

SECTION 233436 – HIGH VOLUME LOW SPEED FANS**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes**

1. High Volume Low Speed Fans.

1.2 REFERENCES

- A. National Fire Protection Agency (NFPA)
- B. Underwriters Laboratory (UL)
- C. International Organization for Standardization (ISO)
- D. National Electrical Manufacturers Association (NEMA)
- E. National Electrical Code (NEC)

1.3 SUBMITTALS

- A. Shop Drawings: Drawings detailing product dimensions, weight, and attachment methods.
- B. Product Data: Specification sheets on the fan, specifying electrical and installation requirements, features and benefits, and controller information.
- C. Installation Guide: The manufacturer shall furnish a copy of all operating and maintenance instructions for the fan. All data is subject to change without notice.
- D. Schedule

1.4 QUALITY ASSURANCE**A. Certifications**

1. The fan assembly, as a system, shall be Intertek/ETL-certified and built pursuant to the guidelines set forth by UL standard 507.
2. The fan shall be compliant with NFPA 13—Standard for the Installation of Sprinkler Systems, NFPA 72—National Fire Alarm and Signaling Code, and NFPA 70-2017—National Electric Code (NEC).
3. Controllers shall comply with National Electrical Code (NEC) and Underwriters Laboratory (UL) standards and shall be labeled where required by code.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver product in original, undamaged packaging with identification labels intact. The fan shall be new, free from defects, and factory tested.
- B. The fan and its components must be stored in a safe, dry location until installation.

1.6 WARRANTY

- A. The manufacturer shall replace any products, components, or finishes that are defective in material or workmanship for one (1) year. In addition, provide at minimum, five (5) year warranty on hub, airfoils, gear box motor, and controllers.

PART 2 - PRODUCT

2.1 MANUFACTURER

- A. Subject to compliance with the requirements, provide products by one of the following:
 - 1. BAF.
 - 2. Greenheck
 - 3. HVLS Corporation.
 - 4. Macroair Technologies.
 - 5. Approved equal.

2.2 HIGH VOLUME, LOW SPEED FANS

- A. Complete Unit
 - 1. Regulatory Requirements: The entire fan assembly shall be Intertek/ETL-certified and built pursuant to the construction guidelines set forth by UL standard 507.
 - 2. Sustainability Characteristics: The fan shall be designed to move an effective amount of air for cooling and destratification in industrial applications over an extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise.
- B. Airfoil System
 - 1. The fan shall be equipped with at minimum six (6) airfoils of precision extruded aluminum alloy. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
 - 2. The fan shall be equipped with at minimum six (6) winglets on the ends of the airfoils. Refer to schedule for type of wiglet required.
 - 3. Airfoils shall be constructed from 6005A-T6 extruded aluminum.
 - 4. Provide airfoils in mill finish.
 - 5. Provide airfoil with internal reinforcement to minimize blade deflection. Maximum allowable blade deflection shall be 3.7”.
- C. Motor
 - 1. The fan motor shall be a brushless DC type. Power connections for voltage and phase shall be as indicated on the drawings.

2. The motor shall be totally enclosed, fan cooled (TEFC) with an IP56. A standard frame shall be provided. The motor shall be manufactured with Class F insulation and be capable of continuous operation in 5⁰ F to 104⁰ F ambient conditions.

D. Motor Frame

1. The motor frame and mount shall be constructed of steel and powder coated. Non-visible, steel, threaded rods in each structural member of the motor frame shall provide a redundant safety feature in the event of a catastrophic event.

E. Mounting System

1. The fan mounting system shall be designed for secure installation on a variety of structural supports. The mounting yoke shall be of steel, welded construction, at least 3/16" thick, and powder coated.
2. All mounting bolts shall be SAE Grade 8 or equivalent.
3. Coordinate with structural drawings for suitable mounting structure. Provide mounting rod to accommodate drop required for clearance to structure above.

F. Hub

1. The fan hub shall be made of aluminum. The hub shall consist of two aluminum plates, aluminum spars and one (1) spacer fastened with a pin and collar rivet system.
2. The hub shall be secured to the output shaft of the gearbox by means of a steel coupling interface. The hub shall incorporate four (4) safety retaining clips made of 1/4" thick steel that shall restrain the hub/airfoil assembly.

G. Safety Cable

1. The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure. The safety cable shall be at least 1/4" in diameter and fabricated out of galvanized steel cable. The end loops shall be secured, pre-loaded and tested to 3,200 lbf.
2. Field construction of safety cables is not permitted.

H. Variable Frequency Drive

1. Onboard Variable Frequency Drive: The VFD may be mounted on the fan motor frame. A wall-mounted remote keypad equipped with touchpad controls and an LED display shall be provided for such installations, allowing access to all VFD functions.

I. Fire Control Panel Integration

1. Includes a 10–30 VDC pilot relay for seamless fire control panel integration. The pilot relay can be wired Normally Open or Normally Closed in the field.

J. Guy wires

1. Provide with manufacturer supplied cables to limit the potential for lateral movement.

PART 3 - EXECUTION**3.1 PREPARATION**

- A. Coordinate fan mounting with structural drawings.

3.2 INSTALLATION

- A. The fan shall be installed by a factory-certified installer according to the manufacturer's Installation Guide.
- B. Maintain Manufacturers recommended clearances.
- C. In buildings equipped with sprinklers, including ESFR sprinklers, fan installation shall comply with all of the following:
 - 1. The HVLS fan shall be centered approximately between four adjacent sprinklers.
 - 2. The vertical clearance from the HVLS fan to the sprinkler deflector shall be a minimum of 3 ft.
 - 3. All HVLS fans shall be interlocked to shut down immediately upon receiving a waterflow signal from the alarm system in accordance with the requirements of NFPA 72—National Fire Alarm and Signaling Code.
- D. Electrical Connections: Comply with applicable requirements in Division 26 Sections.
 - 1. Install electrical devices furnished with equipment but not specified to be factory mounted.

3.3 FIELD QUALITY CONTROL

- A. Test and Inspections: Test and adjust safeties and controls. Replace damaged and/or malfunctioning controls and equipment.

END OF SECTION 233400

SECTION 233713 - DIFFUSERS AND GRILLES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Diffusers and grilles.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser and Grille Schedule: Indicate drawing designation, quantity, model number, size, and accessories furnished.
- B. Samples: For each color specified.

PART 2 - PRODUCTS**2.1 DIFFUSERS AND GRILLES**

- A. Diffusers and Grilles, as specified on drawings:
 - 1. Subject to compliance with requirements, provide products by one of the following:
 - a. Krueger.
 - b. Nailor Industries.
 - c. Price Industries.
 - d. Titus.
 - e. Approved equal.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Install diffusers and grilles level and plumb.

- B. Ceiling- and Wall-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where Architectural features or other items conflict with installation, notify Engineer for a determination of final location.
- C. Install diffusers and grilles with airtight connections to ducts and to allow service and maintenance of volume and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233716 - LOUVERS AND VENTS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Fixed aluminum louvers.
 - 2. Extruded-aluminum brick vents.

1.2 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Louvers shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver blade rattle or flutter, or permanent damage to fasteners and anchors.
 - 1. Wind Loads: Determine loads based on a uniform pressure of 30 lbf/sq. ft., acting inward or outward.
- B. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width according to AMCA 500-L.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections and details. Show frame profiles and blade profiles, angles, and spacing.
- C. Samples: For each type of metal finish required. Electronic submittal of colors/finishes is not acceptable.
- D. Product Test Reports: Based on tests performed according to AMCA 500-L.

PART 2 - PRODUCTS**2.1 MATERIALS**

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5, T-52, or T6.
- B. Fasteners: Use types and sizes to suit unit installation conditions.
 - 1. For color-finished louvers, use fasteners with heads that match color of louvers.

2.2 FABRICATION, GENERAL

- A. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- B. Join frame members to each other and to fixed louver blades with fillet welds, threaded fasteners, or both, as standard with louver manufacturer unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.3 FIXED, EXTRUDED-ALUMINUM LOUVERS

A. Louver:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Greenheck Fan Corporation.
 - b. Nailor.
 - c. NCA.
 - d. Ruskin Company.
 - e. Twin City.
 - f. United Enertech.
 - g. Approved equal.
- 2. Louver Depth: As specified on drawings.
- 3. Frame and Blade Nominal Thickness: Not less than 0.060 inch for blades and 0.080 inch for frames.
- 4. Louver Performance Ratings: As specified on drawings.
- 5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.
- 6. Additional accessories as specified on drawings.

2.4 LOUVER SCREENS

- A. General: Provide screen at each exterior louver.
- B. Louver Screen Frames: Same kind and form of metal as indicated for louver to which screens are attached.
- C. Louver Screening:
 - 1. Bird Screening: Aluminum, 1/2-inch- square mesh, 0.063-inch wire.

2.5 EXTRUDED ALUMINUM BRICK VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck.
 - 2. Nailor.
 - 3. Ruskin.
 - 4. Twin City.
 - 5. United Enertech.
 - 6. Approved equal.

- B. Extruded-aluminum louvers and frames; not less than 0.125-inch nominal thickness, assembled by welding with 18-by-14- mesh, aluminum insect screening on inside face; incorporating weep holes, continuous drip at sill, and integral waterstop on inside edge of sill; of load-bearing design and construction.

2.6 ALUMINUM FINISHES

- A. High-Performance Organic Finish: Factory applied, 2-coat fluoropolymer finish complying with AAMA 2604 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 - 1. Color and Gloss: Custom color as selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Locate and place louvers and vents level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- D. Repair damaged finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory and refinish entire unit or provide new units.
- E. Protect galvanized and nonferrous-metal surfaces that will be in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint.

END OF SECTION 233716

SECTION 233813 - KITCHEN HOODS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes Type II (heat and condensate) commercial kitchen hoods and appurtenances.

1.2 SUBMITTALS

- A. Product Data: Hood
- B. Shop Drawings:
 - 1. Show plan view, elevation view, sections, roughing-in dimensions, service requirements, duct connection sizes, and attachments to other work.
 - 2. Show equipment plan and elevation to confirm minimum overhang.
 - 3. Indicate performance, exhaust and makeup air airflow, and pressure loss at actual Project-site elevation.
 - 4. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 5. Design Calculations: Calculate requirements for selecting seismic restraints.
 - 6. Wiring Diagrams: Power, signal, and control wiring.
 - 7. Piping Diagrams: Detail fire-suppression piping and components and differentiate between manufacturer-installed and field-installed piping. Show cooking equipment plan and elevation to illustrate fire-suppression nozzle locations.
- C. Welding certificates.
- D. Manufacturer Seismic Qualification Certification: Submit certification that commercial kitchen hoods, accessories, and components will withstand seismic forces defined in Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- E. Field quality-control test reports.

1.3 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code - Steel," for hangers and supports; and AWS D9.1, "Sheet Metal Welding Code," for joint and seam welding.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 HOOD MATERIALS

- A. Stainless-Steel Sheet: ASTM A 666, Type 430.
 - 1. Minimum Thickness: 0.050 inch
 - 2. Finish: Comply with SSINA's "Finishes for Stainless Steel" for recommendations for applying and designating finishes.
 - a. Finish shall be free from tool and die marks and stretch lines and shall have uniform, directionally textured, polished finish indicated, free of cross scratches. Grain shall run with long dimension of each piece.
 - 3. Concealed Stainless-Steel Surfaces: ASTM A 480, No. 2B finish (bright, cold-rolled, unpolished finish).
 - 4. Exposed Surfaces: ASTM A 480, No. 8 finish (mirror-like reflective, non-directional polish).
 - 5. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
- B. Zinc-Coated Steel Shapes: ASTM A 36, zinc coated according to ASTM A 123 requirements.
- C. Gaskets: NSF certified for end-use application indicated; of resilient rubber, neoprene, or PVC that is nontoxic, stable, odorless, nonabsorbent, and unaffected by exposure to foods and cleaning compounds, and that passes testing according to UL 710.

2.2 GENERAL HOOD FABRICATION REQUIREMENTS

- A. Welding: Use welding rod of same composition as metal being welded. Use methods that minimize distortion and develop strength and corrosion resistance of base metal. Make ductile welds free of mechanical imperfections such as gas holes, pits, or cracks.
 - 1. Welded Butt Joints: Full-penetration welds for full-joint length. Make joints flat, continuous, and homogenous with sheet metal without relying on straps under seams, filling in with solder, or spot welding.
 - 2. Grind exposed welded joints flush with adjoining material and polish to match adjoining surfaces.
 - 3. Where fasteners are welded to underside of equipment, finish reverse side of weld smooth and flush.
 - 4. Coat concealed stainless-steel welded joints with metallic-based paint to prevent corrosion.
- B. For metal butt joints, comply with SMACNA's "Kitchen Equipment Fabrication Guidelines."
- C. Form metal with break bends that are not flaky, scaly, or cracked in appearance; where breaks mar uniform surface appearance of material, remove marks by grinding, polishing, and finishing.
- D. Sheared Metal Edges: Finish free of burrs, fins, and irregular projections.
- E. In food zones, as defined in NSF, fabricate surfaces free from exposed fasteners.
- F. Cap exposed fastener threads, including those inside cabinets, with stainless-steel lock washers and stainless-steel cap (acorn) nuts.

- G. Fabricate pipe slots on equipment with turned-up edges sized to accommodate service and utility lines and mechanical connections.
- H. Fabricate enclosures, including panels, housings, and skirts, to conceal service lines, operating components, and mechanical and electrical devices including those inside cabinets.
- I. Fabricate seismic restraints according to SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints of Kitchen Equipment."
- J. Fabricate equipment edges and backsplashes according to SMACNA's "Kitchen Equipment Fabrication Guidelines."
- K. Fabricate enclosure panels to ceiling and wall as follows:
 - 1. Fabricate panels on all exposed side(s) with same material as hood and extend from ceiling to top of hood canopy and from canopy to wall.
 - 2. Wall Offset Spacer: Minimum of 3 inches.
 - 3. Wall Shelves and Over-Shelves: Fabricate according to SMACNA's "Kitchen Equipment Fabrication Guidelines," with minimum 0.0625-inch thick, stainless-steel shelf tops.

2.3 TYPE II EXHAUST HOOD FABRICATION

- A. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Subject to compliance with requirements, provide products by one of the following:
- C. Product: Subject to compliance with requirements, provide one of the following:
 - 1. Captive-Aire Systems.
 - 2. Grease Master; a division of Custom Industries, Inc.
 - 3. Greenheck.
 - 4. Vent Master; Div. of Garland Commercial Ranges, Ltd.
 - 5. Approved equal.
- D. Fabricate hoods according to NSF 2, "Food Equipment."
- E. Fabricate hoods to comply with SMACNA's "HVAC Duct Construction Standards: Metal and Flexible."
- F. Hood Configuration: Exhaust only.
- G. Hood Type: Heat and Condensate removal.
- H. Hood Style: Canopy.
- I. Condensate Hood Baffles: Removable, stainless-steel baffles to drain into a hood drain trough, and stainless-steel drain piping.
- J. Capacities and Characteristics: As indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Complete field assembly of hoods where required.
 - 1. Make closed butt and contact joints that do not require filler.
 - 2. Grind field welds on stainless-steel equipment smooth, and polish to match adjacent finish. Comply with welding requirements in Part 2 "General Hood Fabrication Requirements" Article.
- B. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, filters/baffles, grease extractor, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.
- C. Make cutouts in hoods where required to run service lines and to make final connections, and seal openings according to UL 1978.
- D. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners, unless otherwise indicated.
- E. Install hoods to operate free from vibration.
- F. Install seismic restraints according to SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints of Kitchen Equipment."
- G. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless-steel fasteners at 48 inches o.c. maximum.
- H. Install sealant in joints between equipment and abutting surfaces with continuous joint backing, unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.
- I. Install LED lamps, with maximum recommended lumens, in equipment with integral lighting.
- J. Set initial temperatures and calibrate sensors.
- K. Set field-adjustable switches.
- L. Connect ducts according to requirements in Section "Air Duct Accessories." Install flexible connectors on makeup air supply duct. Weld exhaust-duct connections with continuous liquid tight joint.
- M. Install fire-suppression piping for remote-mounted suppression systems according to NFPA 17A, "Wet Chemical Extinguishing Systems."

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
1. Test each equipment item for proper operation. Repair or replace equipment that is defective, including units that operate below required capacity or that operate with excessive noise or vibration.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Perform hood performance tests required by authorities having jurisdiction.
 4. Perform fire-suppression system performance tests required by authorities having jurisdiction.
- D. Prepare test and inspection reports.

END OF SECTION 233813

SECTION 233850 – OUTDOOR HEATING-ONLY MAKEUP AIR UNITS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes heating-only makeup-air units.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories.
- B. Shop Drawings: Include details of installation and wiring diagrams.
- C. Startup service reports.
- D. Operation and maintenance data.
- E. Warranty.

1.3 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of rooftop make up air units and are based on the specific system indicated.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than ten (10) years from date of Substantial Completion.

1.5 EXTRA MATERIALS

- 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 for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Captive-Aire Systems.
2. Accurex.
3. Greenheck
4. K-Tech.
5. Approved equal.

2.2 DIRECT-FIRED GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code"; ANSI Z83.4, "Non-Recirculating Direct Gas-Fired Industrial Air Heaters"; and ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters," for direct-fired gas furnace.

B. Burners: Cast-iron burner with stainless-steel mixing plates.

1. Rated for a maximum turndown ratio of 4:1.
2. Fuel: Natural Gas.

C. Safety Controls:

1. Gas manifold safety switches and controls shall comply with ANSI standards and FMG.
2. Pilot: Intermittent spark igniter.
3. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
4. External gas-pressure regulator shall regulate pressure to not more than 0.5 psig.
5. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
6. Manual-Reset, High-Limit Switch: Stops burner and closes main gas valve if high-limit temperature is exceeded.
7. Gas Train: Redundant, main gas valves, electric pilot valve, main and pilot gas-pressure regulators, main and pilot manual shutoff valves, main and pilot pressure taps, to comply with FMG requirements.

2.3 OUTDOOR-AIR INTAKE AND DAMPERS

A. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of 2000 fpm through damper and pressure differential of 4-inch wg.

B. Damper Operators: Electric.

2.4 FILTERS

A. Comply with NFPA 90A.

B. Cleanable Filters: 2-inch- thick, cleanable metal mesh.

2.5 CONTROLS

- A. Factory-wire connection for controls' power supply.
- B. Control devices, including sensors, transmitters, relays, switches, thermostats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.
- C. Unit Controls: Solid-state control board and components with field-adjustable control parameters.
- D. Heating Controls:
 - 1. Factory-mounted sensor in supply-fan outlet with sensor adjustment located in control panel modulates gas furnace burner to maintain discharge-air temperature.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Piping installation requirements are specified in Section "Facility Natural Gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install unit on insulated roof curb. Secure unit to roof curb.
- C. Install piping adjacent to machine to allow service and maintenance.
 - 1. Gas Burner Connections: Comply with requirements Section "Facility Natural Gas Piping". Sections. Connect 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.
- D. Duct Connections: Duct installation requirements are specified in Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply ducts to rooftop units with flexible duct connectors. Flexible duct connectors are specified in Section "Air Duct Accessories".
- E. Electrical Connections: Comply with requirements in other Specification Sections for power wiring, switches, and motor controls.
- F. Ground equipment according to other Specification Sections.

3.2 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions:
- B. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
- C. Remove and replace components that do not pass tests and inspections and retest as specified above.
- D. Prepare written report of the results of startup services.

3.3 ADJUSTING

- A. Adjust initial temperature set points.

- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop makeup air units. Refer to other Specification Sections.

END OF SECTION 233850

SECTION 234100 - PARTICULATE AIR FILTRATION**PART 1 - GENERAL****1.1 SUMMARY**

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

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

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.

2.2 PLEATED PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
- B. Filter Unit Class: UL 900, Class 1.
- C. Media: Cotton and synthetic fibers coated with nonflammable adhesive.
 - 1. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

2. Media shall be coated with an antimicrobial agent.
 3. Separators shall be bonded to the media to maintain pleat configuration.
 4. Welded-wire grid shall be on downstream side to maintain pleat.
 5. Media shall be bonded to frame to prevent air bypass.
 6. Support members on upstream and downstream sides to maintain pleat spacing.
- D. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.
- E. Capacities and Characteristics:
1. Thickness or Depth: 2 inches, minimum.
 2. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
 3. Arrestance: 85 percent when tested according to ASHRAE 52.2.
 4. Initial Resistance: 0.25-inch wg at.
 5. MERV Rating: 13 when tested according to ASHRAE 52.2

PART 3 - EXECUTION

3.1 INSTALLATION

- 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. Replace temporary filters used during construction and testing with new, clean filters.
- C. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

- A. Prepare test and inspection reports.

3.3 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. Provide Owner with an additional third set (spare) for Owner's first filter changing approximately one month into building's final occupancy.

END OF SECTION 234100

SECTION 235523 - GAS-FIRED RADIANT HEATERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes gas-fired, tubular infrared radiant heaters.

1.2 SUBMITTALS

- A. Product Data: For each type of gas-fired radiant heater indicated. Include rated capacities, operating characteristics, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power and control wiring.
- C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of gas-fired radiant heater that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of shipment from factory.

PART 2 - PRODUCTS**2.1 TUBULAR INFRARED HEATERS**

- A. Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
 - 1. Sterling HVAC Products; Div. of Mestek Technology Inc.
 - 2. Ambirad.
 - 3. Modine.
 - 4. Reznor/Thomas & Betts Corporation.
 - 5. Schwank Inc.
 - 6. Approved equal.

- B. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.20/CSA 2.34.
- C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- D. Combustion Tubing: 4-inch- diameter steel with high-emissivity, high-temperature, corrosion-resistant external finish.
- E. Tubing Connections: Stainless-steel couplings or flared joints with stainless-steel draw bolts.
- F. Reflector: Polished aluminum, 97 percent minimum reflectivity, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Provide for rotating reflector or heater around a horizontal axis for minimum 30-degree tilt from vertical.
 - 1. Reflector Extension Shields: Same material as reflectors, arranged for fixed connection to lower reflector lip and rigid support to provide 100 percent cutoff of direct radiation from tubing at angles greater than 30 degrees from vertical.
 - 2. Include hanger kit.
- G. Burner Safety Controls:
 - 1. Gas Control Valve: Single-stage, regulated redundant 24-V ac gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - 2. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.
 - 3. Control Panel Interlock: Stops burner if panel is open.
 - 4. Indicator Lights: Burner-on indicator light.
- H. Burner and Emitter Type: Gravity-vented power burner, with the following features:
 - 1. Emitter Tube: 4-inch- diameter, aluminized-steel tubing with sight glass for burner and pilot flame observation.
 - 2. Venting: Connector at exit end of emitter tubing for vent-pipe connection.
- I. Capacities and Characteristics: As indicated on drawings.

2.2 CONTROLS

- A. Thermostat provided separately by temperature control contractor.
- B. Control Transformer: Integrally mounted.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect gas-fired radiant heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.
- B. Suspended Units: Suspend from substrate using chain hanger kits and building attachments.

- C. Maintain manufacturers' recommended clearances to combustibles.
- D. Install piping adjacent to gas-fired radiant heaters to allow service and maintenance.
- E. Gas Piping: Comply with other Specification Sections. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
- F. Electrical Connections:
 - 1. Install electrical devices furnished with heaters but not specified to be factory mounted.
- G. Adjust initial temperature set points.
- H. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 235523

SECTION 235533 - FUEL-FIRED UNIT HEATERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes gas-fired unit heaters.

1.2 SUBMITTALS

- A. Product Data: For each type of fuel-fired unit heater indicated. Include rated capacities, operating characteristics, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of fuel-fired unit heater that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: ten (10) years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 GAS-FIRED UNIT HEATERS**

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Modine Manufacturing Company.
 - 2. Reznor/Thomas & Betts Corporation.
 - 3. Sterling HVAC Products.
 - 4. Approved equal.

- B. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
- C. Fuel Type: Design burner for gas having characteristics same as those of gas available at Project site.
- D. Type of Venting: Concentric vent for separated combustion unit.
- E. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
- F. Heat Exchanger: Aluminized steel.
- G. Burner Material: Aluminized steel with stainless-steel inserts.
- H. Unit Fan: Propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
- I. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - 1. Gas Control Valve: Single-stage or two stage as specified in equipment schedule.
 - 2. Ignition: Electronically controlled electric spark with flame sensor.
 - 3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
 - 4. Vent Flow Verification: Differential pressure switch to verify open vent.
 - 5. Control transformer.
 - 6. High Limit: Thermal switch or fuse to stop burner.
 - 7. Thermostat: Provided separately by temperature control contractor.
- J. Discharge Louvers: Independently adjustable horizontal blades.
- K. Capacities and Characteristics: As specified on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written installation instructions.
- B. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
- C. Install piping adjacent to fuel-fired unit heater to allow service and maintenance.
- D. Gas Piping: Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service. Refer to division 23 sections for requirements.
- E. Electrical Connections: Comply with applicable requirements in Division 26 Sections.
 - 1. Install electrical devices furnished with heaters but not specified to be factory mounted.
- F. Adjust initial temperature set points.
- G. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 235533

SECTION 237413 - PACKAGED, ROOF-TOP UNITS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes packaged, outdoor, central-station air-handling units with the following components and accessories:
 - 1. Direct-expansion cooling.
 - 2. Gas furnace.
 - 3. Economizer outdoor- and return-air damper section.
 - 4. Hot gas reheat circuit/coil.
 - 5. Roof curb.

1.2 DEFINITIONS

- A. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- B. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- C. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units.
- D. Supply-Air Fan: The fan providing supply-air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- E. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

1.3 SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and maintenance data.
- E. Warranty.

1.4 QUALITY ASSURANCE

- A. ARI Compliance:
 - 1. Comply with ARI 340/360 for testing and rating energy efficiencies for RTUs.
 - 2. Comply with ARI 270 for testing and rating sound performance for RTUs.
- B. ASHRAE Compliance:
 - 1. Comply with ASHRAE 15 for refrigerant system safety.
 - 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
 - 3. Comply with IECC-2012 for minimum efficiency of heating and cooling.
- C. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
- D. UL Compliance: Comply with UL 1995.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
 - 2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
 - 3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than one year from date of Substantial Completion.
 - 4. Warranty Period for Control Boards: Manufacturer's standard, but not less than one year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Corporation.
 - 2. Daikin.
 - 3. Trane.
 - 4. AAON, Inc.
 - 5. Johnson Controls, Inc.
 - 6. Approved equal.

2.2 CASING

- A. General Fabrication Requirements for Casings: Formed and reinforced insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
 - 1. Exterior Casing Thickness: 0.052-inch minimum thickness.
- C. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - 1. Materials: ASTM C 1071, Type I.
 - 2. Thickness: 1 inch.
 - 3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
 - 4. Liner Adhesive: Comply with ASTM C 916, Type I.
- D. Condensate Drain Pans: Formed sections of stainless-steel sheet, or poly carbonate a minimum of 2 inches deep and complying with ASHRAE 62.
 - 1. Drain Connections: Threaded nipple.

2.3 FANS

- A. Direct-Driven Supply-Air Fans: Double width, centrifugal; with permanently lubricated motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels and galvanized- or painted-steel fan scrolls.
- B. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.
- C. Relief-Air Fan (where scheduled): Forward curved, shaft mounted on permanently lubricated motor.

2.4 COILS

- A. Supply-Air Refrigerant Coil and Reheat Coil:
 - 1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
 - 2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
 - 3. Coil Split: Interlaced.
 - 4. Condensate Drain Pan: Stainless steel formed with pitch and drain connections complying with ASHRAE 62.
- B. Outdoor-Air Refrigerant Coil:
 - 1. Aluminum-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
 - 2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

2.5 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- B. Refrigeration Specialties:
 - 1. Expansion valve with replaceable thermostatic element.
 - 2. Refrigerant filter/dryer.
 - 3. Manual-reset high-pressure safety switch.
 - 4. Automatic-reset low-pressure safety switch.
 - 5. Minimum off-time relay.
 - 6. Automatic-reset compressor motor thermal overload.
 - 7. Brass service valves installed in compressor suction and liquid lines.

2.6 AIR FILTRATION

- A. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - 1. Refer to schedule.

2.7 GAS FURNACE

- A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and International Fuel Gas Code.
- B. Burners: Stainless steel with a minimum thermal efficiency of 80 percent.
 - 1. Fuel: Natural gas.
 - 2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
- C. Heat-Exchanger and Drain Pan: Stainless steel.
- D. Venting: Gravity vented.
- E. Safety Controls:
 - 1. Gas Control Valve: See schedule for stages.
 - 2. 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.

2.8 DAMPERS

- A. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-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 linkages so dampers operate simultaneously.
 - 1. Damper Motor: Modulating with adjustable minimum position.

2. Relief-Air Damper: See schedule for type.

2.9 ELECTRICAL POWER CONNECTION

- A. Provide for single connection of power to unit with factory installed unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.10 CONTROLS

- A. Refer to schedules for controls responsibilities.
- B. Refer to Section "Sequence of Operations" and equipment schedule on drawings for controls requirements.

2.11 ACCESSORIES

- A. 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. See Schedules for which units receive convenience outlet.
- B. Hail guards of galvanized steel painted to match casing.

2.12 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 C 1071, 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 C 916, 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 C 916, Type I.
- B. Curb Height: Refer to schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install on manufacturer's insulated roof curb. Secure curb to roof structure and unit to curb.
- B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- C. Install piping adjacent to RTUs to allow service and maintenance.
 - 1. Gas Piping: Comply with applicable requirements in Section "Facility Natural-Gas Piping." Connect 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.
- D. Duct installation requirements are specified in other Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Connect supply ducts to RTUs with flexible duct connectors specified in Section "Air Duct Accessories."
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.

3.2 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B. 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.
- C. Remove and replace malfunctioning units and retest as specified above.

3.3 CLEANING AND ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.
- B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.4 DEMONSTRATION

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

END OF SECTION 237413

SECTION 238128 - DUCTLESS SPLIT-SYSTEM HEAT PUMPS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes ductless split-system heat-pumps consisting of separate evaporator-fan and compressor-condenser component.
- B. Evaporator-Fan Unit ("Indoor Unit"): The part of the split-system heat-pump that contains a coil for cooling and a fan to circulate air to conditioned space.
 - 1. Wall-mounted style
- C. Heat Pump ("Outdoor Unit"): The part of the split-system heat-pump that contains a refrigerant compressor, reversing valve, and a coil for heat rejection.

1.2 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.4 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace split-system air-conditioning units that fail in materials and workmanship within one (1) year from date of Substantial Completion.
- B. Extended Warranty: The compressor shall be warranted for five (5) years from date of Substantial Completion.

1.5 EXTRA MATERIALS

- 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 additional set.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis of Design Product: Subject to compliance with the requirements, provide a ductless split heat pump system by LG or a comparable product by one of the following:
1. Carrier
 2. Daikin.
 3. LG.
 4. Mitsubishi.
 5. Approved equal.

2.2 EVAPORATOR-FAN UNIT (INDOOR UNIT) – WALL-MOUNTED

- A. General:
1. Indoor, direct-expansion, in-ceiling cassette fan coil. Unit shall be complete with cooling/heating coil, fan, fan motor, piping connectors, electrical controls, microprocessor control system, and integral temperature sensing.
 2. Wall-mounted unit is furnished with an integral wall mounting bracket and mounting hardware.
- B. Unit Cabinet:
1. Wall-mounted: Cabinet discharge and inlet grilles are attractively styled, high-impact polystyrene. Cabinet is fully insulated for improved thermal and acoustic performance.
- C. Fans:
1. Wall-mounted: Fan is the tangential direct-drive blower type with air intake at the top of the unit and discharge at the bottom front. An automatic, motor-driven vertical and horizontal air sweep is provided as standard equipment
 2. Air sweep operation shall be user selectable.
- D. Coil:
1. Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins shall be bonded to the tubes by mechanical expansion and especially golden hydrophilic pre-coated for enhanced wet-ability. A drip pan under the coil shall have a factory installed condensate pump and drain connection for hose attachment to remove condensate.
- E. Condensate Pump (for units indicated on drawing schedule)
1. Wall-mounted: Condensate pump is field installed.
 2. Pump shall consist of two parts: an internal reservoir/sensor assembly, and a remote sound shielded pump assembly. A liquid level sensor in the reservoir stops the cooling operation if the liquid level in the reservoir is unacceptable.
- F. Motors:
1. Motors shall be open drip-proof, permanently lubricated ball bearing with inherent overload protection.

2. Wall-mounted: The fan motor is 4-speed. Blower wheel and motor are easily removed for cleaning and service without removing the cabinet.

G. Controls:

1. Controls shall consist of a microprocessor-based control system which shall control space temperature, determine optimum fan speed, and run self-diagnostics.

H. The unit shall have the following functions as a minimum:

1. An automatic restart after power failure at the same operating conditions as at failure.
2. A timer function to provide a minimum 24-hour timer cycle for system Auto Start/Stop.
3. Temperature-sensing controls shall sense return air temperature.
4. Indoor coil freeze protection.
5. A wired thermostat to enter set points and operating conditions. Thermostat shall be 7-day programmable with battery backup and temporary override.
6. Automatic air sweep control to provide on or off activation of air sweep louvers.
7. Dehumidification mode shall provide increased latent removal capability by modulating system operation and set point temperature.
8. Fan-only operation to provide room air circulation when no cooling is required.
9. Diagnostics shall provide continuous checks of unit operation and warn of possible malfunctions. Error messages shall be displayed at the unit.
10. Fan speed control shall be user-selectable: high, medium, low, or microprocessor controlled automatic operation during all operating modes.
11. Automatic heating-to-cooling changeover in heat pump mode. Control shall include deadband to prevent rapid mode cycling between heating and cooling.
12. Indoor coil high temperature protection shall be provided to detect excessive indoor discharge temperature when unit is in heat pump mode.

I. Filters:

1. Unit shall have filter track with factory-supplied cleanable filters.

J. Electrical Requirements:

1. Indoor units are 208/230-1-60 and are powered from the outdoor unit.

K. Operating Characteristics:

1. The system shall have a minimum SEER (Seasonal Energy Efficiency Ratio) AHRI conditions, as listed on the drawing schedule.

L. Refrigerant Lines:

1. Wall-mounted: Unit should have refrigerant lines that can be oriented to connect from the side of unit.

2.3 AIR-COOLED HEAT PUMP (OUTDOOR UNIT)

A. General:

1. Factory assembled, single piece, air-cooled outdoor unit. Contained within the enclosure are the factory wiring, piping, controls, and the compressor.

2. Outdoor air-cooled split system compressor sections suitable for on-the-ground, rooftop, wall hung or balcony mounting. Units consist of a variable speed rotary compressor, an air-cooled coil, propeller-type draw-through outdoor fan, reversing valve, accumulator, electronic expansion valves, multiple service valves, and controls that allow multiple indoor units to be connected to the outdoor unit. Units discharge horizontally as shown on the contract drawings. Units function as the outdoor component of an air-to-air heat pump system.
3. Units are designed for use in a refrigeration circuit matched to two, three, four, or five multi style heat pump fan coil units.

B. Unit Cabinet:

1. The unit cabinet is constructed of galvanized steel, bonderized and coated with baked-enamel finish on the inside and outside.
2. The unit access panel is removable and provides full access to the compressor, fan, and the control components.
3. The outdoor compartment is isolated and has an acoustic lining to assure a quiet operation.

C. Fans:

1. The outdoor fans are direct-drive propeller type, and discharge air horizontally. The fan draws air through the outdoor coil.
2. Outdoor fan motors are multi-speed, totally-enclosed, single phase motors with permanently lubricated ball bearings. The motor is protected by internal thermal overload protection.
3. The shaft has an inherent corrosion resistance.
4. Outdoor fan openings are equipped with a metal/mesh PVC coated protection grille over the fan.

D. Compressor:

1. The compressor is the fully hermetic variable speed rotary type.
2. The compressor is inverter driven.
3. The compressor is equipped with an oil system, operating oil charge, and motor.
4. The motor is suitable for operation in a refrigerant and oil atmosphere.
5. The compressor assembly is installed on rubber vibration isolators.
6. The inverter and compressor are protected against over temperature and over current.

E. Outdoor Coil:

1. The coil is constructed of aluminum golden hydrophilic pre-coated fins mechanically bonded to seamless copper tubes, which are cleaned, dehydrated and sealed.

F. Refrigerant Components:

1. Refrigerant circuit components include multiple brass external liquid line service valves with a service gauge connection port, multiple suction line service valves with a service gage connection port, accumulator, reversing valve, and electronic expansion valves.

G. Safeties: Operating safeties are factory selected, assembled, and tested. The minimum functions include the following:

1. Compressor discharge over temperature protection.
2. System low voltage protection.
3. Compressor overload protection.
4. Compressor over current protection.
5. IPM module protection.

H. Electrical Requirements:

1. Units operate on single-phase, 60 Hz power at 208v.
2. The unit electrical power is a single point connection.
3. All power and control wiring must be installed per NEC and all local electrical codes.
4. Units have multiple terminal blocks to connect to multiple indoor units.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install evaporator-fan components using manufacturer's standard mounting devices.

3.2 CONNECTIONS

- A. Connect refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit. Refer to Section "Refrigerant Piping" for additional requirements.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Unless otherwise indicated, connect piping with unions and shutoff valves to allow units to be disconnected without draining piping.

3.3 FIELD QUALITY CONTROL

- A. Installation Inspection: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to prepare a written report of inspection.
- B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new components, and retest.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 238128

SECTION 238323 – ELECTRIC RADIANT HEATERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes:
 - 1. Electric radiant panel heater

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For electric radiant heaters. Include plans, sections, details, and attachments to other work.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace electric heating panels that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 GENERAL 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. Provide unit with control transformer.
- C. Unit shall be capable of being controlled by low-voltage thermostat provided separately by temperature control transformer.
- D. Capacities and Characteristics:
 - 1. All capacities, voltages, physical sizes and options shall be as specified in the heater schedule.

2.2 ELECTRIC RADIANT PANEL HEATER

- A. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid. Comply with UL 2021.
 - 1. Panel: Minimum 0.0276-inch-thick, galvanized sheet steel back panel riveted to minimum 0.0396-inch-thick, galvanized sheet steel front panel with fused-on crystalline surface.
 - 2. Heating Element: Powdered graphite sandwiched between sheets of electric insulation.
 - 3. Heating Element: Insulated resistive wires.
 - 4. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
 - 5. Exposed-Side Panel Finish: Baked-enamel or high temperature silicone paint finish in manufacturer's standard white paint color.
 - 6. Surface-Mounted Trim: Sheet metal with baked-enamel or high temperature silicone paint finish in manufacturer's standard white paint color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panels level and plumb.
- B. Support for Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
- C. Install a minimum of four ceiling-support-system rods or wires for each panel. Locate not more than 6 inches from panel corners.
- D. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
- E. Retain subparagraph below if Project is in a seismic area.
- F. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of the panel at a safety factor of 3.
- G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operate electric-heating elements through each stage to verify proper operation and electrical connections.
 - 2. Test and adjust controls and safeties.
- B. Electric heaters will be considered defective if they do not pass tests and inspections.
- C. Remove and replace damaged electric heaters.

END OF SECTION 238323

SECTION 260000 – GENERAL PROVISIONS FOR ELECTRICAL**PART 1 - GENERAL****1.1 SCOPE**

- A. Special Conditions section and General Requirements section are made part of this Division.
- B. This Division includes the sections, but not necessarily limited to, listed in the Division Table of Contents.

1.2 GENERAL

- A. The work included in this division consists of furnishing all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Electrical System(s) indicated or specified in the Contract Documents.
- B. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Electrical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the drawings and/or specifications, shall be included as part of this Contract.
- C. It is the intent of this Contract to deliver to the Owner's a "like new" project once work is complete. Although plans and specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing items which interfere with the new work required for the complete installation without additional cost to the Owner.

1.3 INTENT

- A. It is the intention of the Contract Documents to call for finished work, tested and ready for operation.
- B. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

1.4 EXAMINATION OF SITE AND CONDITIONS

- A. Each Proposer shall inform himself of all conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. Each Proposer shall also fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. His proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after bids are accepted.

1.5 DRAWINGS AND SPECIFICATIONS

- A. The drawings are diagrammatic only and indicate the general arrangement of the work to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The drawings are not intended to show every item, which may be necessary to complete the systems. All Proposers shall anticipate that additional items may be required and submit their bid accordingly.
- B. The drawings and specifications are intended to supplement each other. No Proposer shall take advantage of conflict between them, or between parties of either. Should this condition exist, the Proposer shall request a clarification not less than twelve days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.
- C. The drawings and specifications shall be considered to be cooperative and anything appearing in the specifications, which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
- D. The Contractor shall make all his own measurements in the field and shall be responsible for correct fitting. He shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.
- E. The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.
- F. Should conflict or overlap (duplication) of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.
- G. Unless dimensioned, the drawings only indicate approximate locations. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.
- H. Where on the Drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.
- I. Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- J. Where on the Contract Documents the word typical is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.
- K. Special Note: Always check ceiling heights indicated on Architectural Drawings and Schedules and ensure that they may be maintained after all mechanical and electrical equipment is installed. Do not install equipment in the affected area until the conflict is resolved.

1.6 REVIEW OF CONTRACT DOCUMENTS AND FIELD CONDITIONS BY CONTRACTOR

- A. By execution of this Contract, the Contractor warrants that he has visited the site of the proposed work, and fully acquainted himself with the conditions there existing relating to construction and labor and that he fully understands the facilities, difficulties, and restrictions attending the execution of the work under

Contract. The Contractor further warrants that he has thoroughly examined and is familiar with the drawings, specifications and all other documents comprising the Contract. The Contractor further warrants that by execution of this Contract, his failure, when he was bidding on this Contract, to receive or examine any form, instrument, or document, or to visit the site and acquaint himself with the conditions there existing, in no way relieves the Contractor. The Contractor agrees that the Owner shall be justified in rejecting any claim based on facts regarding conditions for which he should have been on prior notice.

- B. Before ordering material or performing any work, the Contractor shall verify all measurements at the work site. Any difference between dimensions on the Drawings and actual measurements shall be brought to the Engineer's attention for his consideration before the work may proceed. No extra compensation will be allowed because of difference between actual measurements and dimensions indicated on the Drawings. The Contractor shall assume full responsibility for accuracy of measurements obtained at the Work Site.
- C. Dimensions, which are lacking, shall be obtained from the Architect. In no case shall Drawings be scaled.
- D. All subcontractors shall familiarize themselves with all of the conditions relating to this Contract since the terms set forth in the General Conditions binds all subcontractors to the Contract.

1.7 WORK LAYOUT

- A. This contractor shall layout his work from construction lines and levels established by the General Contractor and shall be responsible for the proper location and placement of his work.
- B. Maintain all benchmarks, monuments, and other reference points; replace as directed if disturbed or destroyed.

1.8 PROTECTION OF STORED EQUIPMENT

- A. Provide suitable storage for, and completely protect all materials and equipment prior to installation. Storage shall be dry, clean and safe. Any materials or equipment damaged, deteriorated, rusted or defaced due to improper storage shall be fully repaired, refinished or replaced, as directed by the Engineer and any materials or equipment lost through theft or mishandling shall be replaced, all without additional cost to the Owner.

1.9 COORDINATION BETWEEN TRADES

- A. Each Proposer shall review all drawings and specifications including Architectural, Mechanical, Electrical, Fire Protection, Landscaping, Structural, Surveys, etc., to ensure that the work he intends to provide does not encroach a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Proposer's responsibility to satisfactorily eliminate any such encroachment conflict or effect prior to the submission of his proposal. Each Proposer shall in particular ensure that there is adequate space to install his equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded to the Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.

- B. It shall be the responsibility of this contractor to leave the necessary room for other trades. No extra compensation will be allowed to cover the cost of relocating conduit, boxes, etc., or equipment found encroaching on space required by others.

1.10 EQUIPMENT CONNECTIONS AND WIRING

- A. This contractor shall make all electrical connections, etc., to existing equipment to be reused and all equipment furnished by others whenever such equipment is shown on any part of the drawings or mentioned in any section of the specifications, unless otherwise specified. For bidding, if circuits are not specifically indicated, new code compliant circuit shall extend to the nearest suitable electrical panel with capacity and terminated on contractor furnish circuit breakers.
- B. Supervision, to assure proper functioning and operation shall be provided by the trade furnishing the equipment or apparatus so connected.
- C. Unless otherwise specifically noted on the drawings or elsewhere in these specifications, all wiring shall be done by this contractor, including connections, etc., to all equipment requiring electrical services furnished under other sections of this specification. This contractor shall furnish and install all disconnects, overload protection, motor control apparatus, etc., for all equipment unless otherwise specifically noted elsewhere as being provided with, or as a part of, the equipment.

1.11 SUBSTITUTION OF MATERIALS AND EQUIPMENT

- A. When this contractor requests approval of substitute materials and/or equipment, except when under formal alternate proposal, it shall be understood and agreed that such substitution, if approved, will be made without cost to the Owner or Engineer, regardless of changes in connections, spacing, electrical services, etc. In all cases where substitutions affect other trades, the contractor offering such substitutions shall reimburse all affected contractors for all necessary changes in their work.

1.12 CODES AND STANDARDS

- A. Pertinent Federal, State and Local requirements and regulations are hereby made part of this contract. In case of conflict between Contract Documents and above listed requirements, the latter shall govern. Requirements of authority having local jurisdiction shall supersede all other requirements. Use of the term "code" in sections of the specification refers to applicable requirements and regulations of above agencies.
- B. All electrical installation shall be made in accordance with the latest edition of the National Electrical Code and supplements in force at the time of bid opening, all materials employed shall bear Underwriters' official labels where such labeling is customary. In the event that local codes are more rigid than the National Electrical Code, both codes shall be considered as jointly governing and the requirements of either and/or both then prevail.
- C. Following is a list of abbreviations for codes and standards, which are referred to in the specifications. Where such reference is made, the code or standard becomes a part of the specification as if the code or standard were included herein. Reference is always to the latest edition of the code or standard unless otherwise specifically noted.

1. Industry and Agency Standards, Codes and Specifications

ANSI - American National Standards Institution

ASTM - American Society of Testing and Materials

NBFU - National Board of Fire Underwriters'

NBS - National Bureau of Standards

NEMA - National Electrical Manufacturers Association

UL - Underwriters' Laboratories

NEC - National Electrical Code

NESC - National Electrical Safety Code

IPCEA - Insulated Power Cable Engineers Association

IEEE - Institute of Electrical and Electronics Engineers

- D. Compliance with the Occupational Safety and Health Act shall be the responsibility of the contractor and under no circumstances shall the Engineer/Architect be an authority or be held responsible for any acts concerning this regulation.

1.13 MATERIALS AND EQUIPMENT

- A. General. Material and equipment shall be furnished as specified in this section and in each individual electrical section of these specifications and shall be in strict accordance with the required ANSI, ASTM, NEMA, IPCEA, UL, NEC, or other recognized standards, codes and specifications listed. Applicable codes, standards and manufacturers' products referred to in these specifications shall establish minimum requirements for material, equipment and installation furnished.
- B. Bolting shall be carbon steel conforming to ASTM A-307 with heavy hexagonal nut.
- C. Angles, Channels, Beams, Bars and Rods shall be steel conforming to ASTM A-36.

1.14 INSTALLATION

- A. Installation of all electrical equipment for the project as specified in these specifications and indicated on the drawings shall be in accordance with the general requirements of this section. Additional installation requirements applicable to individual systems are specified in the specific system section.
- B. All equipment shall be installed at locations indicated on the drawings and as specified herein.
- C. Assembly and installation of equipment shall be in strict accordance with manufacturer's installation instructions.
- D. Equipment shall be securely anchored in place. Care shall be exercised to correctly orient equipment before securing in place.
- E. All equipment and material shall meet the minimum requirements of seismic bracing as governed by the authority having jurisdiction.

1.15 OBSOLETE OR REMOVED EQUIPMENT AND MATERIALS

- A. The Electrical Contractor shall remove all existing materials and equipment made obsolete by, and interfering with the additions, alterations, or razing as shown on the plans and specified. Maintain such existing equipment and materials intact and in existing condition insofar as possible.
- B. Unless otherwise specifically stated in the specifications or shown on the drawings, all such removed material and equipment, not to be reused, shall be removed from the site and disposed of in a proper manner.

1.16 TESTS

- A. Following the completion of all wiring installation, test the individual systems and eliminate any existing grounding of potential conductors, short circuits, other faults, etc.

1.17 PERMITS, FEES AND CERTIFICATES

- A. Each respective contractor shall obtain and pay all permits and licenses required by Federal, State and Local Ordinances for his type work. All fees in connection with inspections, permits, licenses and approvals shall be paid by the contractor whose work is affected.

1.18 ELECTRICAL INSPECTION FOR CONTRACT COMPLIANCE

- A. The contractor shall be responsible for obtaining and coordination of required electrical inspections. Inspections shall be made by an Electrical Inspector Certified by the authority having jurisdiction and any fees and charges associated with the inspections will be paid for by the contractor. The contractor shall furnish the Engineer and Owner a copy of the Electrical Certificate of approval before final payment will be made.

1.19 PROJECT CLEAN-UP

- A. The Contractor shall export off site, all debris resulting from work under this Division. Burning of debris at the project site is not permitted.
- B. Each contractor shall maintain his portion of this project in a neat and orderly fashion, disposing of debris, cartons, crates and boxes as the contents are installed in the project. This clean-up shall be accomplished each day in order not to create hardships on the other trades.

1.20 GUARANTEES AND WARRANTIES

- A. This Contractor shall guarantee all equipment, apparatus, materials and workmanship entering into this contract to be the best of its respective kind, and shall replace all parts at his own expense, which have been proven defective, within one year from final acceptance of the work by the Owner. Items of equipment, which may have longer guarantees, shall have warranties and guarantees completed, in order, and in effect at the time of final acceptance of the work by the Architect. This contractor shall furnish all such warranties and guarantees at the time of final acceptance of the work.

1.21 SHOP DRAWINGS AND OTHER RELATED SUBMITTALS

- A. The type of submittal information required for each item of equipment is scheduled at the end of this section. Unless noted otherwise, submittals shall be furnished in electronic format. The Contractor shall furnish a single pdf file for each submittal. Submittals shall be clearly labeled as to what is contained within and shall note the related Specification Section. The Contractor shall be responsible for providing a numbering convention for submittals to allow easy tracking of submittals.
- B. Submittals for color selections shall not be electronically submitted. Provide hard copies of the colors. Printed color selections are not acceptable.
- C. Unless otherwise specified, materials and equipment must be a standard product of manufacturers regularly engaged in production of such items.
 - 1. The contractor shall secure right to use any patented article, method or apparatus used in work.
 - 2. When substitute item of equipment has been submitted for approval, the mechanical contractor shall submit layout drawings indicating the changes necessary to adapt the substitute item of equipment to the design, when requested by the Engineer. All cost of the requested drawings shall be the responsibility of the contractor offering the substitutions.
 - 3. Under no circumstances will materials be considered for substitution, which are not a product of a manufacturer regularly engaged in production of such material or which is a product of one who merely assembles products of other manufacturers into fabricated units. Material submitted for substitution shall be subject to express and implied warranties of one manufacturer only.
- D. If substitution of material results in incidental extra costs on part of any trade under contract, such costs shall be borne by contractor desiring substitution.
 - 1. Submittal data shall include specification data, such as metal gauges, finishes, optional accessories, etc., even though such equipment and materials may be detailed on the drawings or specified. In addition, the submittal data shall include performance (certification) data, wiring diagrams where applicable, accurate dimensional data and a recommended spare parts list. Outline or dimensional drawings alone are not acceptable.
 - 2. No roughing-in connections, etc., shall be done until approved equipment submittals are in the hands of the contractors. It shall be the contractor's responsibility to obtain approved drawings and to make all connections, etc., in the neatest and most workmanlike manner possible. Each contractor shall coordinate with all other contractors having any connections, roughing-in, etc., to the equipment.
 - 3. In general, normal catalog information (with the particular items underlined or otherwise denoted as being the submitted item) will be acceptable as submittal data. Installation, operating and maintenance instructions must be that information, specifically applicable to the item furnished, ordinarily supplied with the equipment to the owner with any modifications indicated. Wiring diagrams must be correct for the application. Generalized wiring diagrams, showing alternate methods of connection, will not be acceptable unless all unrelated sections are marked out.
 - 4. Submittal data sheets, which indicate several different model numbers, figure numbers, optional accessories, installation arrangements, etc., shall be clearly marked to indicate the specific items of equipment to be furnished. Samples and certificates shall be furnished as requested. Submittal data must be complete for each piece of equipment; piecemeal data will not be processed.
 - 5. It shall be noted that approval of shop drawings by the Engineer applies only to general design, arrangement, type, capacity and quality. Such approval doesn't apply to quantities, dimensions, connection locations and the like. In all cases, the contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, that all equipment fits the available space in a satisfactory manner, and that all connections are suitably located.
 - 6. Before the project is accepted, all submittal data (shop drawings, etc.) must be complete and approved.

7. In addition to shop drawings described above, the following information is required of the contractor to be furnished to the Engineer.

1.22 ELECTRICAL DOCUMENT REQUIREMENTS

ITEM OR DESCRIPTION OF EQUIPMENT REQUIRING SHOP DRAWINGS	P A R T S	L I S T	O P E R A T I N G	M A T E R I A L	W I R I N G	D I A G R A M	C E R T I F I C A T I O N	S A M P L E S
Low-Voltage Power Conductors and Cables	X		X		X		X	
Light Fixtures	X		X		X		X	
Dry-Type Transformers	X				X		X	
Panelboards	X		X		X		X	
Switchboards	X		X		X		X	
Wiring Devices/ Lighting Controls	X		X					
Enclosed Switches and Circuit Breakers	X		X					
Components/Materials of Div. 27 and 28	X				X			
Enclosed Controller (motor starters)	X		X		X			
Transient-Voltage Suppression Devices (SPD's)	X		X		X			
Fire Alarm System	X		X		X		X	

1.23 OPERATION AND MAINTENANCE DATA

- A. The Contractor shall submit a single copy of the Operation and Maintenance Manuals prior to final completion.
- A. Operation and Maintenance Manuals (O&M's) shall be submitted in electronic format. Provide one pdf file per Specification Division.
- B. Prepare pdf files with the title for each file to include the Specification Division Number and brief description of contents (example: "Division 23 – HVAC Equipment").
- C. The first page of pdf file shall be a coversheet titled "Operation and Maintenance Manual". Include table of contents with page numbers. Provide bookmarks within the pdf file labeled for each section contained within the file.
- D. Include the following within O&M's
 - 1. Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.
 - 2. Part 2: Operation and maintenance instructions, arranged by system and subdivided. For each category, identify names, addresses, and telephone numbers of subcontractors and suppliers. Identify the following:
 - a. Significant design criteria.
 - b. List of equipment
 - c. Parts list for each component.
 - d. Operating instructions.
 - e. Maintenance instructions for equipment and systems.
 - f. Maintenance instructions for special finishes, including recommended cleaning methods and materials and special precautions identifying detrimental agents.
 - 3. Part 3: Project documents and certificates, including the following:
 - a. Shop drawings and product data.
 - b. Power quality test results (including any required grounding tests).
 - c. Certificates.
 - d. Photocopies of warranties and bonds.
- E. Submit one copy of completed pdf's in final form on DVD or solid-state media fifteen (15) days prior to final inspection. This copy will be returned after final inspection with Owner's comments. Revise content of documents as required prior to final submittal.
- F. Submit final pdf's revised within ten (10) days after final inspection. Provide at minimum three (3) DVD or solid-state copies.

1.24 TRAINING/INSTRUCTION

- A. General Operating/Maintenance Instruction: Arrange for each installer of work requiring continuing maintenance or operation, to meet with the Owner's personnel, at project site, to provide basic instructions needed for proper operation and maintenance of entire work. Include instructions by manufacturer's representatives where installers are not expert in the required procedures. Review maintenance manuals, record documentations, tools, spare parts and materials, lubricants, fuels,

identification system, control sequences, hazards, cleaning and similar procedures and facilities. For operational equipment, demonstrate start-up, shutdown, emergency operations, noise and vibration adjustments, safety, economy/efficiency adjustments, energy effectiveness, and similar operations. Review maintenance and operations in relation with applicable Warranties, Agreements to Maintain, Bonds, and similar continuing commitments.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 260000

SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Sleeves for raceways and cables.
 - 2. Sleeve seals.
 - 3. Grout.
 - 4. Common electrical installation requirements.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Comply with all requirements of N.E.C. article 110 and others, which apply.

- D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- F. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Cut sleeves to length for mounting flush with both surfaces of walls.
- E. Extend sleeves installed in floors 2 inches above finished floor level.
- F. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in other sections of this specification or as indicated on the drawings.
- I. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with architectural approved means or flexible boot-type flashing units applied in coordination with roofing work.
- J. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- K. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

END OF SECTION 260500

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Copper building wire rated 600 V or less.
 - 2. Aluminum building wire rated 600 V or less.
 - 3. Metal-clad cable, Type MC, rated 600 V or less.
 - 4. Fire-alarm wire and cable.
 - 5. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

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

1.3 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 an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. 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:
 - 1. Type THHN and Type THWN-2: Comply with UL 83.
 - 2. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
 - 3. Type XHHW-2: Comply with UL 44.

2.2 ALUMINUM BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.
- D. Conductor Insulation:
 - 1. Type THHN and Type THWN-2: Comply with UL 83.
 - 2. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
 - 3. Type XHHW-2: Comply with UL 44.

2.3 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Comply with UL 1569.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Circuits:
 - 1. Single circuit.
 - 2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.
- D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- E. Ground Conductor: Insulated.
- F. Conductor Insulation:
 - 1. Type TFN/THHN/THWN-2: Comply with UL 83.
 - 2. Type XHHW-2: Comply with UL 44.
- G. Armor: Aluminum, interlocked.

2.4 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.
 - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 - 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NRTL listed for fire-alarm and cable tray installation, plenum rated.

2.5 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 a qualified testing agency, and marked for intended location and use.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. 3M Electrical Products.
 - 2. AFC Cable Systems; Atkore International.
 - 3. Hubbell Power Systems, Inc.
 - 4. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - 5. Tyco Electronics Corp.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. Copper; stranded.
- B. Branch Circuits:
 - 1. Copper, stranded.
- C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: 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 according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to 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 according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

- A. Comply with NFPA 72.
- B. Wiring Method: Install wiring in metal pathway according to Section 280528 "Pathways for Electronic Safety and Security."
 - 1. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
 - a. 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. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is not permitted.
 3. Signaling Line Circuits: Power-limited fire-alarm cables may be installed in the 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 the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all 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 the 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. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.
- G. Wiring to Remote Alarm Transmitting Device: 1 inch conduit between the fire-alarm control panel and the 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 according to 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 unspliced conductors.
1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.
- D. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.

3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

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."

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Foundation steel electrodes.

1.2 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data include the following:
 - 1. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - a. Test wells.
 - b. Ground rods.
 - c. Ground rings.
 - d. Grounding arrangements and connections for separately derived systems.

PART 2 - PRODUCTS**2.1 SYSTEM DESCRIPTION**

- 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. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.

2.3 CONNECTORS

- A. Listed and labeled by an 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. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Mechanical-Type Bus-Bar Connectors: Cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Compression-Type Bus-Bar Connectors: Copper or copper alloy, with two wire terminals.
- E. Conduit Hubs: Mechanical type, terminal with threaded hub.
- F. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- G. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- H. Straps: Solid copper, rated for 600 A.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 5/8 inch by 10 ft.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install stranded unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
 1. Bury at least 30 inch below grade.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.
 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- D. Conductor Terminations and Connections:
 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.

3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

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

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inch from the foundation.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
- C. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 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.
- B. Ground Rods: Drive rods until tops are 12 inch below finished floor or final grade unless otherwise indicated.
 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

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

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.
- B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 1. Flame Rating: Class 1.
 2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Atkore International.
 - g. Wesanco, Inc.
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
 4. Channel Width: Selected for applicable load criteria.

5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the 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.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
 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.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Cooper B-line; brand of Eaton, Electrical Sector.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 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.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 SELECTION

- A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA NEIS 101
- B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."
- C. Provide vibration and seismic controls with hangers and supports in accordance with requirements specified in "Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERM as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

3.2 INSTALLATION OF SUPPORTS

- A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.
- B. 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 must be weight of supported components plus 200 lb.
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the 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 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
 6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

END OF SECTION 260529