: National Electrical Contractors Association, Inc., 3 Bethesda Metro Center, Suite 1100; Bethesda, MD 20814

20. NEMA: National Electrical Manufacturers Association, 1300 North 17th Street, Suite 1847; Rosslyn, VA 22209
21. NESC: National Electrical Safety Code (ANSI C2)
22. NFPA: National Fire Protection Association, 1 Batterymarch Park, P. O. Box 9101; Quincy, MA 02269-9101
23. OSHA: Occupational Safety & Health Administration (U.S. Dept. of Labor), Government Printing Office; Washington, DC 20402
24. SBCCI: Southern Building Code Congress International, 900 Montclair Road; Birmingham, AL 35213-1206
25. UBC: Uniform Building Code, 900 Montclair Road; Birmingham, AL 35213-1206
26. UL: Solutions, 333 Pflingsten Road; Northbrook, IL 60062

C. Electrical Symbols

1. Electrical contract drawings and Owner's detail sheets are diagrammatic and show requirements by use of graphic symbols. In general, these are recognized symbols of industry and engineering profession. Questions of meaning or intent will be decided by Owner and shall be consistent with system of symbols indicated or, if none is indicated, with recognized conventions.
2. Listing of Symbols: Listing of (or key to) specific graphic symbols used to show electrical work on contract documents is shown on drawings.

1.24 PROJECT CLOSEOUT

- A. To close out Electrical Work of project, work hereinafter noted is required.
- B. Requirements for project closeout are, but not necessarily limited to, following.
 1. Record Drawings.
 2. Tests.
 3. Operation and Maintenance Manuals.
 4. Owner's Instructions.
 5. Shop Drawings.
 6. Correction of Deficiencies Found on Final Observation.
 7. Guarantees.
 8. Final Cleaning.

C. RECORD DOCUMENTS

1. Maintain set of Contract Drawings consisting of complete set of prints at jobsite.
2. Indicate on record drawings installed locations of:
 - a. Service entrance
 - b. Feeders
 - c. Outlets
 - d. Equipment
 - e. Dimensional locations of underground work
 - f. Dimensional locations of site work
3. Include addenda, change orders, clarifications, and other modifications to Drawings.
4. Deliver Drawings to Owner on completion of work.
5. Do not use these Drawings for reference or construction, nor allow them to leave field office.
6. Drawings will be reviewed by Owner as required and before approval of each month's Certificate for Payment. Certificate for Payment will not be approved until record drawings are brought up to date.

D. Test and Start-Up Data

1. Conduct tests as specified for various systems.
2. Log pertinent data at time of testing, including:
 - a. System identification
 - b. Date and time
 - c. Personnel
 - d. Description
 - e. Test conditions
 - f. Test results
 - g. Corrective measures taken
3. Log of start-up for all equipment including:
 - a. Equipment identification
 - b. Date and time
 - c. Personnel
 - d. Start-up procedures
 - e. Problems encountered
 - f. Corrective measures taken

E. Operation and Maintenance Instructions

1. Complete written operating instructions at each item of equipment and related systems.
2. Written instructions for preventative maintenance for each item of equipment and related systems.
3. Release, signed by Owner and Owner's Authorized Representative, for demonstration of operating and maintenance procedures.
 - a. List of equipment and system
 - b. Dates and times
 - c. Personnel present for demonstrations
4. List of equipment serial numbers.
5. Systems diagrams and drawings.
6. List of manufacturers', suppliers', and subcontractors' names, addresses, and telephone numbers; give both local representatives and service headquarters.
7. Spare Parts Data:
 - a. List of parts and supplies
 - b. Current unit prices
 - c. Sources of supply (local and national)
 - d. List of parts and supplies recommended by manufacturer for Owner to keep on hand
8. Provide 3 bound copies of data in loose-leaf, 3-ring binders with identifying tabs.

F. Final Cleaning

1. Employ experienced workmen, or professional cleaners for final cleaning.
2. In preparation for substantial completion or occupancy, conduct final inspection of sight-exposed interior and exterior surfaces, and of concealed spaces, and clean as follows:
 - a. Remove grease, dust, dirt, stains, labels, fingerprints, and other foreign materials from sight-exposed interior and exterior surfaces; polish surfaces so designated to shine finish.
 - b. Repair, patch and touch-up marred surfaces to specified finish, to match adjacent surfaces.
3. Owner will assume responsibility for cleaning as of time designated on Certificate of Substantial Completion for Owner's acceptance of Project or portion thereof.

PART 2 - PRODUCTS
Not used.

PART 3 - EXECUTION
Not used.

END OF SECTION 260500

SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Copper building wire rated 600 V or less.
 - 2. Fire-alarm wire and cable.
 - 3. Connectors, splices, and terminations.

1.3 DEFINITIONS

- A. RoHS: Restriction of Hazardous Substances.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with overall insulation layer or jacket, or both, rated 600V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.

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3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- D. Conductor Insulation: Type THHN and Type THWN-2: Comply with UL 83.

2.2 FIRE-ALARM WIRE AND CABLE

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for 2-hour rating.
 1. Low-Voltage Circuits: 16 AWG, minimum, in pathway.
 2. Line-Voltage Circuits: 12 AWG, minimum, in pathway.

2.3 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and use.
- B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 1. Material: Copper.
 2. Type: One-hole with standard barrels.
 3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders and Branch Circuits: Copper; solid for 10 AWG and smaller; stranded for 8 AWG and larger.
- B. Power-Limited Fire Alarm and Control: Solid for 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders and Branch Circuits: Type THHN/THWN-2, single conductors in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points per Section 260533, "Raceways and Boxes for Electrical Systems," before pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- F. Support cables per Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRING

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method:
 - 1. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
 - 2. Signaling Line Circuits: Power-limited fire-alarm cables shall not be installed in same cable or pathway as signaling line circuits.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in enclosure associated with fire-alarm system to terminal blocks. Mark each terminal per system's wiring diagrams. Make connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.
- E. Color-Coding: Color-code fire-alarm conductors differently from normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.
- F. Wiring to Remote Alarm Transmitting Device: one-inch conduit between fire-alarm control panel and transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals per manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test feeder conductors for compliance with requirements.
 - 2. Perform each of following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to single-line diagram.
 - b. Test bolted connections for high resistance using one of following:
 - 1) Low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply potential of 500V dc for 300V rated cable and 1000V dc for 600V rated cable for one-minute.

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- g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
 - 3. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600V unless otherwise required by applicable Code or authorities having jurisdiction.

2.3 CONNECTORS

- A. Listed and labeled by NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Conduit Hubs: Mechanical type, terminal with threaded hub.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
- B. Grounding Conductors: Green-colored insulation.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with feeders and branch circuits.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where maximum ground-resistance level is specified.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed following values: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Steel slotted support systems.
2. Conduit support devices.
3. Structural steel for fabricated supports and restraints.
4. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
5. Fabricated metal equipment support assemblies.

1.3 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Welding Qualifications: Qualify procedures and personnel per following.
 1. AWS D1.1/D1.1M.
 2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at maximum of 8 inches on center in at least one surface.
 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 2. Material for Channel, Fittings, and Accessories: Galvanized steel.
 3. Channel Width: 1-5/8 inches.
 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
- B. Conduit Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

- C. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- D. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
 - 6. Toggle Bolts: All-steel springhead type.
 - 7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA 101
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits. Secure raceways and cables to these supports with 2-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 pounds.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount pull and junction boxes and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 260529

SECTION 260533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Metal wireways and auxiliary gutters.
 - 3. Boxes, enclosures, and cabinets.
- B. Related Requirements: Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For wireways and fittings, hinged-cover enclosures, and cabinets.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Metal Conduit:
 - 1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
 - 2. GRC: Comply with ANSI C80.1 and UL 6.
 - 3. EMT: Comply with ANSI C80.3 and UL 797.
 - 4. FMC: Comply with UL 1; zinc-coated steel.

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5. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Comply with NEMA FB 1 and UL 514B.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Set-screw.
6. Expansion Fittings: Steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

C. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- D. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- E. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- F. Gang-able boxes are not allowed.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed: GRC.

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2. Concealed in Ceilings and Interior Walls and Partitions: EMT.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
4. Damp or Wet Locations: GRC.
5. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use set-screw, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto bottom side of metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

H. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

I. Support conduit within 12 inches of enclosures to which attached.

J. Threaded Conduit Joints, Exposed to Wet, Damp, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

K. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than 4 AWG.

L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal

bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

- M. Install raceways square to enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in locknut area before assembling conduit to enclosure to ensure continuous ground path.
- O. Cut conduit perpendicular to length. For conduits 2-inch trade size and larger, use roll cutter or guide to make cut straight and perpendicular to length.
- P. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-pound tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- Q. Install raceway sealing fittings at accessible locations per NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in flush steel box with blank cover plate having finish like that of adjacent plates or surfaces. Install raceway sealing fittings per NFPA 70.
- R. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between seal and following changes of environments. Seal interior of raceways at following points:
 - 1. Conduit extending from interior to exterior of building.
 - 2. Where otherwise required by NFPA 70.
- S. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 3. Install expansion fittings at locations where conduits cross building or structure expansion joints.
 - 4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- T. Flexible Conduit Connections: Comply with NEMA RV 3. Use maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors. Use LFMC in damp or wet locations.
- U. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- V. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide flat surface for raintight connection between box and cover plate or supported equipment and box.
- W. Horizontally separate boxes mounted on opposite sides of walls so they are not in same vertical channel.

- X. Locate boxes so that cover or plate will not span different building finishes.
- Y. Support boxes of 3 gangs or more from more than one side by spanning 2 framing members or mounting on brackets specifically designed for purpose.
- Z. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

SECTION 260544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Sleeves for raceway penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.

- B. Related Requirements: Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves: Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- B. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- C. Sleeves for Rectangular Openings:
 1. Material: Galvanized sheet steel.
 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway.
 - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, water-stop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber water-stop collar with center opening to match piping OD.

2.4 GROUT

- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

C. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

D. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible boot-type flashing units applied in coordination with roofing work.

E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for one-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

3.2 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water-stop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Color and legend requirements for raceways, conductors, and warning labels.
 - 2. Labels.
 - 3. Paint for identification.
 - 4. Fasteners for labels.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables:
 - 1. Black letters on orange field.
 - 2. Legend: Indicate voltage.
- B. Color-Coding for Phase-and Voltage-Level Identification: Use colors listed below for ungrounded feeder and branch-circuit conductors.
 - 1. Color shall be factory-applied or field-applied for sizes larger than 8 AWG if authorities having jurisdiction permit.

2. Colors for 208Y/120V Circuits:

- a. Phase A: Black.
- b. Phase B: Red.
- c. Phase C: Blue.
- d. Neutral: White.

3. Colors for 480Y/277V Circuits:

- a. Phase A: Brown.
- b. Phase B: Orange.
- c. Phase C: Yellow.
- d. Neutral: Gray.

4. Color for Equipment Grounds: Green.

C. Warning Label Colors: Identify system voltage with black letters on orange background.

D. Equipment Identification Labels: Black letters on white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

- 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
- 2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

C. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Minimum Nominal Size:

- a. 1-1/2 by 6 inches for raceway and conductors.
- b. As required by authorities having jurisdiction.

2.4 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Fasteners for Labels: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of 2-color markings in contact, side by side. Secure tight to surface of conductor, cable, or raceway.
- G. Accessible Fittings for Raceways: Identify covers of each junction and pull box of the systems with wiring system legend and system voltage. System legends shall be as follows: "POWER."
- H. Vinyl Wraparound Labels: Secure tight to surface of raceway or cable at location with high visibility and accessibility.
- I. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.
- J. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where 2 lines of text are required, use labels 2 inches high.
- K. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.
- L. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inches where splices or taps are made. Apply last 2 turns of tape with no tension to prevent possible unwinding.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Accessible Raceways for Feeder and Branch Circuits, More Than 30A and 120V to Ground: Identify with self-adhesive raceway labels. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box of following systems with self-adhesive labels containing wiring system legend and system voltage. System legends shall be as follows: "POWER."
- E. Power-Circuit Conductor Identification: For conductors in pull and junction boxes, use vinyl wraparound labels to identify phase. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- F. Warning Labels for Indoor Boxes and Enclosures for Power and Lighting: Self-adhesive labels. Apply to exterior of door, cover, or other access.

END OF SECTION 260553