SECTION 237433 - DEDICATED OUTDOOR-AIR UNITS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
   * + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
      1. SUMMARY
         1. Section includes factory-assembled, dedicated outdoor air-handling units, including multiple components, capable of heating and cooling 100 percent outdoor air.
      2. DEFINITIONS:
         1. ECM: Electronically commutated motor.
         2. ISCOP: Integrated Seasonal Coefficient of Performance.
         3. ISMRE: Integrated Seasonal Moisture Removal Efficiency.
         4. MRC: Moisture Removal Capacity.
      3. SUBMITTALS
         1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
         2. Manufacturer’s installation instructions shall be provided along with product data.
         3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
         4. Product Data: For each dedicated outdoor-air unit.

Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

Include unit dimensions and weight.

Include cabinet material, metal thickness, finishes, insulation, and accessories.

Fans:

Certified fan-performance curves with system operating conditions indicated.

Certified fan-sound power ratings.

Fan construction and accessories.

Motor ratings, electrical characteristics, and motor accessories.

Include certified coil-performance ratings with system operating conditions indicated.

Include filters with performance characteristics.

Include heat exchangers with performance characteristics.

Include dampers, including housings, linkages, and operators.

* + - * 1. Shop Drawings: For each dedicated outdoor-air unit.

Include plans, elevations, sections, and mounting details.

Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

Include diagrams for power, signal, and control wiring.

Retain subparagraph below if roof curb is supplied by unit manufacturer.

Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. Coordination Drawings: Floor/roof plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
        2. Sample Warranty: For manufacturer's warranty.

Retain "Seismic Qualification Data" paragraph below if required by seismic criteria applicable to Project. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC." See ASCE/SEI 7 for certification requirements for equipment and components.

* + - * 1. Seismic Qualification Data: Certificates, for dedicated outdoor-air units, accessories, and components, from manufacturer.

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

Restraint of internal components.

Retain "Product Certificates" paragraph below if required by wind design criteria applicable to Project.

* + - * 1. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.

Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

* + - * 1. Source quality-control reports.
        2. Startup service reports.

Retain "Field quality-control reports" paragraph below if Contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
      1. CLOSEOUT SUBMITTALS
         1. Operation and Maintenance Data: For dedicated outdoor-air units to include in emergency, operation, and maintenance manuals.
      2. MAINTENANCE MATERIAL SUBMITTALS
         1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

Fan Belts: **[One] <Insert number>** set(s) for each belt-driven fan.

Filters: **[One] <Insert number>** set(s) for each unit.

Gaskets: **[One] <Insert number>** set(s) for each access door.

* + - 1. WARRANTY

When warranties are required, verify with Director’s Representative's that warranties stated in this article are not less than remedies available to Director’s Representative under prevailing local laws.

* + - * 1. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.

Verify available warranties and warranty periods for units and components with manufacturers listed in Part 2 articles.

Warranty Period for Dedicated Outdoor-Air-Handling Units: **[Two] [Three] <Insert number>** years from date of Substantial Completion.

Warranty Period for Compressors: **[Five] <Insert number>** years from date of Substantial Completion.

Warranty Period for Heat Exchangers: **[Five] [10] <Insert number>** years from date of Substantial Completion.

Warranty Period for Rotary Heat Exchangers: **[Five] <Insert number>** years from date of Substantial Completion.

**<Insert components requiring extended warranty>**.

1. PRODUCTS

Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. PERFORMANCE REQUIREMENTS
         1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory), and marked for intended location and application.
         2. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.

"ASHRAE 62.1 Compliance" paragraph below may be required to comply with Project requirements or authorities having jurisdiction. Sustainable design may require compliance with requirements in ASHRAE 62.1, including requirements for controls, surfaces in contact with the airstream, particulate and gaseous filtration, humidification and dehumidification, drain pan construction and connection, finned-tube coil selection and cleaning, and equipment access. Verify, with manufacturers, the availability of units with components and features that comply with these requirements.

* + - * 1. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
        2. ASHRAE 15 and ASHRAE 34 Compliance: For refrigeration system safety.

"ASHRAE/IES 90.1 Compliance" paragraph below may be required to comply with Project requirements or authorities having jurisdiction. Sustainable design may require minimum efficiency equal to requirements in ASHRAE/IES 90.1. Insert a specific version of the standard if required to satisfy a Project sustainability requirement. ASHRAE/IES 90.1-2016 includes specific performance requirements for dedicated outdoor-air units with and without energy recovery and requires ratings be based on AHRI 920, indicating minimum ISMRE requirements. Previous version of ASHRAE 90.1 did not differentiate dedicated outdoor-air units from other types of cooling units and indicated minimum integrated energy efficiency ratio requirements.

* + - * 1. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
        2. ASHRAE 84 Compliance: Comply with capacity ratings for [heat-wheel] [fixed plate] energy-recovery equipment.
        3. UL Compliance:

Retain "Electric Coils" subparagraph below if unit includes electric coils.

Electric Coils: Comply with requirements in UL 1995.

Retain "Delegated Design" paragraph below if Contractor is required to assume responsibility for design.

* + - * 1. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design **[vibration isolation] [seismic restraints] [and] [wind restraints]**.

Retain "Seismic Performance" paragraph below with "Seismic Qualification Data" paragraph in "Informational Submittals" Article for projects requiring seismic design. Delete paragraph if performance requirements are indicated on Drawings. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Coordinate requirements with structural engineer and with Section 230548 "Vibration and Seismic Controls for HVAC."

* + - * 1. Seismic Performance: Units shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7] <Insert requirement>**. See Section 230548 "Vibration and Seismic Controls for HVAC."

Retain first subparagraph below to define the term "withstand" as it applies to this Project. Definition varies with type of building and occupancy and is critical to valid certification. Option is used for essential facilities where equipment must operate immediately after an earthquake.

The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified**[ and the unit will be fully operational after the seismic event]**."

Coordinate "Component Importance Factor" paragraph below with Section 230548 "Vibration and Seismic Controls for HVAC" and ASCE/SEI 7.

Component Importance Factor: **[1.5] [1.0]**.

See ASCE/SEI 7, Coefficients for Architectural Component Table and Seismic Coefficients for Mechanical and Electrical Components Table for requirements to be inserted in subparagraph below. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."

**<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.

Coordinate "Wind-Restraint Performance" paragraph below with "Delegated-Design Submittal" paragraph in Part 1 "Action Submittals" Article for projects requiring wind-restraint design. Model building codes and ASCE/SEI 7 establish criteria for wind loads. Verify requirements of authorities having jurisdiction.

* + - * 1. Wind-Restraint Performance:

See **[Section 230548 "Vibration and Seismic Controls for HVAC] [Section 230548.13 "Vibration Controls for HVAC"]** for requirements.

If Project has more than one type or configuration of dedicated outdoor-air units, delete "Capacities and Characteristics" Article below and schedule units on Drawings.

* + - 1. CAPACITIES AND CHARACTERISTICS

If Project has more than one type or configuration of dedicated outdoor-air unit, delete this article and schedule units on Drawings.

* + - * 1. Supply-Air Fan:

Type: **[DWDI, backward-inclined centrifugal fan] [DWDI, forward-curved centrifugal fan] [DWDI, airfoil centrifugal fan] [SWSI, airfoil unhoused centrifugal fan] <Insert fan type>**.

Coordinate options in "Class" subparagraph below with fan performance requirements and fan class availability of manufacturers.

Class: **[Class I] [Class II]**, AMCA 99.

Airflow: **<Insert cfm>**.

External Static Pressure: **<Insert inches wg>**.

Size: **<Insert wheel size>**.

Design Fan Speed: **<Insert number>** rpm.

Motor Characteristics:

Horsepower: **<Insert number>** hp.

Motor Speed: **[Multispeed] [ECM] [Constant] <Insert number>** rpm.

Volts: **[120] [208] [230] [460] <Insert number>** V.

Phase: **[Single] [Three]**.

Hertz: 60.

Fan Discharge Sound Power, dB:

1st Octave: **<Insert value>**.

2nd Octave: **<Insert value>**.

3rd Octave: **<Insert value>**.

4th Octave: **<Insert value>**.

5th Octave: **<Insert value>**.

6th Octave: **<Insert value>**.

7th Octave: **<Insert value>**.

8th Octave: **<Insert value>**.

* + - * 1. Relief (Exhaust)-Air Fan:

Type: **[DWDI, backward-inclined centrifugal fan] [DWDI, forward-curved centrifugal fan] [DWDI, airfoil centrifugal fan] [SWSI, airfoil unhoused centrifugal fan] <Insert fan type>**.

Coordinate options in "Class" subparagraph below with fan performance requirements and fan class availability of manufacturers.

Class: **[Class I] [Class II]**, AMCA 99.

Airflow: **<Insert cfm>**.

External Static Pressure: **<Insert inches wg>**.

Design Fan Speed: **<Insert number>** rpm.

Motor Characteristics:

Horsepower: **<Insert number>** hp.

Motor Speed: **[Multispeed] [ECM] [Constant] <Insert number>** rpm.

Volts: **[120] [208] [230] [460] <Insert number>** V.

Phase: **[Single] [Poly]**.

Hertz: 60.

Fan Inlet Sound Power, dB:

1st Octave: **<Insert value>**.

2nd Octave: **<Insert value>**.

3rd Octave: **<Insert value>**.

4th Octave: **<Insert value>**.

5th Octave: **<Insert value>**.

6th Octave: **<Insert value>**.

7th Octave: **<Insert value>**.

8th Octave: **<Insert value>**.

* + - * 1. Condenser-Air Fan:

Motor Characteristics:

Horsepower: **<Insert number>** hp.

Motor Speed: **[Multispeed] [ECM] [Constant] <Insert number>** rpm.

Volts: **[120] [208] [230] [460] <Insert value>** V.

Phase: **[Single] [Poly]**.

Hertz: 60.

* + - * 1. Refrigerant Cooling Coil:

Capacity: **<Insert tons>**.

ISMRE: **<Insert number>**.

Condenser Ambient-Air Temperature: **<Insert deg F>**.

Evaporator Coil:

Sensible Heat-Transfer Rate: **<Insert Btu/h>**.

Total Heat-Transfer Rate: **<Insert Btu/h>**.

Entering-Air, Dry-Bulb Temperature: **<Insert deg F>**.

Entering-Air, Wet-Bulb Temperature: **<Insert deg F>**.

Leaving-Air, Dry-Bulb Temperature: **<Insert deg F>**.

Leaving-Air, Wet-Bulb Temperature: **<Insert deg F>**.

Face Area: **<Insert sq. ft.>**.

Maximum Face Velocity: **<Insert fpm>**.

Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg>**.

Fin Spacing: **<Insert fins per inch>**.

Fin Thickness: **<Insert inches>**.

Number of Rows: **<Insert number>**.

* + - * 1. Hot-Gas Reheat Coil:

Heating Capacity: **<Insert Btu/h>**.

Entering-Air Temperature: **<Insert deg F>**.

Air-Temperature Rise: **<Insert deg F>**.

Refrigerant Type: **<Insert refrigerant type>**.

Retain "Electric-Resistance Heating Coils," "Gas-Fired Furnace Heating," or "(Hot Water) (Steam) Heating Coils" paragraph below.

* + - * 1. Electric-Resistance Heating Coils:

Heat-Transfer Rate: **<Insert Btu/h>**.

Entering-Air Temperature: **<Insert deg F>**.

Leaving-Air Temperature: **<Insert deg F>**.

Power Input: **<Insert number>** kW.

Volts: **[120] [208] [230] [480] <Insert number>** V.

Phase: **[Single] [Three]**.

Hertz: 60.

Full-Load Amperes: **<Insert number>** A.

Maximum Overcurrent Protection: **<Insert number>** A.

Capacity Control: Number of Steps or SCR: **<Insert number or SCR>**.

* + - * 1. Gas-Fired Furnace Heating:

Heat-Transfer Rate: **<Insert Btu/h>**.

Entering-Air Temperature: **<Insert deg F>**.

Leaving-Air Temperature: **<Insert deg F>**.

Sustainable design systems require minimum efficiency equal to requirements in ASHRAE/IES 90.1, Table 6.8.1E, "Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters."

Efficiency: **[80] <Insert number>** percent.

Fuel: **[Natural] [Propane]** gas.

Burner: **[Modulating] [Staged]**.

Turndown Ratio: Minimum **[5:1] [6:1] [8:1] <Insert ratio>**.

Consider actual heating value of fuel source if retaining "Gas Heating Value" subparagraph below. Contact fuel supplier and unit manufacturers to determine impact. Insert text indicating heating value of fuel if applicable.

Gas Heating Value: **<Insert Btu/cu. ft.>**.

Gas Input: **<Insert cfh>**.

Gas Burner Electrical Characteristics:

Power Input: **<Insert number>** kW.

Volts: **[120] [208] [230] [460] <Insert number>** V.

Phase: **[Single] [Three]**.

Hertz: 60.

Full-Load Amperes: **<Insert number>** A.

Minimum Circuit Ampacity: **<Insert number>** A.

Maximum Overcurrent Protection: **<Insert number>** A.

* + - * 1. **[Hot-Water] [Steam]** Heating Coils:

Heat-Transfer Rate: **<Insert Btu/h>**.

Entering-Air Temperature: **<Insert deg F>**.

Leaving-Air Temperature: **<Insert deg F>**.

Face Area: **<Insert sq. ft.>**.

Maximum Face Velocity: **<Insert fpm>**.

Maximum Air-Side, Static-Pressure Drop: **<Insert inches wg>**.

In "Coil Type" subparagraph below, last two options are for steam coils.

Coil Type: **[Continuous circuit] [Self-draining] [Cleanable] [Distributing] [Single tube]**.

Piping Connections: **[Threaded] [Flanged]; [same end] [opposite ends]** of coil.

Tube Thickness: **<Insert inches>**.

Fin Spacing: **<Insert fins per inch>**.

Fin Thickness: **<Insert inches>**.

Number of Rows: **<Insert number>**.

Value option "Coil Working-Pressure Ratings" subparagraph below is standard for most copper tube coils. Verify manufacturer's ability to achieve specified ratings.

Coil Working-Pressure Ratings: **[200 psig, 325 deg F] <Insert value>**.

Retain "Fluid Flow," "Maximum Fluid-Pressure Drop," "Entering-Fluid Temperature," "Leaving-Fluid Temperature," and "Fluid Velocity" subparagraphs below for hot-water heating coils.

Fluid Flow: **<Insert gpm>**.

Maximum Fluid-Pressure Drop: **<Insert feet of head>**.

Entering-Fluid Temperature: **<Insert deg F>**.

Leaving-Fluid Temperature: **<Insert deg F>**.

Fluid Velocity: **<Insert fpm>**.

Retain "Steam Flow" and "Inlet Steam Pressure" subparagraphs below for steam heating coils.

Steam Flow: **<Insert lb/h>**.

Inlet Steam Pressure: **<Insert psig>**.

* + - * 1. Rotary Heat Exchanger:

Effectiveness: **<Insert number>** percent.

Intake Airflow: **<Insert cfm>**.

Pressure Differential: **<Insert inches wg>**.

Entering Supply-Air Dry-Bulb Temperature: **<Insert deg F>**.

Entering Supply-Air Wet-Bulb Temperature: **<Insert deg F>**.

Leaving-Air Dry-Bulb Temperature: **<Insert deg F>**.

Leaving-Air Wet-Bulb Temperature: **<Insert deg F>**.

Relief/Exhaust Airflow: **<Insert cfm>**.

Entering Relief/Exhaust-Air Dry-Bulb Temperature: **<Insert deg F>**.

Entering Relief/Exhaust-Air Wet-Bulb Temperature: **<Insert deg F>**.

Leaving Relief/Exhaust-Air Dry-Bulb Temperature: **<Insert deg F>**.

Leaving Relief/Exhaust-Air Wet-Bulb Temperature: **<Insert deg F>**.

* + - * 1. Filters:

Type: **[Panel] <Insert type>**.

Face Dimensions, Each: **<Insert inches by inches>**.

Depth: **<Insert inches>**.

Number of Filters in Filter Bank: **<Insert number>** wide by **<Insert number>** high.

Access Location: **[Side] <Insert location>**.

Maximum or Rated Face Velocity: **<Insert fpm>**.

Initial Resistance: **<Insert inches wg>**.

Recommended Final Resistance: **<Insert inches wg>**.

Retain "Minimum Efficiency Reporting Value and Average Arrestance" subparagraph below if requiring MERV 1, 2, 3, or 4.

Minimum Efficiency Reporting Value and Average Arrestance:

MERV Rating and Corresponding Average Arrestance: **[MERV 1] [MERV 2] [MERV 3] [MERV 4]**, and corresponding average arrestance, in accordance with ASHRAE 52.2.

Retain "Minimum Efficiency Reporting Value" subparagraph below if inserting requirements for MERV 5 and higher. LEED 2009 Prerequisite IEQ 1 and LEED v4 Prerequisite EQ, "Minimum Indoor Air Quality Performance," require compliance with ASHRAE 62.1 (2007 and 2010 versions, respectively), which require a MERV rating of 6 or higher for service to occupied spaces. LEED 2009 IEQ Credit 5 and LEED v4 EQ Credit, "Enhanced Indoor Air Quality Strategies," require MERV 13 or higher. Insert values appropriate to Project sustainability goals.

Minimum Efficiency Reporting Value:

MERV Rating: **[MERV 6] [MERV 8] [MERV 11] [MERV 13] [MERV 14] <Insert value>**, in accordance with ASHRAE 52.2.

* + - * 1. Electrical Characteristics for Single-Point Connection:

Volts: **[120] [208] [230] [460] <Insert number>** V.

Phase: **[Single] [Three]**.

Hertz: 60.

Full-Load Amperes: **<Insert number>** A.

Minimum Circuit Ampacity: **<Insert number>** A.

Maximum Overcurrent Protection: **<Insert number>** A.

* + - 1. MANUFACTURERS
         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:

AAON.

Addison.

Desert Aire.

Munters Corporation.

REZNOR, a brand of Nortek Global HVAC.

Approved equivalent.

* + - * 1. Source Limitations: Obtain dedicated outdoor-air units from single manufacturer.
      1. UNIT CASING
         1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
         2. Configuration: Horizontal unit with **[top] [horizontal] [bottom]** discharge for **[roof-mounting] [concrete-base]** installation.
         3. Double-Wall Configuration:

Outside Casing Wall: **[Galvanized steel] [Stainless steel] [, stainless steel in cooling coil section] <Insert material>**, minimum **[18 gauge] <Insert value>** thick with **[manufacturer's standard finish] [corrosion-resistant coating] <Insert special coating>**, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

Inside Casing Wall:

Inside Casing, Burner Section: **[Galvanized steel] <Insert material>**, solid, minimum **[14-gauge-] <Insert value>** thick steel.

Inside Casing, All Other Sections: **[Galvanized steel] <Insert material>**, **[solid] [perforated]**.

Antimicrobial Coating: Applied during the manufacturing process. Coating is to be **[EPA approved] [NSF approved] [FDA listed]**.

Floor Plate: Reinforced metal surface; reinforced to limit deflection when walked on by service personnel. Insulation is provided below metal walking surface.

Roof: Standing seam or membrane; sloped to drain water.

Casing Insulation:

Materials: Polyurethane foam insulation.

Casing Panel R-Value: Minimum **[R-6.5] [R-11] [R-13] <Insert value>**.

Insulation Thickness: **[1 inches] [2 inches] <Insert dimension>**.

Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

"Airstream Surfaces" paragraph below may be required to comply with Project requirements or authorities having jurisdiction. Retain below to comply with LEED Prerequisite IEQ 1.

* + - * 1. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
        2. Static-Pressure Classifications:

For Unit Sections Upstream of Fans: Minus **[2 inches wg] [3 inches wg] <Insert value>**.

For Unit Sections Downstream and Including Fans: **[2 inches wg] [3 inches wg] [4 inches wg] <Insert value>**.

* + - * 1. Panels and Doors:

Panels:

Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.

Fasteners: Two or more camlock-type fasteners for panel lift-out operation. Arrangement shall allow panels to be opened against airflow

Gasket: Neoprene, applied around entire perimeters of panel frames.

Size: Large enough to allow unobstructed access for inspection and maintenance of unit's internal components

Doors:

Fabrication: Formed and reinforced double-wall and insulated panels of same materials and thicknesses as casing.

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.

Gasket: Neoprene, applied around entire perimeters of panel frames.

Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.

Locations and Applications:

Verify that sections listed in subparagraphs below are large enough for access panels and doors.

Fan Section: **[Panels] [Doors]**.

Access Section: Doors.

Gas-Fired Burner Section: **[Panels] [Doors]**.

Damper Section: **[Panels] [Doors]**.

Filter Section: **[Panels] [Doors]** large enough to allow periodic removal and installation of filters.

Relief Section: Doors.

* + - * 1. Condensate Drain Pans:

Location: Each refrigerant coil**[ and rotary heat exchanger].**

Construction:

Single-wall, **[galvanized-steel or noncorrosive polymer] [stainless steel]** sheet.

Size: Large enough to collect condensate from cooling coils, including coil piping connections, coil headers, and return bends.

Drain Connection:

Located on **[one end] [both ends]** of pan, at lowest point of pan.

Terminated with threaded nipple.

Minimum Connection Size: **[NPS 1] [NPS 2] <Insert pipe size>**.

Retain last option in "Slope" subparagraph below to comply with LEED 2009 IEQ Prerequisite 1 or LEED v4 EQ Prerequisite, "Minimum Indoor Air Quality Performance," if required by Project requirements or authorities having jurisdiction.

Slope: Minimum **[0.125-inch/ft.] <Insert value>** 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.

Retain option in "Length" subparagraph below to comply with LEED 2009 IEQ Prerequisite 1 or LEED v4 EQ Prerequisite, "Minimum Indoor Air Quality Performance," if required by Project requirements or authorities having jurisdiction.

Length: Extend drain pan downstream from leaving face **[for distance to comply with ASHRAE 62.1] <Insert distance>**.

Width: Entire width of water-producing device.

Depth: A minimum of **[2 inches] <Insert dimension>** deep.

Retain "Pan-Top Surface Coating for Galvanized-Steel Drain Pans" subparagraph below for galvanized-steel drain pans.

Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.

Provide units having stacked coils with intermediate drain pan to collect condensate from top coil.

* + - 1. FANS, DRIVES, AND MOTORS
         1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
         2. Supply-Air Fans and Relief-Air Fans: Centrifugal; galvanized or painted steel; mounted on solid-steel shaft.

Shafts: With field-adjustable alignment.

Turned, ground, and polished hot-rolled steel with keyway.

Shaft Bearings:

Heavy-duty, self-aligning, pillow-block type with an **[L-50] <Insert bearing life rating>** rated life of minimum **[100,000] <Insert number>** hours in accordance with ABMA 9.

Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.

Retain "Backward-Inclined, Centrifugal Fan Wheels"; "Forward-Curved, Centrifugal Fan Wheels"; or "Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels)" subparagraph below if these fan wheels are retained as options in "Capacities and Characteristics" Article. Not all manufacturers offer each option. Consult manufacturers.

Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; **[steel] [aluminum]** hub riveted to backplate and fastened to shaft with setscrews.

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] [aluminum]** hub swaged to backplate and fastened to shaft with setscrews.

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.

Mounting: For internal vibration isolation**[ and seismic control]**. Factory mount fans with manufacturer's standard**[ restrained]** vibration isolation mounting devices having a minimum static deflection of **[1 inch] [2 inches] <Insert dimension>**.

Shaft Lubrication Lines: Extended to a location outside the casing.

In "Flexible Connector" subparagraph below, select metal compatible with casing material option retained.

Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches **<Insert dimension>** wide, attached to two strips of minimum 2-3/4-inch- wide **<Insert width>** by 0.028-inch- thick, galvanized-steel sheet.

Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

* + - * 1. Drive, Direct: Factory-mounted direct drive.
        2. Drive, Belt: Factory-mounted V-belt drive, with adjustable alignment and belt tensioning, and with **[1.5] [1.25]** service factor based on fan motor.

Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.

Belts: Oil resistant, nonsparking and nonstatic; in matched sets for multiple-belt drives.

Belt Guards: Comply with requirements specified by OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards"; **[0.146 inch] <Insert dimension>** thick, **[3/4-inch] <Insert dimension>** diamond-mesh wire screen, welded to steel angle frame; prime coated.

* + - * 1. Condenser-Coil Fan: **[Variable-speed ]propeller, mounted on shaft of permanently lubricated [multispeed] [electronically commutated]** motors.
        2. Motors:

Retain first subparagraph below if motor characteristics are specified in Section 230513 "Common Motor Requirements for HVAC Equipment." If different characteristics are required, insert subparagraphs to suit Project.

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."

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.

Verify enclosure types with manufacturer of specified equipment.

Enclosure Type: **[Open, dripproof] [Totally enclosed, fan cooled] <Insert type>**.

Retain "Enclosure Materials," "Motor Bearings," "Unusual Service Conditions," "Efficiency," and "NEMA Design" subparagraphs below if options are available from equipment manufacturers and are different from default requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment." Consider each subparagraph and retain only those that vary from default requirements.

Enclosure Materials: **[Cast iron]** **<Insert material>**.

Motor Bearings: **<Insert requirements>**.

Unusual Service Conditions:

Ambient Temperature: **<Insert deg C>**.

Altitude: **<Insert feet>** above sea level.

High humidity.

**<Insert conditions>**.

Efficiency: Premium efficient as defined in NEMA MG 1.

NEMA Design: **<Insert designation>**.

5-hp limit in "Motor Pulleys" subparagraph below is standard with many manufacturers but is a designer's choice.

Motor Pulleys: Adjustable pitch for use with **[5] <Insert number>** hp motors and smaller; fixed pitch for use with motors larger than **[5] <Insert number>** hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

If unique characteristics are required for motors in this Section, insert subparagraphs below.

**<Insert unique motor characteristics>**.

Retain subparagraph below to require that disconnect switches be supplied with unit.

Mount unit-mounted disconnect switches on **[exterior] [interior]** of unit.

First paragraph below is an example of variable-frequency controllers. Retain features and attributes to suit Project, and verify their availability with manufacturers.

Retain one of two paragraphs below. First paragraph coordinates with electrical variable-frequency motor-control specification. Second paragraph describes basic features of variable-frequency motor controllers and can be used when variable-frequency motor controller is not on a schedule on Drawings or is different from that specified in variable-frequency motor-controller specification. Coordinate either paragraph with electrical engineer and manufacturers. A few manufacturers do not offer variable-frequency controllers with outdoor units. Consult manufacturers.

* + - * 1. Comply with Section 262923 "Variable-Frequency Motor Controllers."
        2. Variable-Frequency Motor Controller: Serving **[each fan individually] [all fans combined]** in fan array.

Manufactured Units: Pulse-width modulated; **[constant torque] [and] [variable torque] <Insert application>** for **[Design A and Design B] [inverter-duty]** motors.

Output Rating: Three phase; 10 to **[60 Hz, with voltage proportional to frequency throughout voltage range] [66 Hz, with torque constant as speed changes]**; maximum voltage equals input voltage.

Unit Operating Requirements:

Internal Adjustability:

Minimum Speed: 5 to 25 percent of maximum rpm.

Maximum Speed: 80 to 100 percent of maximum rpm.

Acceleration: **[0.1 to 999.9] <Insert range>** seconds.

Deceleration: **[0.1 to 999.9] <Insert range>** seconds.

Current Limit: 30 to minimum of 150 percent of maximum rating.

Self-Protection and Reliability Features:

Surge suppression.

Loss of input signal protection.

Under- and overvoltage trips.

Variable-frequency motor controller and motor-overload/overtemperature protection.

Critical frequency rejection.

Loss-of-phase protection.

Reverse-phase protection.

Motor-overtemperature fault.

Bidirectional autospeed search.

Torque boost.

Motor temperature compensation at slow speeds.

Panel-mounted operator station.

Historical logging information and displays.

Digital indicating devices.

Control Signal Interface: Electric.

Proportional Integral Directive (PID) control interface.

DDC system for HVAC Protocols for Network Communications: **[ASHRAE 135] <Insert protocol type>**.

Line Conditioning:

Input line conditioning.

Output filtering.

EMI/RFI filtering.

Bypass is not available from all manufacturers; consult manufacturers.

Bypass Systems:

Bypass Mode: **[Manual operation only] [Field-selectable automatic or manual]**.

Retain one of first two subparagraphs below. Bypass is not available from all manufacturers; consult manufacturers.

Bypass Controller, Two-Contactor Style: With bypass and output isolating contactors**[ and isolating switch]**.

Bypass Controller, Three-Contactor Style: With bypass and input and output isolating contactors**[ and isolating switch]**.

Bypass Contactor Configuration: **[Full-voltage (across the line)] [Reduced-voltage (autotransformer)] <Insert type>** type.

* + - 1. COILS
         1. General Requirements for Coils:

Comply with AHRI 410.

Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).

Coils are not to act as structural component of unit.

* + - * 1. Supply-Air Refrigerant Coils:

Tubes: **[Copper] <Insert material>**.

Fins:

Material: **[Aluminum] [Copper] <Insert material>**.

Fin Spacing: Maximum **[12] [10] [8] <Insert spacing>** fins per inch.

Fin and Tube Joints: Mechanical bond.

Headers: **[Seamless-copper headers with brazed connections] <Insert material and connections>**.

Frames: **[Galvanized steel] <Insert material frame>**.

Coatings: **[None] [Corrosion-resistant coating]**.

Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.

Working Pressure: Minimum 300 psig.

* + - * 1. Hot-Gas Reheat Refrigerant Coils:

Tubes: **[Copper] <Insert material>**.

Fins:

Material: **[Aluminum] [Copper] <Insert material>**.

Fin Spacing: Maximum **[12] [10] [8] <Insert spacing>** fins per inch.

Fin and Tube Joints: Mechanical bond.

Headers: **[Seamless-copper headers with brazed connections] <Insert material and connections>**.

Frames: **[Galvanized steel] [Stainless steel] <Insert material frame>**.

Coatings: **[None] [Corrosion-resistant coating]**.

Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.

Working Pressure: Minimum 300 psig.

Coating: **[None] [Corrosion-resistant coating]**.

Suction-discharge bypass valve.

* + - * 1. Electric-Resistance Heating Coils: Comply with UL 1995.

Casing Assembly: **[Slip-in] [Flanged]** type with galvanized-steel frame.

Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.

Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

Control Panel: **[Unit] [Remote]** mounted with disconnecting means and overcurrent protection.

Magnetic contactor.

Solid-state, stepless pulse controller.

Toggle switches, one per step.

**[Step] [SCR]** controller.

Time-delay relay.

Pilot lights, one per step.

Airflow proving switch.

In "Heating-Water Coils" paragraph below, coordinate type with manufacturers.

* + - * 1. Heating-Water Coils: **[Continuous circuit] [Self-draining] [Cleaning]**.

Piping Connections: **[Threaded] [Flanged], [same end] [opposite ends]** of coil.

Tube Material: **[Copper] <Insert material>**.

Fin Type: Plate.

Fin Material: **[Aluminum] [Copper] <Insert material>**.

Fin Thickness: **<Insert inches>**.

Fin and Tube Joint: **[Mechanical bond] [Silver brazed]**.

Headers:

Cast iron with**[ cleaning plugs and] drain and air vent tappings [ extended to exterior of unit]**.

Seamless copper tube with brazed joints, prime coated.

Fabricated steel, with brazed joints, prime coated.

Provide insulated cover to conceal exposed outside casings of headers.

Frames: Channel frame, minimum 0.052-inch thick galvanized steel.

Pressure and temperature ratings in "Coil Working-Pressure Ratings" subparagraph below are standard for most copper tube coils. Other materials have different ratings.

Coil Working-Pressure Ratings: **[200 psig, 325 deg F] <Insert value and temperature>**.

Coating: **[None] [Corrosion-resistant coating]**.

* + - * 1. Steam Heating Coils:

In "Steam Coils" subparagraph below, coordinate type with manufacturers.

Steam Coils: **[Distributed] [Single tube]**.

Steam Outer-Tube Diameter: **<Insert inches>**.

Piping Connections: **[Threaded] [Flanged], [same end] [opposite ends]** of coil.

Tube Material: **[Copper] <Insert material>**.

Fin Type: Plate.

Fin Material: **[Aluminum] [Copper] <Insert material>**.

Fin Thickness: **<Insert inches>**.

Fin and Tube Joint: **[Mechanical bond] [Silver brazed]**.

Headers:

Cast iron with[**cleaning plugs and**] drain and air vent tappings[**extended to exterior of unit**].

Seamless copper tube with brazed joints, prime coated.

Fabricated steel, with brazed joints, prime coated.

Provide insulated cover to conceal exposed outside casings of headers.

Frames: Channel frame, minimum 0.052-inch thick galvanized steel.

Pressure and temperature ratings in "Coil Working-Pressure Ratings" subparagraph below are standard for most copper tube coils. Other materials have different ratings.

Coil Working-Pressure Ratings: **[200 psig, 325 deg F] <Insert value and temperature>**.

Coating: **[None] [Corrosion-resistant coating]**.

* + - * 1. Condenser Refrigerant coils:

Tube Material: **[Copper] <Insert material>**.

Fin Material: **[Aluminum] [Copper]**.

Fin and Tube Joint: Mechanical bond.

Coating: **[None] [Corrosion-resistant]**.

* + - 1. REFRIGERATION CIRCUIT COMPONENTS

Verify, with manufacturers, availability of crankcase heater in "Compressors" paragraph below.

* + - * 1. Compressors: Hermetic, **[variable-speed]** scroll compressors, mounted on integral vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief**[, and crankcase heater]**.
        2. Refrigerant: **[R-410A] <Insert other available type>**.

In "Refrigeration Specialties" paragraph below, not all manufacturers offer each option. Consult manufacturers.

* + - * 1. Refrigeration Specialties:

Expansion valve with replaceable thermostatic element.

Refrigerant filter/dryer.

Manual-reset high-pressure safety switch.

Automatic-reset low-pressure safety switch.

Minimum off-time relay.

Automatic-reset compressor motor thermal overload.

Thermostat for coil freeze-up protection during low-ambient-temperature operation or loss of air.

Brass service valves installed in discharge and liquid lines.

Low-ambient kit high-pressure sensor.

Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.

**[Single stage] [Modulating]** hot-gas reheat solenoid valve with a replaceable magnetic coil.

Heat-pipe heat exchanger, wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.

Hot-gas bypass refrigerant control for capacity control with continuous dehumidification for single-speed compressor.

* + - 1. AIR FILTRATION

Retain first paragraph below to require that filters be provided under other filter Sections. Retain second paragraph below to require filters to be provided by air-handling manufacturer.

* + - * 1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
        2. Panel Filters:

Description: **[Flat, nonpleated] [Pleated]** factory-fabricated, self-supported disposable air filters with holding frames.

Filter Unit Class: UL 900.

Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive and antimicrobial coating.

Filter-Media Frame: **[High wet-strength beverage board] <Insert material>** with perforated metal retainer, or metal grid, on outlet side.

* + - * 1. Mounting Frames:

Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.

Cartridge filters arranged for flat orientation, removable from access plenum.

Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks**[ with space for prefilter]**.

* + - 1. ROTARY HEAT EXCHANGER
         1. Casing:

Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory-painted finish.

Integral purge section limiting carryover of exhaust air to between **[0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg] <Insert values>** differential pressure.

Casing seals on periphery of rotor and on duct divider and purge section.

Support vertical rotor on grease-lubricated ball bearings having extended grease fittings**[ or permanently lubricated bearings]**. Support horizontal rotors on tapered roller bearings.

* + - * 1. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
        2. Drive: Fractional horsepower motor and gear reducer**[, with speed changed by variable-frequency controller]**. Provide permanently lubricated wheel bearings.

Retain "Controls" paragraph below to require controls to be an integral part of dedicated outdoor-air unit. Consult manufacturers. Delete if controls are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" or stated on Drawings.

* + - * 1. Controls:

Starting relay, factory mounted and wired, and manual motor starter for field wiring.

Variable-frequency controller, factory mounted and wired, permitting input of 4-20 mA or 1-10 V control signal.

Control energy recovery to permit air economizer operation.

Bypass dampers to assist energy recovery control.

Pilot-Light Indicator: Display rotor rotation and speed.

Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

Integral purge section limiting carryover of exhaust air to between [0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg] <Insert value> differential pressure.

Defrost cycle.

**<Insert additional control features>**.

* + - 1. INDIRECT-FIRED GAS FURNACE HEATING
         1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47 and with NFPA 54.
         2. CSA Approval: Designed and certified by and bearing label of CSA.
         3. Burners:

Heat-Exchanger Material: **[Aluminized steel with stainless steel inserts] [Stainless steel]**.

Fuel: **[Natural] [Propane]** gas.

Ignition: Electronically controlled electric spark with flame sensor.

Gas Control Valve: **[Single stage] [Two stage] [Electronic modulating]**.

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.

High-altitude feature in "High-Altitude (Model) (Kit)" subparagraph below is available from some manufacturers; consult manufacturers.

High-Altitude **[Model] [Kit]**: For Project elevations of more than 2000 feet above sea level.

Retain "Venting, Gravity" or "Venting, Power" paragraph below.

* + - * 1. Venting, Gravity: Gravity vented.
        2. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.
        3. Heat-Exchanger Drain Pan: Stainless steel.
        4. Safety Controls:

Gas Manifold: Safety switches and controls complying with ANSI standards **[and] [FM Global] <Insert insurer>**.

Vent Flow Verification: **[Differential pressure switch to verify open vent] [Flame rollout switch]**.

High Limit: Thermal switch or fuse to stop burner.

Purge-period timer shall automatically delay burner ignition and bypass low-limit control.

Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.

Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.

Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

* + - 1. DAMPERS

Retain "Dampers" paragraph below if dampers are specified in Section 230923.12 "Control Dampers." Retain "Outdoor- and Return-Air Dampers" paragraph if dampers are to be provided by unit manufacturer. Not all manufacturers offer this option; consult manufacturers.

* + - * 1. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."

Low-leakage dampers in "Outdoor- and Relief-Air Dampers" paragraph below are available from most manufacturers and from manufacturers of temperature-control equipment. ASHRAE/IES 90.1 limits maximum damper leakage based on climate zone, number of stories, damper function (intake, exhaust/relief), and damper type (motorized, nonmotorized). The most restrictive across all climate zones, number of stories, damper function, and damper type is 4 cfm/sq. ft. at 1 inch wg.

* + - * 1. Outdoor- and Relief-Air Dampers: Low-leakage, double-skin, airfoil-blade, **[galvanized-steel] <Insert material>** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **[opposed] [parallel]**-blade arrangement with **[zinc-plated ]steel operating rods rotating in [sintered bronze or nylon] <Insert material>** bearings mounted in a single **[galvanized-steel] <Insert material>** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1 inch wg and 8 cfm/sq. ft. at 4 inches wg.

Retain "Damper Operators" paragraph below if damper operators are specified in Section 230923.12 "Control Dampers." Retain "Electronic Damper Operators" paragraph below to require that damper operators be provided by unit manufacturer. Not all manufacturers offer this option; consult manufacturers. If retaining second paragraph, coordinate with Division 23 controls Sections for electrical service to devices.

* + - * 1. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
        2. Electronic Damper Operators:

Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

Electronic damper position indicator shall have visual scale indicating percentage of travel and 2 to 10 V dc feedback signal.

Default motor characteristics are specified in Section 230513 "Common Motor Requirements for HVAC Equipment." Insert subparagraphs to suit Project if different characteristics are required.

Operator Motors:

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."

Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

Size dampers for running torque calculated as follows:

Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.

Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.

Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.

Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.

Dampers with 2 to 3 Inches wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

Dampers with 3 to 4 Inches wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

Coupling: V-bolt and V-shaped, toothed cradle.

Overload Protection: Electronic overload or digital rotation-sensing circuitry.

Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.

Coordinate "Power Requirements (Two-Position Spring Return)," "Power Requirements (Modulating)," and "Proportional Signal" subparagraphs below with Division 23 controls Sections.

Power Requirements (Two-Position Spring Return): **[24 V dc] [120 V ac] [230 V ac]**.

Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.

Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2 to 10 V dc position feedback signal.

Temperature Rating: **[Minus 22 to plus 122 deg F] [40 to 104 deg F]**.

Run Time: **[12 seconds open, 5 seconds closed] [30 seconds] [60 seconds] [120 seconds]**.

* + - 1. ELECTRICAL POWER CONNECTIONS

Not all manufacturers provide all features in this article. Consult manufacturers. Option in "Single-Point Power Connection" paragraph below allows for constant power of lighting and convenience outlets when unit disconnect is engaged.

* + - * 1. Single-Point Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a **[single-point ]**field power connection to unit **[except for service lights and convenience outlets, which are to be powered separately]**.
        2. Enclosure: NEMA 250, **[Type 3R] [Type 4] [Type 4X] <Insert type>**, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key.
        3. Wiring: Numbered and color-coded to match wiring diagram.
        4. Wiring Location: Install factory wiring outside an enclosure in a raceway.
        5. Power Interface: Field power interface to be **[wire lugs] [NEMA KS 1, heavy-duty, nonfused disconnect switch]**.
        6. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:

NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.

NEMA KS 1, heavy-duty, nonfusible switch.

UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

* + - * 1. Factory-Mounted, Overcurrent-Protection Service: For each motor.

Retain "Transformer" paragraph below if required for controls or unit-mounted convenience power receptacle.

* + - * 1. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
        2. Controls: Factory wire unit-mounted controls where indicated.

Retain "Service Lights" and "Convenience Outlets" subparagraphs below to add service lights and convenience outlets to unit access section.

Service Lights: **<Insert number of watts> [LED] <Insert lamp type>** vaporproof luminaire with individual switched junction box located **[outside] [inside]**, adjacent to each access door and panel.

Locations: **[Each section accessed with door or panel] [Fan section] <Insert location>**.

Convenience Outlets: One 20 A duplex GFCI receptacle per location with junction box located on outside casing wall.

Locations: **[Each section accessed with a door or panel] [Fan section] <Insert location>**.

* + - * 1. Control Relays: Auxiliary and adjustable time-delay relays.
      1. CONTROLS

Retain first paragraph below to specify temperature controls in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC." Delete first paragraph and retain remainder of this article to require controls integral to the dedicated outdoor-air unit to be provided by the dedicated outdoor-air unit manufacturer. Verify availability with dedicated outdoor-air unit manufacturers.

* + - * 1. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control equipment and sequence of operation.

Retain "Control Valves" paragraph below if dedicated outdoor-air unit manufacturers do not provide control valves for water and steam coils. Coordinate requirements for control valves with Section 230923.11 "Control Valves."

* + - * 1. Control Valves: Comply with requirements in Section 230923.11 "Control Valves."
        2. Control Wiring: Factory wire connection for controls' power supply.
        3. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.
        4. **[Remote] [Unit]**-Mounted Status Panel:

Cooling/Off/Heating Controls: Control operational mode.

Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.

Status Lights:

Filter dirty.

Fan operating.

Cooling operating.

Heating operating.

Smoke alarm.

General alarm.

**<Insert points>**.

Digital Numeric Display:

Outdoor airflow.

Supply airflow.

Outdoor dry-bulb temperature.

Outdoor dew point temperature.

Space temperature.

Supply temperature.

Space relative humidity.

Space carbon dioxide level.

**<Insert points>**.

* + - * 1. Refrigeration System Controls:

Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than **[28 Btu/lb] <Insert value>** of dry air or outdoor-air temperature is less than 60 deg F **<Insert value>**.

Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F**<Insert value>**.

Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than **[50] <Insert value>** percent.

* + - * 1. Furnace Controls:

Retain first subparagraph below for discharge sensing.

**[Factory-mounted sensor in supply outlet] [Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.

Retain first subparagraph below for remote sensing.

Wall-mounted, space-temperature sensor with **[temperature adjustment] [unit-mounted temperature adjustment] [adjustment on remote-control panel]** to modulate gas furnace burner to maintain space temperature.

Remote Setback: Adjustable room thermostat selected by timer, set at **[50 deg F] <Insert temperature>**; cycles supply fan and gas furnace burner to maintain space temperature.

Burner Control: **[Two] [Four] [steps of control] [Modulating]**.

* + - * 1. Rotary Heat-Exchanger Control:

Sequence with refrigeration system controls and heating controls.

For operation of rotary heat exchanger itself, see "Rotary Heat Exchanger" Article.

Retain "Electric-Resistance Heat Controls" paragraph below for units with electric-resistance heating coil option.

* + - * 1. Electric-Resistance Heat Controls:

Retain first subparagraph below for electric-resistance heat with discharge-air temperature control.

**[Factory-mounted sensor in unit discharge] [Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control electric coil to maintain temperature.

Retain first subparagraph below for electric-resistance heat with remote temperature control.

Wall-mounted, space-temperature sensor with **[temperature adjustment] [unit-mounted temperature adjustment] [adjustment on remote-control panel]** to control electric coil to maintain temperature.

Capacity Controls: **[On/off] [Multiple steps] [Modulating SCR] <Insert type>**.

Retain first paragraph below for units with hot-water or steam heating coils and for discharge-air temperature control.

* + - * 1. **[Hot-Water] [and] [Steam]** Coil Controls, Discharge Temperature Sensor: **[Factory-mounted sensor in unit discharge] [Remote sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate factory-**[mounted] [furnished]** coil control valve to maintain temperature.

Retain first paragraph below for hot-water or steam heating coils with remote temperature control.

* + - * 1. **[Hot-Water] [and] [Steam]** Coil Controls, Space Temperature Sensor: With **[temperature adjustment] [unit-mounted temperature adjustment] [adjustment on remote-control panel]** to modulate factory-**[mounted] [furnished]** coil control valve to maintain temperature.

Retain "Damper Controls" paragraph below if unit maintains minimum building pressure by introducing variable quantities of outdoor air.

* + - * 1. Damper Controls: Space-pressure sensor modulates outdoor- and relief-air dampers to maintain a positive pressure in space at a minimum of **[0.05 inch wg] <Insert value>** with respect to outdoor reference.
        2. DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Links shall include the following:

Start/stop interface relay and relay to notify DDC temperature-control system alarm condition.

Hardware interface or additional sensors for the following:

Room temperature.

Discharge-air temperature.

Refrigeration system operation.

Furnace operation.

Retain "Interface with DDC System for HVAC" paragraph below if unit controls interface with the DDC system for HVAC. Coordinate with Section 230923 "Direct Digital Control (DDC) System for HVAC."

* + - * 1. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display unit status and alarms.

Retain "Hardwired Points" subparagraph below if interface with the DDC system for HVAC is through hardwired points and minimal interface is required.

Hardwired Points:

Monitoring: On-off status, **[common trouble alarm] <Insert monitoring point>**.

Control: On-off operation, **[space temperature set-point adjustment] [supply temperature set-point adjustment] [space humidity set-point adjustment] [space pressure set-point adjustment] <Insert control point>**.

Delete "Hardwired Points" subparagraph above and retain subparagraph below if extensive interface with the DDC system for HVAC is required and is beyond what hardwired points can provide. Requirement may exclude some manufacturers.

**[ASHRAE 135 (BACnet)] [LonTalk] [Modbus] [Industry-accepted, open-protocol] <Insert type of interface>** communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the DDC system for HVAC.

* + - * 1. **<Insert additional control sequences and requirements>**.
      1. ROOF CURBS

Retain one of first two paragraphs below. Retain first for curbs with vibration isolation and seismic or wind restraints; retain "Materials" paragraph below for curbs provided by dedicated outdoor-air unit manufacturer without vibration isolation and seismic or wind restraints. Not all manufacturers offer this option; consult manufacturers.

* + - * 1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC." Roof curbs with vibration isolators and wind restraints are specified in Section 230548.13 "Vibration Controls for HVAC."
        2. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with National Roofing Contractors Association manuals for the specific type of roofing applicable to the Project.

Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

Materials: ASTM C1071, Type I or II.

Thickness: **[1 inch] [1-1/2 inches] [2 inches] <Insert dimension>**.

Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

Liner Adhesive: Comply with ASTM C916, Type I.

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.

Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service air velocity.

For healthcare occupancies, ASHRAE 170 and most healthcare authorities having jurisdiction require the outside air-intake opening for roof-mounted equipment to be a minimum of 36 inches (910 mm) above the roof. Coordinate outside-air-intake opening elevation with curb height in order to comply with requirement.

* + - * 1. Curb Dimensions: Height of **[14 inches] [24 inches] [36 inches] <Insert dimension>.[ Provide adaptable horizontal dimensions as required for existing roof openings.]**
        2. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.
      1. INTAKE AND RELIEF OPENINGS
         1. Type: Manufacturer's standard hood or louver, including moisture eliminator, at all unit intake and relief openings.
         2. Materials: Match material and finish of casing exterior.
         3. Bird Screen: Comply with requirements in ASHRAE 62.1.
         4. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.
      2. MATERIALS
         1. Steel:

ASTM A36 for carbon structural steel.

ASTM A568 for steel sheet.

* + - * 1. Stainless Steel:

Manufacturer's standard grade for casing.

Manufacturer's standard type, ASTM A240 for bare steel exposed to airstream or moisture.

* + - * 1. Galvanized Steel: ASTM A653.
        2. Aluminum: ASTM B209.

Retain first paragraph below if corrosion-resistant coating is specified in Section 230546 "Coatings for HVAC."

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

Retain "Corrosion-Resistant Coating" paragraph below if corrosion-resistant coating option is cited in subparagraphs under "Double-Wall Configuration" paragraph in "Unit Casing" Article and in "Supply-Air Refrigerant Coil" paragraph, "Hot-Gas Reheat Refrigerant Coil" paragraph, "Heating-Water Coils" paragraph, "Steam Heating Coils" paragraph, and "Condenser Refrigerant Coils" paragraph in "Coils" Article; and if corrosion-resistant coating is specified in this Section. Determine availability with air-handling unit manufacturers.

* + - * 1. Corrosion-Resistant Coating: Coat **[casing] [coils] [and] [fan guards]** with a corrosion-resistant coating capable of withstanding a **[3,000] <Insert time>**-hour salt-spray test in accordance with ASTM B117.

Standards:

ASTM B117 for salt spray.

ASTM D2794 for minimum impact resistance of 100 in-lb.

ASTM D3359 for cross-hatch adhesion of 5B.

Application: **[Immersion] [Spray]**.

Thickness: **[1 mil] <Insert measurement>**.

Gloss: Minimum gloss of 50 gloss units on a single angle 60-degree meter.

* + - 1. SOURCE QUALITY CONTROL

Not all manufacturers comply with AHRI 920, which is the performance rating standard for DX-dedicated outdoor air system units. This standard includes test conditions that are appropriate for dedicated outdoor air systems, including moisture removal, and for power required for a leaving-supply-air dew point of less than 55 deg. F. The certification program ratings verified by test are as follows: Moisture Removal Capacity (MRC) in lbs of moisture/h and MRE in lbs of moisture/kWh. The ISMRE is a combined value for the four dehumidification MRE ratings. ASHRAE 90.1-2016 now refers to this efficiency rating for DX-dedicated outdoor air system units. At the time this Section was updated, AHRI did not yet have a certification program for AHRI 920, although a program is planned for the future. So until an AHRI 920 compliance program is available, compliance is based on manufacturers' calculations and certification of their own performance test results.

* + - * 1. AHRI 920: Manufacturer to certify that performance ratings are in accordance with AHRI 920 if AHRI 920 certification program is not in place. Provide AHRI 920 certification if AHRI 920 certification program is in place.

Retain "AHRI 260 or AMCA 311 Certification" paragraph below when specifying maximum sound levels. Verify availability with manufacturers.

* + - * 1. AHRI 260 or AMCA 311 Certification: Test and rate air-handling unit fan sound ratings in accordance with AHRI 260 or AMCA Publication 311.
        2. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency.

**[AMCA Certification: Test and rate in accordance with AMCA Publication 211**.]

* + - * 1. Damper Leakage and Air Performance: Factory test dampers for leakage and air performance.

**[AMCA Certification: Test and rate in accordance with AMCA Publication 511.]**

* + - * 1. Water Coils: Factory tested to 300 psig in accordance with AHRI 410 and ASHRAE 33.
        2. Refrigerant Coils: Factory tested to minimum **[300 psig] [450 psig]** internal pressure and to minimum 300 psig internal pressure while under water, in accordance with AHRI 410 and ASHRAE 33.

1. EXECUTION
   * + 1. EXAMINATION
          1. Examine areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
          2. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
          3. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
          4. Proceed with installation only after unsatisfactory conditions have been corrected.
       2. INSTALLATION, GENERAL

Retain "Unit Support" paragraph below if unit is installed on field-fabricated curbs or steel supports.

* + - * 1. Unit Support: Install unit level on structural **[curbs] [steel supports]**. Coordinate roof penetrations and flashing with roof construction. Secure units to structural support with anchor bolts. Coordinate sizes and locations of **[curbs] [steel supports]** with actual equipment provided.

Retain one of two subparagraphs below. Retain first for projects in seismic areas; retain second for projects not in seismic areas. Indicate vibration isolation and seismic-control device types and minimum deflection in supported equipment schedule on Drawings.

Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

Sustainable design systems require filters with a minimum MERV 13 rating for air delivered to the occupied space. Air-handling units should not be used for temporary heating and ventilating unless expressly approved by Director’s Representative. If used during construction, see SMACNA's "IAQ Guidelines for Occupied Buildings under Construction" for procedures to protect HVAC system.

* + - * 1. 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.
        2. 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.

Coordinate duct installations and specialty arrangements with Drawings and with requirements specified in Section 233113 "Metal Ducts" and Section 233300 "Air Duct Accessories."

* + - * 1. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

Retain first paragraph below if wall- and duct-mounted sensors are furnished by unit manufacturer for field installation.

* + - * 1. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
        2. Comply with requirements for gas-fired furnace installation in NFPA 54.
        3. Install separate devices furnished by manufacturer and not factory installed.
        4. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
      1. PIPING CONNECTIONS

Coordinate piping installations and specialty arrangements with Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

* + - * 1. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
        2. Where installing piping adjacent to units, allow space for service and maintenance.
        3. Connect piping to units mounted on vibration isolators with flexible connectors.

Verify condensate drainage requirements of authorities having jurisdiction.

* + - * 1. Hot-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.
        2. Steam and Steam 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 provide inverted bucket steam trap at condensate return connection.
        3. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
        4. Gas Piping: Comply with requirements in **[Section 231123 "Facility Natural-Gas Piping."] [Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Provide AGA-approved flexible connectors.

Retain option in first subparagraph below if pressure regulator is required and not provided by manufacturer.

Connect gas piping to furnace, full size of gas train inlet, and connect with union**[, pressure regulator,]** and shutoff valve with sufficient clearance for burner removal and service.

Install AGA-approved flexible connectors.

Retain "Hydronic Piping Connections" paragraph below for units with hot-water coils.

* + - * 1. Hydronic Piping Connections:

Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

Install shutoff valve and union or flange on each supply connection, and install balancing valve and union or flange on each return connection.

Retain "Steam Piping Connections" paragraph below for units with steam coils.

* + - * 1. Steam Piping Connections:

Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

Install shutoff valve and union or flange on each supply connection.

Install, starting from the coil connection, union or flange, strainer, union, float and thermostatic trap, union, and shutoff valve.

Coordinate duct installation requirements with schematics on Drawings and with requirements specified for duct systems. If Drawings are explicit enough, these requirements may be reduced or omitted.

* + - * 1. Duct Connections:

Comply with requirements in Section 233113 "Metal Ducts."

Drawings indicate the general arrangement of ducts.

Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

* + - 1. ELECTRICAL CONNECTIONS
         1. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
         2. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
         3. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
         4. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

Retain one of two subparagraphs below. First subparagraph cross-references Section 260553 "Identification for Electrical Systems" and should be retained for consistent electrical identification. Second subparagraph is an abbreviated version of the product specified in Section 260553 "Identification for Electrical Systems."

Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

* + - 1. CONTROL CONNECTIONS
         1. Install control and electrical power wiring to field-mounted control devices.
         2. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
      2. STARTUP SERVICE
         1. **[Engage a Company Field Advisor per OGS Spec Section 014216 to perform] [Perform]** startup service.

Complete installation and startup checks in accordance with manufacturer's written instructions.

Retain first three subparagraphs below for units with a furnace.

Inspect units for visible damage to furnace combustion chamber.

Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

Measure gas pressure at manifold.

Measure combustion-air temperature at inlet to combustion chamber.

Measure flue-gas temperature at furnace discharge.

Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.

Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

Verify operation of remote panel, including pilot-light operation and failure modes. Inspect the following:

High-limit heat exchanger.

Alarms.

Coordinate first three subparagraphs below with "Refrigeration Circuit Components" Article.

Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.

Start refrigeration system when outdoor-air temperature is within normal operating limits. and measure and record the following:

Cooling coil leaving-air, dry- and wet-bulb temperatures.

Cooling coil entering-air, dry- and wet-bulb temperatures.

Condenser coil entering-air dry-bulb temperature.

Condenser coil leaving-air dry-bulb temperature.

Simulate maximum cooling demand and inspect the following:

Compressor refrigerant suction and hot-gas pressures.

Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

Inspect casing insulation for integrity, moisture content, and adhesion.

Verify that clearances have been provided for servicing.

Verify that controls are connected and operable.

Verify that filters are installed.

Clean coils and inspect for construction debris.

Retain first three subparagraphs below for units with furnace.

Clean furnace flue and inspect for construction debris.

Inspect operation of power vents.

Purge gas line.

Retain first subparagraph below for units with restrained vibration isolation roof-curb rails.

Inspect and adjust vibration isolators and seismic restraints.

Verify bearing lubrication.

Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.

Adjust fan belts to proper alignment and tension.

Start unit.

Inspect and record performance of interlocks and protective devices, including response to smoke detectors by fan controls and fire alarm.

Operate unit for run-in period.

Calibrate controls.

Adjust and inspect high-temperature limits.

Retain first subparagraph below for units designed to operate, at least part-time, with less than 100 percent outdoor air.

Inspect outdoor-air dampers for proper stroke**[ and interlock with return-air dampers]**.

Verify operational sequence of controls.

Measure and record the following airflows. Plot fan volumes on fan curve.

Supply-air volume.

Retain first subparagraph below for units designed to operate, at least part-time, with less than 100 percent outdoor air.

Relief-air flow.

Outdoor-air flow.

* + - * 1. After startup, change filters, verify bearing lubrication, and adjust belt tension.
        2. Remove and replace components that do not properly operate, and repeat startup procedures as specified above.
        3. Prepare written report of the results of startup services.
      1. ADJUSTING
         1. Adjust initial temperature and humidity set points.
         2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
         3. Occupancy Adjustments: When requested within **[12] <Insert number>** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two] <Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
      2. CLEANING
         1. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.
      3. FIELD QUALITY CONTROL

Retain "Manufacturer's Field Service" and "Perform the following tests and inspections" paragraphs below to identify who shall perform tests and inspections. If retaining second option in "Manufacturer's Field Service" or "Perform the following tests and inspections" paragraph, retain "Field quality-control reports" paragraph in "Informational Submittals" Article.

Retain "Manufacturer's Field Service" paragraph below to require a factory-authorized service representative to perform tests and inspections.

* + - * 1. Manufacturer's Field Service: Engage a Company Field Advisor per OGS Spec Section 014216 to test and inspect components, assemblies, and equipment installations, including connections.

Retain "Perform the following tests and inspections" paragraph below to require Contractor to perform tests and inspections, and retain option to require Contractor to arrange for the assistance of a factory-authorized service agent.

* + - * 1. Perform the following tests and inspections [ with the assistance of a Company Field Advisor per OGS Spec Section 014216]:

Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.

Charge refrigerant coils with refrigerant and test for leaks.

Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

* + - 1. DEMONSTRATION
         1. [Engage a Company Field Advisor per OGS Spec Section to train] [Train] Facility’s maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 237433