## SECTION 237343.16 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

## PART 1 - GENERAL

#### 1.1 SUMMARY

- A. Section includes outdoor, semi-custom air-handling units that are factory assembled using multiple section components; including:
  - 1. Unit casings.
  - 2. Fan, drive, and motor section.
  - 3. Coil section.
  - 4. Air filtration section.
  - 5. Dampers.
  - 6. Sound attenuators.
  - 7. Humidifiers.
  - 8. Intake and relief air openings.

#### 1.2 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 3. Include unit dimensions and weight.
  - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
  - 5. Fans:
    - a. Include certified fan-performance curves with system operating conditions indicated.
    - b. Include certified fan-sound power ratings.
    - c. Include fan construction and accessories.
    - d. Include motor ratings, electrical characteristics, and motor accessories.
  - 6. Include certified coil-performance ratings with system operating conditions indicated.
  - 7. Include dampers, including housings, linkages, and operators.
- B. Sustainable Design Submittals:
  - 1. Product data showing compliance with ASHRAE 62.1.
  - 2. Product Data: For air filtration performance.
  - 3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
  - 4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.

- C. Shop Drawings: For each outdoor, semi-custom air-handling unit.
  - 1. Include plans, elevations, sections, and mounting and attachment details.
  - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Detail fabrication and assembly of outdoor, semi-custom air-handling units, as well as procedure and diagrams.
  - 4. Include diagrams for power, signal, and control wiring.
- D. Delegated Design Submittal: For vibration isolation, supports, and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - 1. Design Calculations: Calculate requirements for selecting vibration isolators, supports, and seismic restraints, and for designing vibration isolation bases.

# 1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  - 4. Restraint of internal components.
- D. Wind Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.
  - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
  - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
  - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Source quality-control reports.
- F. Startup service reports.

G. Field quality-control reports.

#### 1.4 CLOSEOUT SUBMITTALS

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

#### 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: One set(s) for each air-handling unit.
  - 2. Gaskets: One set(s) for each access door.
  - 3. Fan Belts: One set(s) for each air-handling unit fan.

#### 1.6 WARRANTY

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

#### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of airhandling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 "Systems and Equipment" and Section 7 "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

- F. Structural Performance:
  - 1. Casing Panels: Self-supporting and capable of withstanding positive/negative 8-inch wg internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.
  - 2. Floor and Roof Panels: Self-supporting and capable of withstanding 300-lb static load at midspan, without exceeding a midpoint deflection of 0.0042 inch/inch.
  - 3. Roof Panels: Self-supporting and capable of withstanding a static snow load of 30 lb/sq. ft., without exceeding a midpoint deflection of 0.0042 inch/inch.
- G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8-inch wg.
- H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
  - 2. Component Importance Factor: 1.5.
- I. Wind Performance: Air-handling units are to withstand the effects of wind determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."

## 2.2 CAPACITIES AND CHARACTERISTICS

- A. Supply Fan:
  - 1. Class: AMCA 99, Section 14, Class I.
  - 2. Drive: Direct.
- B. Preheat Coil:
  - 1. Fin Spacing: Maximum 4 fins per inch
- C. Reheating Coil:
  - 1. Fin Spacing: Maximum 4 fins per inch.
- D. Cooling Coil:
  - 1. Fin Spacing: Maximum 13 fins per inch.
- E. Prefilters:
  - 1. Type: Pleated.
  - 2. Depth: 2 inches.
  - 3. Access Location: Side.
  - 4. Recommended Final Resistance: 1 inches wg.

- 5. Minimum Efficiency Reporting Value and Average Arrestance:
  - a. MERV Rating: MERV 8, and corresponding average arrestance according to ASHRAE 52.2.
- F. Final Filters:
  - 1. Type: Pleated.
  - 2. Depth: 4 inches.
  - 3. Access Location: Side.
  - 4. Recommended Final Resistance: 1.2 inches wg.
  - 5. Minimum Efficiency Reporting Value:
    - a. MERV Rating: MERV 14, according to ASHRAE 52.2.

#### 2.3 MANUFACTURERS

- 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. Carrier Global Corporation.
  - 2. Trane.
  - 3. YORK; brand of Johnson Controls International plc, Building Solutions North America.
- B. Source Limitations: Obtain from single source from single manufacturer.

#### 2.4 UNIT CASINGS

- A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
- B. Base Rail:
  - 1. Material: Welded structural steel.
  - 2. Height: 6 inches.
- C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
- D. Double-Wall Construction:
  - 1. Outside Casing Wall:
    - a. Material, Galvanized Steel: Minimum 14 gauge thick.
    - b. Factory Finish: Provide corrosion-resistant coating.
  - 2. Inside Casing Wall:
    - a. Material, Galvanized Steel: Solid, minimum 16 gauge thick.

- E. Floor Plate:
  - 1. Material:
    - a. Galvanized steel, minimum 12 gauge thick.
- F. Roof: Cross-broken and pitched with "C" caps over joints to provide watertight seal.
- G. Casing Insulation:
  - 1. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071 or injected polyurethane foam insulation.
  - 2. Casing Panel R-Value: Minimum R-13.
  - 3. Insulation Thickness: 2 inches.
  - 4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
- H. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- I. Panels, Doors, and Windows:
  - 1. Panels:
    - a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
    - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
    - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components.
  - 2. Doors:
    - a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
    - b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
    - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
    - d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
  - 3. Windows:
    - a. Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
    - b. Size: Minimum 6 inches, square or round.

- 4. Service Lights: LED vaporproof luminaire with individual switched junction box adjacent to each access door and panel.
  - a. Locations: Each section accessed with door or panel.
- 5. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.
- J. Condensate Drain Pans:
  - 1. Location: Each type of cooling coil heat wheel.
  - 2. Construction:
    - a. Single-wall, stainless-steel sheet.
  - 3. Drain Connection:
    - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
    - b. Minimum Connection Size: NPS 1.
  - 4. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
  - 5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
  - 6. Width: Entire width of water producing device.
  - 7. Depth: A minimum of 2 inches deep.
  - 8. Formed sections.
  - 9. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
  - 10. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

## 2.5 FAN, DRIVE, AND MOTOR SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
  - 1. Shafts: With field-adjustable alignment.
    - a. Turned, ground, and polished hot-rolled steel with keyway.
  - 2. Shaft Bearings:
    - a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.

- b. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing and an L-50 Insert bearing life rating rated life of 200,000 hours according to ABMA 11.
- c. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing and an L-50 rated life of 200,000.
- 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
  - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
- 4. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
- 5. Plenum Fan Arrays: Contained as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide motorized dampers at each fan to prevent short circuiting of flow if one fan is not operating.
- 6. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- 7. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel hub swaged to backplate and fastened to shaft with setscrews.
- 8. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.
- 9. Mounting: For internal vibration isolation and seismic control. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
- 10. Shaft Lubrication Lines: Extended to a location outside the casing.
- 11. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.
  - a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
    - 1) Fabric Minimum Weight: 26 oz./sq. yd..
    - 2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
    - 3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.
- C. Drive, Direct: Factory-mounted, direct drive.
- D. Motors:
  - 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

- 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- 3. Enclosure Type: Totally enclosed, fan cooled.
- 4. Enclosure Materials: Cast iron.
- 5. Efficiency: Premium efficient as defined in NEMA MG 1.
- 6. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
- 7. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
- E. Comply with Section 262923 "Variable-Speed Motor Controllers."
- F. Variable-Frequency Motor Controller: Serving all fans combined in fan array.
  - 1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for inverter-duty motors.
  - 2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
  - 3. Unit Operating Requirements:
    - a. Internal Adjustability:
      - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
      - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
      - 3) Current Limit: 30 to minimum of 150 percent of maximum rating.
    - b. Self-Protection and Reliability Features:
      - 1) Surge suppression.
      - 2) Loss of input signal protection.
      - 3) Under- and overvoltage trips.
      - 4) Variable-frequency motor controller and motor-overload/overtemperature protection.
      - 5) Critical frequency rejection.
      - 6) Loss-of-phase protection.
      - 7) Reverse-phase protection.
      - 8) Motor-overtemperature fault.
    - c. Bidirectional autospeed search.
    - d. Torque boost.
    - e. Motor temperature compensation at slow speeds.
      - 1) Panel-mounted operator station.
      - 2) Historical logging information and displays.
      - 3) Digital indicating devices.
    - f. Control Signal Interface: Electric.
    - g. Proportional Integral Directive (PID) control interface.
    - h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

- 4. Line Conditioning:
  - a. Input line conditioning.
  - b. Output filtering.
  - c. EMI/RFI filtering.
- 5. Bypass Systems:
  - a. Bypass Mode: Field-selectable automatic or manual.
  - b. Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors and isolating switch.
  - c. Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors and isolating switch.

## 2.6 COIL SECTION

- A. General Requirements for Coil Section:
  - 1. Comply with AHRI 410.
  - 2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
  - 3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
  - 4. Coils shall not act as structural component of unit.
- B. Preheat Coils:
  - 1. Hot-Water Coils; Continuous circuit .
    - a. Piping Connections: Threaded, same end of coil.
    - b. Tube Material: Copper.
    - c. Fin Type: Plate.
    - d. Fin Material: Aluminum.
    - e. Fin Spacing: Maximum 4 per inch.
    - f. Fin and Tube Joint: Mechanical bond.
    - g. Headers:
      - 1) Cast iron with cleaning plugs and drain and air vent tappings.
      - 2) Seamless copper tube with brazed joints, prime coated.
      - 3) Fabricated steel, with brazed joints, prime coated.
      - 4) Provide insulated cover to conceal exposed outside casings of headers.
    - h. Coating: None.
- C. Reheating Coils:
  - 1. Hot-Water Coils: Continuous circuit.
    - a. Piping Connections: Threaded, same end of coil.
    - b. Tube Material: Copper.
    - c. Fin Type: Plate.
    - d. Fin Material: Aluminum.

- e. Fin Spacing: Maximum 4 per inch.
- f. Fin and Tube Joint: Mechanical bond.
- g. Headers:
  - 1) Cast iron with cleaning plugs and drain and air vent tappings.
  - 2) Seamless copper tube with brazed joints, prime coated.
  - 3) Fabricated steel, with brazed joints, prime coated.
  - 4) Provide insulated cover to conceal exposed outside casings of headers.
- h. Coating: None.
- D. Cooling Coils:
  - 1. Chilled-Water Coil:
    - a. Piping Connections: Threaded, same end of coil.
    - b. Tube Material: Copper.
    - c. Fin Type: Plate.
    - d. Fin Material: Aluminum.
    - e. Fin Spacing: 13 fins per inch.
    - f. Fin and Tube Joint: Mechanical bond.
    - g. Headers:
      - 1) Cast iron with cleaning plugs and drain and air vent tappings.
      - 2) Seamless copper tube with brazed joints, prime coated.
      - 3) Fabricated steel, with brazed joints, prime coated.
      - 4) Provide insulated cover to conceal exposed outside casings of headers.
    - h. Coatings: None.
    - i. Working-Pressure Ratings: 200 psig, 325 deg F.

## 2.7 AIR FILTRATION SECTION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
  - 1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
  - 2. Filter Unit Class: UL 900.
  - 3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive.
- C. Access Filter Mounting Frames:
  - 1. Particulate Air Filter Frames: Galvanized-steel or Aluminum framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

- a. Prefilters: Incorporate a separate 2-inch-thick track with spring clips, with same access as primary filter.
- b. Sealing: Full periphery foam gaskets.
- D. Side-Access Filter Mounting Frames:
  - 1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel or Aluminum track.
    - a. Prefilters: Incorporate an integral 2-inch-thick track with same access as primary filter.
    - b. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

## 2.8 DAMPERS

- A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."
- B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement with zinc-replated steel operating rods rotating in stainless steel sleeve bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 3 cfm/sq. ft. at 1-inch wg, tested, rated, and labeled in accordance with AMCA 500-D.
- C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
- D. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

## 2.9 HUMIDIFIER GRID

- A. Capacity: See Mechanical Dehumidification Unit Schedule on mechanical drawings
- B. Components: Steam valve, separator, actuator/linkage and steam distributor(s).
- C. Configuration: Configured to operate with regular boiler steam, up to 50 psig.
- D. Materials: Standard bronze and stainless steel components

## E. Features:

- 1. Stainless steel separators
- 2. Bronze steam valves with stainless steel seat, stem, and plug
- 3. Pneumatic or electric actuator/linkage
- 4. Stainless steel steam distributors
- 5. On/Off or modulating control
- 6. Two-year limited warranty
- 7. Steam Headers:

- F. Delivers clean steam, precisely controlled, uniformly into the entire air stream, and void of any condensate spray. Steam distribution takes place via steam tubes with integrated nozzles. The steam is kept dry as condensate is drained through the main header.
- G. The stainless steel headers are typically installed with vertical tubes for horizontal airflow applications, but can also be mounted horizontally for vertical airflow applications. The headers can be ordered 3, 6, 9, or 12 inch center to center tube spacing for maximum flexibility and optimal steam distribution.
- H. Manufactured out of high grade 304 stainless steel, the header features welded inlet and condensate connections to ensure leak-free operation. Stainless steel inlet adapter is factory supplied for connection to steam supply line. Specialized synthetic grommets form an air and water-tight seal around the base of the steam tubes.
- I. Additional Features:
  - 1. Steam tubes with end support bracket.
  - 2. Ten year limited warranty.

# 2.10 INTAKE AND RELIEF AIR OPENINGS

A. Provide hood, including moisture eliminator, over all unit intake and relief openings. Match material and finish of casing exterior.

## 2.11 MATERIALS

- A. Steel:
  - 1. ASTM A36/A36M for carbon structural steel.
  - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
  - 1. Manufacturer's standard grade for casing.
  - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: ASTM B209.
- E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
- F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.
  - 1. Standards:
    - a. ASTM B117 for salt spray.
    - b. ASTM D2794 for minimum impact resistance of 100 in-lb.
    - c. ASTM B3359 for cross-hatch adhesion of 5B.

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

#### 2.12 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
- B. AHRI 1060 Certification: Test, rate, and label air-handling units that include air-to-air energy recovery devices in accordance with AHRI 1060.
- C. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
- D. Fan Aerodynamic Performance Rating: Test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.
- E. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- F. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- G. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.
- H. Steam Coils: Factory tested to 300 and 200 psig underwater according to AHRI 410 and ASHRAE 33.
- I. Refrigerant Coils: Factory tested to minimum 450-psig internal pressure and to minimum 300psig internal pressure while underwater, according to AHRI 410 and ASHRAE 33.
- J. Witnessed Casing Leakage Tests:
  - 1. Pay for all expenses, for one representative designated by Owner, to travel to the factory to witness cabinet air-leakage testing on the specific assembled unit(s) prior to release for delivery to Project site.
  - 2. If the unit(s) does not meet specified leakage requirements, perform factory modifications and retest. Do not release unit for shipment until tested leakage is measured to be within specified leakage and leakage testing report has been accepted by Owner's designated representative.

## PART 3 - EXECUTION

#### 3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

#### 3.2 INSTALLATION, GENERAL

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to AHRI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Unit Support: Install unit level on structural steel supports. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of steel supports with actual equipment provided.
  - 1. Comply with requirements for vibration isolation, wind-control and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. 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.
- E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

#### 3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

- F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

## 3.4 ELECTRICAL CONNECTIONS

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

## 3.5 CONTROL CONNECTIONS

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

## 3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
  - 1. Complete installation and startup checks according to manufacturer's written instructions.
  - 2. Verify that shipping, blocking, and bracing are removed.
  - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
  - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
  - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.

- 6. Verify that zone dampers fully open and close for each zone.
- 7. Verify that face-and-bypass dampers provide full face flow.
- 8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
- 9. Comb coil fins for parallel orientation.
- 10. Verify that proper thermal-overload protection is installed for electric coils.
- 11. Install new, clean filters.
- 12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
  - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
  - 2. Measure and record motor electrical values for voltage and amperage.
  - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

#### 3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

## 3.8 CLEANING

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

## 3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

- 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
- 2. Charge refrigerant coils with refrigerant and test for leaks.
- 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- 4. HEPA Filters: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
- 5. HEPA Filters, Critical Applications: Pressurize housing to a minimum of 3-inch wg or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME AG-1, pressure-decay method.
- 6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- 7. Air-handling unit and components will be considered defective if unit or components do not pass tests and inspections.
- 8. Prepare test and inspection reports.

## 3.10 DEMONSTRATION

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

END OF SECTION 237343.16