SECTION 237416.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING 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.

This Section may include provisions for LEED 2009, LEED v4, ASHRAE 189.1, IgCC, and Green Globes. Note that some sustainable design requirements are either mandatory or optional requirements that may be inserted in the Section Text using the hypertext links. Other requirements that are associated with sustainable design, and may be considered "best practice" or retained even if a sustainable design standard is not a project requirement, are discussed in the Evaluations.

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 packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components:

Casings.

Fans, drives, and motors.

Rotary heat exchangers.

Coils.

Refrigerant circuit components.

Air filtration.

Gas furnaces.

Dampers.

Electrical power connections.

Controls.

Roof curbs.

Accessories.

* + - 1. DEFINITIONS

Retain terms that remain after this Section has been edited for a project.

* + - * 1. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, small-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
			1. 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 RTU.

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

Include rated capacities, dimensions, required clearances, characteristics, and furnished specialties and accessories.

Include unit dimensions and weight.

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

Fans:

Include certified fan-performance curves with system operating conditions indicated.

Include certified fan-sound power ratings.

Include fan construction and accessories.

Include motor ratings, electrical characteristics, and motor accessories.

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

Include filters with performance characteristics.

Include gas furnaces with performance characteristics.

Include dampers, including housings, linkages, and operators.

* + - * 1. Shop Drawings: For each packaged, small-capacity, rooftop air-conditioning unit.

Include plans, elevations, sections, and **[mounting] [attachment]** 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 "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 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 RTUs, 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. System startup 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 RTUs 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.

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

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

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

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

* + - 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 repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.

Warranty Period: **<Insert number>** year(s) from date of Substantial Completion.

Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **[five] [10] <Insert number>** years from date of Substantial Completion

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, and marked for intended location and application.
				2. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs 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 feature 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 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.

* + - * 1. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

If retaining "UL Compliance" paragraph below, delete "ASHRAE 15 Compliance" and "NFPA Compliance" paragraphs. Some manufacturers test and label their equipment according to UL 1995, which requires compliance with ASHRAE 15, NFPA 90A, and NFPA 90B.

* + - * 1. UL Compliance: Comply with 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 mounting and restraints for RTUs, including comprehensive engineering analysis.

Design RTU supports to comply with **[wind] [and] [seismic]** performance requirements.

Retain "Wind-Restraint Performance" paragraph below with "Product Certificates" and "Delegated-Design Submittal" paragraphs in "Informational Submittals" Article for projects requiring wind-restraint design. Model building codes and ASCE/SEI 7 establish criteria for buildings subject to earthquake motions. Verify requirements of authorities having jurisdiction.

* + - * 1. Wind-Restraint Performance:

Obtain values for items in three subparagraphs below from Project structural engineer or from ASCE/SEI 7.

Basic Wind Speed: **<Insert value>**.

Building Classification Category: **[I] [II] [III] [IV]**.

Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

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.

* + - * 1. Seismic Performance: RTUs, accessories, and components shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7] <Insert requirement>**.

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.

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]**."

For life-safety components required to function after an earthquake (such as fire-sprinkler systems, components that contain hazardous content, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

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.

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

* + - 1. CAPACITIES AND CHARACTERISTICS

If Project has more than one type or configuration of RTU, delete this article and schedule RTUs on Drawings.

* + - * 1. Supply-Air Fan:

Retain one of two "Fan Type" subparagraphs below.

Fan Type: Belt driven, double width, **[forward curved] [backward inclined]**, centrifugal.

Fan Type: Double width, forward curved, centrifugal.

Airflow: **<Insert cfm>**.

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

Fan Speed: **[Variable] <Insert rpm>**.

Verify enclosure types with manufacturer of specified equipment.

Enclosure Type: **[Open, dripproof] [Totally enclosed, fan cooled] [Totally enclosed, air over] [Open, externally ventilated] [Totally enclosed, nonventilated] [Severe duty] [Explosion proof] [Dust-ignition-proof machine]**.

Enclosure Materials: **[Cast iron] [Cast aluminum] [Rolled steel]**.

Motor Characteristics:

Horsepower: **<Insert horsepower>**.

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

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

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

Hertz: 60.

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

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

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

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

Airflow: **<Insert cfm>**.

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

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

Verify enclosure types with manufacturer of specified equipment.

Enclosure Type: **[Open, dripproof] [Totally enclosed, fan cooled] [Totally enclosed, air over] [Open, externally ventilated] [Totally enclosed, nonventilated] [Severe duty] [Explosion proof] [Dust-ignition-proof machine]**.

Enclosure Materials: **[Cast iron] [Cast aluminum] [Rolled steel]**.

Motor Characteristics:

Horsepower: **<Insert horsepower>**.

Motor Speed: **<Insert rpm>**.

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

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

Hertz: 60.

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

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

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

* + - * 1. Outdoor-Air-Intake Relief-Air Fan:

Airflow: **<Insert cfm>**.

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

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

Verify enclosure types with manufacturer of specified equipment.

Enclosure Type: **[Open, dripproof] [Totally enclosed, fan cooled] [Totally enclosed, air over] [Open, externally ventilated] [Totally enclosed, nonventilated] [Severe duty] [Explosion proof] [Dust-ignition-proof machine]**.

Enclosure Materials: **[Cast iron] [Cast aluminum] [Rolled steel]**.

Motor Characteristics:

Horsepower: **<Insert horsepower>**.

Motor Speed: **<Insert rpm>**.

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

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

Hertz: 60.

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

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

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

* + - * 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>**.

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

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

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

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

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

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

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

Total Cooling Capacity: **<Insert Btu/h>**.

Sensible Cooling Capacity: **<Insert Btu/h>**.

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

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

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

* + - * 1. Outdoor-Air Refrigerant Coil:

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

Coating: **[Baked phenolic] [Cathodic epoxy]**.

Fan Motor: **<Insert value>**.

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

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

* + - * 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>**.

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

Capacity: **<Insert kilowatts>**.

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

* + - * 1. Compressors:

Number of Refrigerant Circuits: **[One] [Two] <Insert number>**.

Compressor Speed: **[Single] [Variable]**.

Suction Temperature: **<Insert deg F>**.

Power Input: **<Insert kilowatts>**.

Seasonal Energy-Efficiency Ratio (SEER): **<Insert value>**.

* + - * 1. Gas Furnace:

Airflow: **<Insert cfm>**.

Gas Control Valve: [Single stage] [Two stage] [Modulating].

Retain "Minimum AFUE," Minimum Thermal Efficiency," or "Minimum Combustion Efficiency" subparagraph below.

Minimum AFUE: **<Insert number>** percent.

Minimum Thermal Efficiency: **<Insert number>** percent.

Minimum Combustion Efficiency: **<Insert number>** percent.

Input: **<Insert Btu/h>**.

Output: **<Insert Btu/h>**.

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

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

* + - * 1. Dampers:

Retain "Outdoor-Air Damper" or "Outdoor- and Return-Air Mixing Dampers" subparagraph below. First subparagraph is for limited outdoor air; second for units with economizer controls. Retain second option in first subparagraph to comply with requirements in ASHRAE/IES 90.1.

Outdoor-Air Damper: Linked damper blades, for zero to **[25] [30] <Insert number>** percent outdoor air, with **[manual] [motorized]** damper filter.

Outdoor- and Return-Air Mixing Dampers: **[Parallel-] [Opposed-]**blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage **[or gears ]**and interconnect so dampers operate simultaneously.

Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1.

Barometric relief dampers.

* + - * 1. Recirculating-Air Filters:

Type: **<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 according to 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 13] <Insert value>**, according to ASHRAE 52.2.

* + - * 1. Outdoor-Air Filters:

Type: **<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 according to 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 13] <Insert value>**, according to ASHRAE 52.2.

See Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" for vibration isolation and seismic-control devices.

* + - * 1. Vibration Isolation**[ and Seismic-Control]** Devices: **<Insert device type>**, with **<Insert value>** minimum deflection.
				2. Electrical Characteristics for Single-Point Connection:

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

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

Hertz: 60.

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

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

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

* + - * 1. Sound Power: Radiated from condenser casing.

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

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

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

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

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

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

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

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

* + - 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.

Allied Commercial.

Carrier Global Corporation.

Daikin Applied.

Engineered Air.

Lennox Industries, Inc.; Lennox International.

Rheem Manufacturing Company; Heating and Cooling Products.

Trane.

Valent.

YORK; brand of Johnson Controls International PLC, Building Solutions North America.

Approved equivalent.

* + - 1. UNIT CASINGS
				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. Double-Wall Construction:

Outside Casing Wall: **[Galvanized steel] <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: G90-coated galvanized steel, **[0.034 inch] [0.028 inch] <Insert dimension>** thick**[, perforated 40 percent free area]**.

Floor Plate: **[G90 galvanized steel] <Insert material>**, **[treadplate, ]**minimum **[18 gauge] <Insert value>** thick.

Casing Insulation:

Materials: Injected polyurethane foam insulation.

Casing Panel R-Value: Minimum **<Insert value>**.

Insulation Thickness: **[1 inch] [2 inches]**.

Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of 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-inch wg] [3-inch wg] <Insert value>**.

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

* + - * 1. Panels and Doors:

Panels:

Fabrication: Formed and reinforced with same materials and insulation thickness as casing.

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

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

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

Access Doors:

Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.

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

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

Locations and Applications:

Verify that the sections listed below are large enough for panels and doors. Verify applicability with manufacturers.

Fan Section: **[Inspection and access panels] [Doors] [Doors and inspection and access panels]**.

Access Section: Doors.

Coil Section: Inspection and access panels.

Damper Section: **[Inspection and access panels] [Doors]**.

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

Mixing Section: Doors.

* + - * 1. Condensate Drain Pans:

Location: Each type of **[cooling coil] [rotary heat exchanger]**.

Construction:

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

Drain Connection:

Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **[one end] [both ends]** of pan.

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

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

Slope: Minimum **[0.125-in./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 Prerequisite IEQ 1 or LEED v4 Prerequisite EQ "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.

Units with stacked coils shall have an 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: Centrifugal, rated according to AMCA 210; 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 according to 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.

Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.

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] <Insert dimension>**.

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

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

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.

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

* + - * 1. Drives, Direct: Factory-mounted, direct drive.
				2. Drives, 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, non-sparking and nonstatic; in matched sets for multiple-belt drives.

Belt Guards: Comply with requirements specified by OSHA and fabricate according to 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] [ECM]** motors.
				2. Relief-Air Fan: **[Propeller] [Forward curved] [Backward inclined]**, shaft mounted on permanently lubricated motor.
				3. 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 paragraphs to suit Project.

Comply with NEMA designation, temperature rating, service factor, 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.

* + - 1. ROTARY HEAT EXCHANGER
				1. Heat exchanger integral with unit.
				2. 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 bearing.

Retain "Rotor - Aluminum or Polymer" or "Rotor - Aluminum, Metallic, or Polymer" subparagraph below. Not all manufacturers offer each combination of materials and coatings. Consult manufacturers.

* + - * 1. Rotor - Aluminum or Polymer: Segmented wheel, strengthened with radial spokes**[, with nontoxic, noncorrosive, silica-gel desiccant coating]**.
				2. Rotor - Aluminum, Metallic, or Polymer: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
				3. Drive: Fractional horsepower motor and gear reducer**[, with speed changed by variable-frequency controller]**. Permanently lubricated wheel bearings with an **[L-10] <Insert bearing life> [400,000 hours] <Insert hours>**.

Retain "Controls" paragraph below to require controls to be an integral part of air-to-air energy recovery equipment. Delete if controls are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

* + - * 1. Controls:

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

Retain one of first three subparagraphs below.

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

Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.

Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain**[ exhaust temperature above freezing and]** air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.

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.

Defrost cycle.

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

Comply with AHRI 410.

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

Coils shall not act as structural component of unit.

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

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 according to ASHRAE 33 and AHRI 410.

Working Pressure: Minimum 300 psig.

* + - * 1. Outdoor-Air Refrigerant Coil:

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 according to ASHRAE 33 and AHRI 410.

Working Pressure: Minimum 300 psig.

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

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 according to ASHRAE 33 and AHRI 410.

Working Pressure: Minimum 300 psig.

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] [Mercury]** contactor.

Solid-state, stepless pulse controller.

Toggle switches, one per step.

Step controller.

Time-delay relay.

Pilot lights, one per step.

Airflow proving switch.

* + - 1. REFRIGERANT CIRCUIT COMPONENTS

Indicate number of circuits for each RTU in "Capacities and Characteristics" Article or in schedule on Drawings.

Verify, with manufacturer, availability of crankcase heater in "Compressor" paragraph below.

* + - * 1. Compressor: Hermetic, **[variable-speed]** scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief**[, and crankcase heater]**.
				2. Refrigeration Specialties:

Refrigerant: **[R-410A] <Insert refrigerant type>**.

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.

Brass service valves installed in compressor suction and liquid lines.

Four subparagraphs below are optional features. Verify availability with manufacturers.

Low-ambient kit high-pressure sensor.

Hot-gas reheat solenoid valve **[single stage] [modulating]** with a replaceable magnetic coil.

Hot-gas bypass solenoid valve with a replaceable magnetic coil.

Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

* + - 1. AIR FILTRATION

Verify available filter types with manufacturer. Retain first paragraph below if filters are to be provided under other filter Sections.

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

Description: **[Flat, non-pleated] [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: **[Beverage board] <Insert material>** with perforated metal retainer, or metal grid, on outlet side.

Retain "Adhesive, Sustainability Projects" paragraph below if required for sustainability.

* + - * 1. Adhesive, Sustainability Projects: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.

Retain "Adhesive, LEED for Schools Projects" paragraph below if required for sustainability.

* + - * 1. Adhesive, LEED for Schools Projects: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
			1. GAS FURNACES
				1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
				2. CSA Approval: Designed and certified by and bearing label of CSA.
				3. Burners: Stainless steel.

Rated Minimum Turndown Ratio: **[30 to 1] <Insert ratio>**.

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

Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

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

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

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

* + - * 1. Heat-Exchanger and Drain Pan: Stainless steel.

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

* + - * 1. Venting, Gravity: Gravity vented**[ with vertical extension]**.
				2. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve**[ with vertical extension]**.
				3. Safety Controls:

Director’s Representative 's insurance underwriter may require gas train by FM Global or another insurer. Verify with Director’s Representative.

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

* + - 1. DAMPERS

Retain "Dampers" or "Outdoor- and Return-Air Dampers" paragraph below. Retain "Dampers" paragraph 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 Return-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, non-motorized). The most restrictive across all climate zones, number of stories, damper function, and damper type is 4 cfm/sq. ft. at 1-inch wg. This is the maximum leakage cited in paragraph.

* + - * 1. Outdoor- and Return-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-inch wg rated in accordance with AMCA 500D.
				2. Barometric relief dampers.

Retain "Damper Operators" or "Electronic Damper Operators" paragraph below. Retain first paragraph if damper operators are specified in Section 230923.12 "Control Dampers." Retain second paragraph 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 percent 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-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.

Dampers with 3- to 4-Inch 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

Retain this article to require RTU manufacturer to provide a single-point disconnecting means. Delete article if disconnecting means is specified in electrical Sections and indicated on electrical Drawings. Unit-mounted disconnect in option below can be equipped to provide constant power to duplex, 115-V receptacles described in "Accessories" Article. Field-mounted disconnects specified in electrical and indicated on electrical Drawings will disconnect power to these outlets unless they are powered from another source.

* + - * 1. RTU shall have a single connection of power to unit with**[ unit-mounted disconnect switch accessible from outside unit and]** control-circuit transformer with built-in overcurrent protection.
			1. CONTROLS

Retain first paragraph below and delete remainder of article to specify temperature controls in Section 230923 "Direct Digital Control (DDC) System for HVAC." Delete first paragraph and retain remainder of article to require controls integral to the RTU provided by RTU manufacturer. Delete sequences if indicated on Drawings.

* + - * 1. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

Controls in "Basic Unit Controls" paragraph below contain standard features available on most RTUs. Include those required for Project. Verify control features with manufacturer.

* + - * 1. Basic Unit Controls:

Control-voltage transformer.

Wall-mounted thermostat or sensor with the following features:

Heat-cool-off switch.

Fan on-auto switch.

Fan-speed switch.

**[Manual] [Automatic]** changeover.

Adjustable deadband.

**[Concealed] [Exposed]** set point.

**[Concealed] [Exposed]** indication.

**[Degree F] [Degree C]** indication.

Unoccupied-period-override push button.

Data entry and access port to input temperature**[ and humidity]** set points, occupied and unoccupied periods, and output room temperature**[ and humidity]**, supply-air temperature, operating mode, and status.

Wall-mounted humidistat or sensor with the following features:

**[Concealed] [Exposed]** set point.

**[Concealed] [Exposed]** indication.

**[Remote Wall] [Unit]**-Mounted Annunciator Panel for Each Unit:

Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.

DDC controller or programmable timer and interface with HVAC instrumentation and control system.

Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

* + - * 1. **[Electronic] [DDC]** Controller:

Controller shall have volatile-memory backup.

Safety Control Operation:

Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.

Firestats: Stop fan and close outdoor-air damper if air greater than **[130 deg F]** **<Insert temperature>** enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.

Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in **[Section 284621.11 "Addressable Fire-Alarm Systems."] [Section 284621.13 "Conventional Fire-Alarm Systems."]**

Retain "Low-Discharge Temperature" subparagraph below for low-ambient feature.

Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply-air temperature is less than **[40 deg F] <Insert temperature>**.

Retain "Defrost Control for Condenser Coil" subparagraph below for air-to-air heat-pump feature.

Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

Scheduled Operation: Occupied and unoccupied periods on **[seven] [365]**-day clock with a minimum of **[two] [four]** programmable periods per day.

Unoccupied Period:

Heating Setback: **[10 deg F] <Insert temperature>**.

Cooling Setback: System off.

Override Operation: **[Two] <Insert number>** hours.

Supply Fan Operation:

Occupied Periods: Run fan continuously.

Unoccupied Periods: Cycle fan to maintain setback temperature.

Refrigerant Circuit Operation:

Occupied Periods: Cycle or stage compressors**[, and operate hot-gas bypass]** to match compressor output to cooling load to maintain **[room] [discharge]** temperature**[ and humidity]**. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.

Refrigerant coil may be cooling or heating with air-to-air heat pump. Retain second option in "Unoccupied Periods" subparagraph below for air-to-air heat pumps.

Unoccupied Periods: **[Compressors off] [Cycle compressors and condenser fans for heating to maintain setback temperature]**.

Switch reversing valve for heating or cooling mode on air-to-air heat pump.

Retain "Hot-Gas Reheat-Coil Operation" subparagraph below for hot-gas reheat feature.

Hot-Gas Reheat-Coil Operation:

Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles the compressor.

Unoccupied Periods: Reheat not required.

Gas Furnace Operation:

Occupied Periods: **[Cycle] [Stage] [Modulate]** burner to maintain **[room] [discharge]** temperature.

Unoccupied Periods: Cycle burner to maintain setback temperature.

Electric-Heating-Coil Operation:

Occupied Periods: **[Cycle] [Stage] [Modulate]** coil to maintain **[room] [discharge]** temperature.

Unoccupied Periods: Energize coil to maintain setback temperature.

Retain first subparagraph below for air-to-air heat pump.

Operate supplemental electric heating coil with compressor for heating with outdoor temperature below **[25 deg F] <Insert temperature>**.

Retain "Fixed Minimum Outdoor-Air Damper Operation" subparagraph below for fixed outdoor-air intake.

Fixed Minimum Outdoor-Air Damper Operation:

Occupied Periods: Open to **[25] <Insert number>** percent.

Unoccupied Periods: Close the outdoor-air damper.

Retain "Economizer Outdoor-Air Damper Operation" subparagraph below for economizer cycle to comply with ASHRAE/IES 90.1.

Economizer Outdoor-Air Damper Operation:

Morning **[warm-up] [cool-down] [building outdoor-air flush]** cycles.

Occupied Periods: Open to **[10] [25] <Insert number>** percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than **[60 deg F] <Insert temperature>**. Use **[outdoor-air temperature] [mixed-air and outdoor-air temperature] [outdoor-air enthalpy] [mixed-air temperature and select between outdoor-air and return-air enthalpy]** to adjust mixing dampers.**[ Start relief-air fan with end switch on outdoor-air damper.]** During economizer cycle operation, lock out cooling.

Unoccupied Periods: Close outdoor-air damper and open return-air damper.

Retain "Outdoor-Airflow Monitor" subparagraph below if monitoring outdoor-air intake rate if required by Project requirements or authorities having jurisdiction.

Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from **[2- to 10-V dc] [4 to 20 mA] <Insert value>**.

Carbon Dioxide Sensor Operation:

Occupied Periods: Reset minimum outdoor-air ratio down to minimum **[10] <Insert number>** percent to maintain maximum **[1000-ppm] <Insert value>** concentration.

Unoccupied Periods: Close outdoor-air damper and open return-air damper.

Terminal-Unit Relays:

Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

* + - * 1. Interface Requirements for HVAC Instrumentation and Control System:

Interface relay for scheduled operation.

Interface relay to provide indication of fault at the central workstation and diagnostic code storage.

Provide **[BACnet] [or] [LonWorks]** compatible interface for central HVAC control workstation for the following:

Adjusting set points.

Monitoring supply fan start, stop, and operation.

Inquiring data to include**[ outdoor-air damper position,]** supply- and room-air temperature**[ and humidity]**.

Monitoring occupied and unoccupied operations.

Monitoring constant and variable motor loads.

Monitoring variable-frequency drive operation.

Monitoring cooling load.

Monitoring economizer cycles.

Monitoring air-distribution static pressure and ventilation air volume.

* + - 1. ROOF CURBS

Retain one of first two paragraphs below. Retain first for curbs with vibration isolation and seismic or wind restraints; retain second for curbs provided by RTU 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."
				2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

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.

Liner Adhesive: Comply with ASTM C916, Type I.

* + - * 1. Curb Dimensions: Height of **[14 inches] [24 inches] [36 inches] <Insert dimension>.[ Adaptable horizontal dimensions as required for existing roof openings.]**
			1. ACCESSORIES
				1. Electric heater with integral thermostat maintains minimum 50 deg F temperature in gas burner compartment.
				2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required.**[ Outlet shall be energized even if the unit main disconnect is open.]**
				3. Low-ambient kit using **[staged] [damper on] [variable-speed]** condenser fans for operation down to **[35 deg F] <Insert temperature>**.
				4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
				5. Remote potentiometer to adjust minimum economizer damper position.
				6. Return-air bypass damper.
				7. Factory- or field-installed, demand-controlled ventilation.
				8. Safeties:

Smoke detector.

Condensate overflow switch.

Phase-loss **[reversal ]**protection.

High **[and low ]**pressure control.

**[Gas furnace] [Electric coil]** airflow-proving switch.

* + - * 1. Coil guards of painted, galvanized-steel wire.
				2. Hail guards of galvanized steel, painted to match casing.
				3. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.
				4. Door switches to disable heating or reset set point when open.
				5. Outdoor-air intake weather hood**[ with moisture eliminator]**.
				6. Oil separator.
				7. Service Lights and Switch: Factory installed in **[fan section] [fan and coil sections] [each accessible section] <Insert locations>** with weatherproof cover. Factory wire lights to a single-point field connection.
			1. 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." Retain "Corrosion-Resistant Coating" paragraph below if corrosion-resistant coating options are cited in "Casings" or "Coils" Article and if corrosion-resistant coating is specified in this Section. Determine availability with air-conditioning unit manufacturers.

* + - * 1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
				2. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **[3000] <Insert time>**-hour salt-spray test according to ASTM B117.

Standards:

ASTM B117 for salt spray.

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

ASTM B3359 for cross-hatch adhesion of 5B.

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

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

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

* + - 1. SOURCE QUALITY CONTROL
				1. AHRI Compliance:

Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.

Retain first subparagraph below for units with cooling capacities in excess of 65,000 Btu/h.

Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.

Comply with AHRI 270 for testing and rating sound performance for RTUs.

Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

* + - * 1. AMCA Compliance:

Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.

Damper leakage tested according to AMCA 500-D.

Operating Limits: Classify according to AMCA 99.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
				2. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
				3. Examine roofs for suitable conditions where RTUs will be installed.
				4. Proceed with installation only after unsatisfactory conditions have been corrected.
			2. INSTALLATION

See the Evaluations for discussion of concrete inside curbs.

Install normal-weight, 3000-psi, compressive strength (28-day) concrete mix inside roof curb, **[4 inches] <Insert dimension>** thick. Concrete, formwork, and reinforcement are specified with concrete.

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 wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

Retain "Equipment Mounting" paragraph below to require equipment to be installed on cast-in-place concrete equipment bases.

* + - * 1. Equipment Mounting:

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 type and minimum deflection in supported equipment in "Capacities and Characteristics" Article or in 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."

* + - 1. PIPING CONNECTIONS

Coordinate piping installations and specialty arrangements with Drawings and with requirements specified in piping and duct 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 RTU, allow space for service and maintenance.
				3. Connect piping to unit mounted on vibration isolators with flexible connectors.

Verify condensate drainage requirements of authorities having jurisdiction.

* + - * 1. Connect condensate drain pans using **[NPS 1-1/4] <Insert pipe size>**, 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.

Retain "Gas Piping" subparagraph below for RTUs with gas-fired heating.

* + - * 1. Gas Piping: Comply with applicable requirements in **[Section 231123 "Facility Natural-Gas Piping."] [Section 231126 "Facility Liquefied-Petroleum Gas Piping."]** Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
				2. 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.
				3. 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.
				4. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
			1. DUCT CONNECTIONS
				1. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

Install ducts to termination at top of roof curb.

Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.

Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

Install return-air duct continuously through roof structure.

* + - 1. ELECTRICAL CONNECTIONS
				1. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
				2. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
				3. Install electrical devices furnished by manufacturer, but not factory mounted, according to 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 to Section 260553 "Electrical Identification" 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 as layers of black with engraved white letters at least 1/2 inch high.

Locate nameplate where easily visible.

* + - 1. CONTROL CONNECTIONS
				1. Install control and electrical power wiring to field-mounted control devices.
				2. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."
			2. FIELD QUALITY CONTROL

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 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 tests and inspections **[ with the assistance of a Company Field Advisor per OGS Spec Section 014216]**.
				2. Tests and Inspections:

After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.

Inspect for and remove shipping bolts, blocks, and tie-down straps.

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

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

* + - * 1. RTU will be considered defective if it does not pass tests and inspections.
				2. Prepare test and inspection reports.
			1. STARTUP SERVICE
				1. **[Engage a Company Field Advisor per OGS Spec Section 014216 to perform] [Perform]** startup service.

Complete installation and startup checks according to manufacturer's written instructions.

Inspect for visible damage to unit casing.

Inspect for visible damage to furnace combustion chamber.

Inspect for visible damage to compressor, coils, and fans.

Inspect internal insulation.

Verify that labels are clearly visible.

Verify that clearances have been provided for servicing.

Verify that controls are connected and operable.

Verify that filters are installed.

Clean condenser coil and inspect for construction debris.

Retain first two subparagraphs below for gas-fired RTUs.

Clean furnace flue and inspect for construction debris.

Connect and purge gas line.

Remove packing from vibration isolators.

Retain first subparagraph below for barometric relief dampers.

Inspect operation of barometric relief dampers.

Verify lubrication on fan and motor bearings.

Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

Adjust fan belts to proper alignment and tension.

Start unit according to manufacturer's written instructions.

Start refrigeration system.

Do not operate below recommended low-ambient temperature.

Complete startup sheets and attach copy with Contractor's startup report.

Inspect and record performance of interlocks and protective devices; verify sequences.

Operate unit for an initial period as recommended or required by manufacturer.

Retain first subparagraph below for gas-fired RTUs.

Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency:

Measure gas pressure on manifold.

Inspect operation of power vents.

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.

Calibrate thermostats.

Adjust and inspect high-temperature limits.

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

Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

Coil leaving-air, dry- and wet-bulb temperatures.

Coil entering-air, dry- and wet-bulb temperatures.

Outdoor-air, dry-bulb temperature.

Outdoor-air-coil, discharge-air, dry-bulb temperature.

Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.

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

Supply-air volume.

Return-air volume.

Relief-air volume.

Outdoor-air intake volume.

Simulate maximum cooling demand and inspect the following:

Compressor refrigerant suction and hot-gas pressures.

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

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

High-temperature limit on gas-fired heat exchanger.

Low-temperature safety operation.

Filter high-pressure differential alarm.

Economizer to minimum outdoor-air changeover.

Relief-air fan operation.

Smoke and firestat alarms.

After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

* + - 1. ADJUSTING
				1. Adjust damper linkages for proper damper operation.
				2. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
				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 and testing, adjusting, and balancing RTUs and air-distribution systems, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.
			3. FIELD QUALITY CONTROL

Retain one of first three paragraphs below.

Retain "Testing Agency" paragraph below to require Contractor to hire an independent testing agency.

* + - * 1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

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 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 tests and inspections**[ with the assistance of a Company Field Advisor per OGS Spec Section 014216**
				2. Tests and Inspections:

After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.

Inspect for and remove shipping bolts, blocks, and tie-down straps.

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

Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

* + - * 1. RTU will be considered defective if it does not pass tests and inspections.
				2. Prepare test and inspection reports.
			1. DEMONSTRATION
				1. **[Engage a Company Field Advisor per OGS Spec Section 014216 to train] [Train]** Facility’s maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.11