

SECTION 23 7416 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

Maintain Section format, including the UH master spec designation and version date in bold in the center columns of the header and footer. Complete the header and footer with Project information.

Edit and finalize this Section, where prompted by Editor's notes, to suit Project specific requirements. Make selections for the Project at text identified in bold.

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

Delete hidden text after this Section has been edited for the Project.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor's attention is specifically directed, but not limited, to the following documents for additional requirements:
 - 1. The current version of the *Uniform General Conditions for Construction Contracts*, State of Texas, available on the web site of the Texas Facilities Commission.
 - 2. The University of Houston's *Supplemental General Conditions and Special Conditions for Construction*.

1.2 SUMMARY

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

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

- A. Product Data: For each RTU.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include full load and part load unit energy performance with **[scheduled ambient air temperature.]****[Insert ambient air temperature.]**
 - 5. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 6. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - 7. Include certified coil-performance ratings with system operating conditions indicated.
 - 8. Include filters with performance characteristics.
 - 9. Include gas furnaces with performance characteristics.
 - 10. Include dampers, including housings, linkages, and operators.
 - 11. Include product data on all special coatings.
 - 12. Include controls equipment and accessories.
 - 13. Include sound power ratings of RTU including radiated, discharge and intake sound power levels.
- B. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
 - 3. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
- C. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning units.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Include diagrams for power, signal, and control wiring.
- D. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 3. Wind-Restraint Details: Detail fabrication and attachment of wind restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty and special warranty.
- C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Source quality-control reports.
- E. System startup reports.
- F. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: [**One**] set(s) of filters for each unit.
 - 2. Gaskets: [**One**] set(s) for each access door.
 - 3. Fan Belts: [**One**] set(s) for each belt-driven fan.
 - 4. Filters: [**One**] set(s) of filters for each unit.

1.8 WARRANTY

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AAON.
 - 2. Carrier Corporation; a unit of United Technologies Corp.
 - 3. Daikin Applied.
 - 4. Trane.
 - 5. YORK; a Johnson Controls company.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE 15 Compliance: For refrigeration system safety.

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- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
 - 1. Design RTU supports to comply with wind performance requirements.
- G. Wind-Restraint Performance: See Structural Drawings for wind speed, classification category and minimum loading.

Coordinate with basis of design manufacturer. Casing performance may vary by manufacturer.

- H. Casing Structural Performance: Floor, walls and roof capable of withstanding 6 inches water column of internal static pressure without exceed a deflection of $[L/240]$ of span.
- I. Casing Leakage Performance: One and half percent of supply air flow at 1 inch water column of internal negative pressure.
- J. Casing Thermal Performance: Overall cabinet R-Value shall not exceed **[R-8.]****[R-13.]** Overall R-Value shall be calculated using ASHRAE methods and shall consider effects of metal to metal contact and thermal bridging.

Coordinate with basis of design manufacturer. All manufacturers can cool down to 50 degrees F on the base unit. Digital compressor allows cooling down to 35 degrees F. Added cost to provide cooling down to 0 degrees F.

- K. Low Ambient Operation: Operation of mechanical cooling down to **[50 degrees F.]** **[35 degrees F.]** **[0 degrees F.]**
- L. Vibration Isolation: Internally isolate all motor driven equipment. Comply with Requirements in ASHRAE Handbook, Chapter 49, Table 47.

2.3 UNIT CASINGS

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Double-Wall Construction:
 - 1. Outside Casing Wall: G-90 coated galvanized steel, minimum **[22 gauge]****[Insert alternative gauge thickness]** thick with factory-painted finish and corrosion-resistant coating.
 - a. Pitched roof panels with overhang above access doors.

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- b. Penetration Seals: Knockouts with grommet seals for electrical and piping connections
- c. Lifting lugs.
- d. Floor Openings: Protected with upturned flange to prevent water drainage.

Minimum gauges have been listed below. Consult basis of design manufacturer to confirm gauge thickness for each project.

- 2. Inside Casing Wall: G90-coated galvanized steel, **[22 gauge]****[Insert alternative gauge thickness]** minimum thick.
- 3. Floor Plate: G-90 coated galvanized steel, minimum **[22 gauge]****[Insert alternative gauge thickness]** minimum thick.
- 4. Base Rail: G-90 coated galvanized steel, minimum **[14 gauge]****[Insert alternative gauge thickness]** minimum thick.
- 5. Casing Insulation:
 - a. Materials: Injected polyurethane foam insulation.
 - b. Casing Panel R-Value: Minimum **[R-8]**.
 - c. Insulation Thickness: 2 inches.
 - d. Insulation Density: Minimum 2 pounds per cubic foot.
 - e. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
- C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. Panels and Doors:
 - 1. Access Doors:
 - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - b. Fasteners: Lockable handle for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - 1) Where access door is not opened against air-pressure differential, provide safety chain to prevent uncontrolled opening of access door.
 - c. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge.
 - d. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - e. Size: Sufficient size and location to permit internal access for inspection and service of all internal components.
- E. Condensate Drain Pans: Double wall, insulated, stainless-steel sheet and complying with ASHRAE 62.1 for design and construction of drain pans
 - 1. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

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2. Width: Entire width of water producing device.
3. Depth: A minimum of 2 inches deep.
4. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

F. Outdoor-Air Intake and Exhaust Weather Hoods: Outdoor-air intake hood with moisture eliminator if required to eliminate moisture from entering the unit.

1. Material: Match adjacent casing.
2. Coatings: Match adjacent casing.
3. Provide [bird screen][insect screen] over opening.

2.4 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Supply-Air Fans:

1. Type: Unhoused, centrifugal, plenum fan with airfoil blades.
2. Fan Materials: Aluminum, galvanized- or painted-steel
3. Drive: Direct-Driven.
4. Vibration: Dynamically balanced to comply with AMCA 204, BV-3 or better.
5. Variable speed via electronically commutated motor or variable-frequency controller.

C. Exhaust-Air Fans:

1. Type: Unhoused, centrifugal, plenum fan with airfoil blocks.
2. Fan Materials: Aluminum, galvanized- or painted-steel
3. Drive: Direct-Driven.
4. Vibration: Dynamically balanced to comply with AMCA 204, BV-3 or better.
5. Variable speed via electronically commutated motor or variable-frequency controller.

D. Relief-Air Fans:

1. Type: Unhoused, centrifugal, plenum fan with airfoil blocks.
2. Fan Materials: Aluminum, galvanized- or painted-steel
3. Drive: Direct-Driven.
4. Vibration: Dynamically balanced to comply with AMCA 204, BV-3 or better.
5. Variable speed via electronically commutated motor or variable-frequency controller.

E. Condenser Fans: Variable-speed, direct-drive, propeller, mounted on shaft of permanently lubricated motors.

F. Vibration Isolation: All fan/motor drive assemblies resiliently mounted with vibration isolation to reduce vibration transmitted to building structure.

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- G. Fan Bearings: Heavy-duty, self-aligning, pillow-block type with an L-10 rated life of minimum 200,000 hours according to ABMA 9.
- H. Shaft Lubrication Lines: Extended to a location outside the casing.
- I. Motors:
 - 1. Comply with Section 23 0400 "Motors and Controllers" and the requirements of this Paragraph.
 - 2. Motor Sizes: Minimum size as indicated on Drawings.
 - 3. Motor Type: Variable speed via electronically commutated or variable frequency controller.
 - 4. Service Factor: 1.15.
 - 5. Efficiency: Premium efficient.
 - 6. Enclosure:
 - a. Supply-Air Fan Motors: ODP or TEFC
 - b. Exhaust-Air Fan Motors: ODP or TEFC.
 - c. Relief-Air Fan Motors: ODP or TEFC.
 - d. Condenser Fan Motors: TEAO, TEFC or TENV.
 - 7. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.5 ENERGY WHEEL

- A. Casing:
 - 1. Galvanized steel, stainless steel, or aluminum with manufacturer's standard factory finish.
 - 2. Integral purge section.
 - 3. Casing seals on periphery of rotor, on duct divider, and on purge section.
 - 4. Support vertical rotors on grease-lubricated ball bearings with extended grease fittings. Mount horizontal rotors on tapered roller bearing.
- B. Rotor: Segmented wheel, strengthened with radial spokes.
- C. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10 rated life of minimum 200,000 hours according to ABMA 9.
- D. Controls:
 - 1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - 2. 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

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- temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
- 3. Control energy recovery to permit air economizer operation.
 - a. Bypass dampers to assist energy recovery control.
- 4. Pilot-Light Indicator: Display rotor rotation and speed.
- 5. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
- 6. Defrost cycle.

2.6 COILS

A. General Requirements for Coils:

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

Confirm coil construction with basis of design manufacturer. Copper fins and stainless-steel coil casings may not be available from all manufacturers.

B. Supply-Air Refrigerant Coil:

- 1. Tubes: Copper.
- 2. Fins: **[Copper]** [or] **[Aluminum]**.
- 3. Fin and Tube Joints: Mechanical bond.
- 4. Headers: Seamless-copper headers with brazed connections.
- 5. Frames: **[Galvanized steel]** [or] **[Stainless steel]**.
- 6. Coatings: **[None]** **[Corrosion-resistant coating]**.
- 7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

C. Hot-Gas Reheat Refrigerant Coil:

- 1. Tubes: Copper.
- 2. Fins: **[Copper]** [or] **[Aluminum]**.
- 3. Fin and Tube Joints: Mechanical bond.
- 4. Headers: Seamless-copper headers with brazed connections.
- 5. Frames: **[Galvanized steel]** [or] **[Stainless steel]**.
- 6. Coatings: **[None]** **[Corrosion-resistant coating]**.
- 7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
- 8. Suction-discharge bypass valve.

D. Electric-Resistance Heating Coils: Comply with UL 1995.

1. 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.
2. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
3. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
4. Control Panel: Unit mounted with disconnecting means and overcurrent protection.
 - a. Magnetic contactor.
 - b. Solid-state, step-less pulse controller.
 - c. Toggle switches, one per step.
 - d. Step controller.
 - e. Time-delay relay.
 - f. Pilot lights, one per step.
 - g. Airflow proving switch.

2.7 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
 1. Where only one compressor is provided, the compressor shall be variable speed. Where multiple compressors are provided, at least one compressor shall be variable speed.
 2. Unit shall be able to operate between 15 to 100 percent of capacity listed on Drawings.
- B. Refrigerant Condenser Coils Coil:
 1. Type: [**Microchannel**][or][**Tube and fin coil**].
 2. Leak Test: Helium-leak tested.
 3. Coatings: [**None**] [**Corrosion-resistant coating**].
 4. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 5. Designed for a minimum of 10 degrees F of refrigerant sub-cooling.
- C. Refrigeration Specialties:
 1. Refrigerant: R-410A.
 2. Refrigeration circuits: 2 or more.
 3. Expansion valve with replaceable thermostatic element for each circuit.
 4. Refrigerant filter/dryer.
 5. Manual-reset high-pressure safety switch.
 6. Automatic-reset low-pressure safety switch.
 7. Minimum off-time relay.
 8. Automatic-reset compressor motor thermal overload.
 9. Brass service valves installed in compressor suction and liquid lines.
 10. Oil separator.
 11. Low ambient kit.

2.8 AIR FILTRATION

A. Panel Filters:

1. Description: Pleated panel filter.
2. Filter Unit Class: UL 900 Class 2.
3. Media: Synthetic blend of fibers arranged in pleats that are attached to a supported by a corrosion resistant welded wire guide.
4. Initial Resistance: 0.31 inches water column at 500 feet per minute air velocity/
5. Minimum Efficiency: Average efficiency of 25 to 30 percent, according to ASHRAE 52.1
6. Minimum MERV: 8, according to ASHRAE 52.2

B. Cartridge Filters:

1. Description: Mini-pleated V-bank filter.
2. Filter Unit Class: UL 900 Class 2.
3. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
4. Initial Resistance: 0.31 inches water column at 500 feet per minute air velocity/
5. Minimum Efficiency: Average efficiency of 90 to 95 percent, according to ASHRAE 52.1
6. Minimum MERV: 14, according to ASHRAE 52.2

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

2.9 GAS FURNACES

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

B. CSA Approval: Designed and certified by and bearing label of CSA.

C. Burners:

1. Construction: Stainless steel.
2. Rated Minimum Turndown Ratio: **[30 to 1]**.
3. Fuel: Natural gas.
4. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
5. Gas Control Valve: **[Single stage] [Two stage] [Modulating]**.
6. 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.

D. Heat-Exchanger and Drain Pan: Stainless steel.

E. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

F. Safety Controls:

1. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.

2.10 DAMPERS

A. Leakage Rate:

1. Comply with ASHRAE/IES 90.1.
2. Not to exceed 4 cfm per square foot at 1 inch water column per AMCA 500.

B. Damper Motor: Electronic, modulating with adjustable minimum position.

C. Material: Aluminum, stainless steel or coated galvanized steel.

D. Provide dampers at [**outdoor air**], [**exhaust air**], [**relief air**][**and**][**supply air**]openings.

2.11 ELECTRICAL POWER CONNECTIONS

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

2.12 CONTROLS

A. Unit Controls: Refer to Sequence of Operations on Drawings for requirements.

B. DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:
 - a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
 - b. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 28 31000 "Addressable Fire-Alarm Systems."
 - c. Phase-loss reversal protection.
 - d. High and low pressure control.
3. Scheduled Operation:
 - a. Controller shall be equipped with a programmable controller capable of occupied and unoccupied periods on seven-day, 365 days per year clock.
 - b. Coordinate with Owner on operating schedules.

4. Airflow Measurement:
 - a. Provide airflow measurement for [**outdoor air**], [**exhaust air**], [**relief air**][**and**] [**supply air**] discharge or intakes.
 - b. Airflow measuring station and transmitter shall have a maximum accuracy of plus or minus 5 percent with 15 to 100 percent of design airflow.

C. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet compatible interface for central HVAC control workstation for the following:
 - a. Adjusting set points.
 - b. Monitoring supply fan start, stop, and operation.
 - c. Inquiring data to include damper position, supply- and room-air temperature and humidity.
 - d. Monitoring occupied and unoccupied operations.
 - e. Monitoring constant and variable motor loads.
 - f. Monitoring variable-frequency drive operation.
 - g. Monitoring cooling load.
 - h. Monitoring economizer cycles.
 - i. Monitoring air-distribution static pressure and ventilation air volume.
4. Refer to Drawings for additional requirements.

2.13 ROOF CURBS

- A. Wind Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with Project requirements regarding wind loading.
- B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C1071, Type I or II.
 - b. Thickness: 1-1/2 inches.
 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C916, Type I.

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- b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C916, Type I.
- C. Curb Dimensions: Height of **[14 inches]** **[16 inches]** **[18 inches]**.

2.14 ACCESSORIES

- A. Electric heater with integral thermostat maintains minimum 50 deg F temperature in gas burner compartment.
- B. Duplex, 115-V, ground-fault-interrupter outlet with 20-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

[Confirm availability of vapor-proof light fixtures with basis of design manufacturer.](#)

- C. Service Light: **[Vapor-proof]** Fixture with switched junction box in weatherproof enclosure located outside adjacent to door. Provide service light in each access section.
- D. Low-ambient kit.
- E. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- F. Remote potentiometer to adjust minimum economizer damper position.
- G. Factory- or field-installed demand-controlled ventilation.
- H. Safeties:
 - 1. Smoke detector.
 - 2. Condensate overflow switch.
 - 3. Phase-loss reversal protection.
 - 4. High and low pressure control.
 - 5. **[Gas furnace]** **[Electric coil]** airflow-proving switch.
- I. Hail guards of galvanized steel, painted to match casing. Provide hail guards for condenser fan assembly and condenser coils.
- J. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.]

- K. Door switches to disable heating or reset set point when open.
- L. Outdoor air intake weather hood[**with moisture eliminator**].

2.15 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: ASTM B209.

Coordinate salt-spray rating with Project Manager and RTU manufacturer. Manufacturers' have varying salt-spray ratings for the standard finish.

- E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a [600][750][2500][4000]-hour salt-spray test according to ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb.
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
 - 2. Application: Immersion.
 - 3. Thickness: 1 mil .
 - 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.16 SOURCE QUALITY CONTROL

- A. AHRI Compliance:
 - 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.

AHRI 210/240 is applicable for units with cooling capacities less than 65,000 Btu/h.

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

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Fan performance tested in accordance with AMCA 210.
3. Fan vibration in accordance with AMCA 204.
4. Damper leakage tested in accordance with AMCA 500-D.
5. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

Keep paragraph below for installations on a roof curb.

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 07 7200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.

Keep paragraph below for installations on a concrete housekeeping pad.

- B. Equipment Mounting:
 1. Install RTUs on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- C. Comply with requirements for vibration isolation devices specified in Section 23 0548 "Vibration Isolation."

3.3 PIPING CONNECTIONS

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

Keep paragraph below when gas piping is needed.

- E. Gas Piping: Comply with applicable requirements in [Section 23 1123 "Facility Natural-Gas Piping."] Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination at top of roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 23 3114 "Ductwork Accessories."
 - 4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring according to Section 26 0519 "Insulated Conductors, Cables, Wires and Terminations."
- B. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

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- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 26 0553 "Identification for Electrical Systems."
 - 2. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Division 26.

3.7 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions.
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to furnace combustion chamber.
 - 3. Inspect for visible damage to compressor, coils, and fans.
 - 4. Inspect internal insulation.
 - 5. Verify that labels are clearly visible.
 - 6. Verify that clearances have been provided for servicing.
 - 7. Verify that controls are connected and operable.
 - 8. Verify that filters are installed.
 - 9. Clean condenser coil and inspect for construction debris.
 - 10. Clean furnace flue and inspect for construction debris.
 - 11. Connect and purge gas line.
 - 12. Remove packing from vibration isolators.
 - 13. Verify lubrication on fan and motor bearings.
 - 14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 15. Adjust fan belts to proper alignment and tension.
 - 16. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.
 - 17. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 18. Operate unit for an initial period as recommended or required by manufacturer.
 - 19. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.

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- c. Measure combustion-air temperature at inlet to combustion chamber.
 - d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
20. Calibrate thermostats.
 21. Adjust and inspect high-temperature limits.
 22. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
 23. Start refrigeration system and measure and record the following when ambient is a minimum of 15 degrees F above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
 24. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 25. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
 26. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
 27. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
 - a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and fire alarm interfaces and safeties.
 28. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.8 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

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

3.10 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. RTU will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs. Provide a minimum of [24] hours of training for Owner's maintenance personnel.

END OF SECTION 23 7416.13