

SECTION 237439 - PACKAGED, OUTDOOR, UNITARY AIR-CONDITIONERS

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. Control equipment and sequence of operation are specified in Division 23 Section[s] "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls".
- C. General wind restraint requirements are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment".

1.2 SUMMARY

- A. This Section includes packaged outdoor unitary air conditioners with the following components and accessories:
 - 1. Direct-expansion cooling.
 - 2. Gas furnace.
 - 3. Hot gas reheat coil.
 - 4. Economizer outdoor- and return-air damper section.
 - 5. Integral temperature controls.
 - 6. Roof curbs.

1.3 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. Prepare the following by or under the supervision of a qualified professional engineer:
 - 1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
 - 2. Detail mounting, securing, and flashing of unit to support frame or base. Indicate coordinating requirements with roof membrane system.
 - 3. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Duct and unit layout and relationships between components and adjacent structural and mechanical elements.
 - 2. Structural members to which units will be attached.
 - 3. Roof openings
 - 4. Roof curbs and flashing. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
- B. Condensate Traps: Prepare a schedule detailing the necessary trap dimensions (trap seal depth and net 'fall') for each unit, based on the predicted maximum static pressure in the cabinet at the location of each trap, including the effect of loaded filters. The schedule shall detail unit tag, unit size, appropriate trap schematic with the recommended trap dimensions, and unit supplied base rail height.
- C. Field Quality Control Test Reports: Include startup report and functional testing report indicating and interpreting test results relative to compliance with specified requirements. Indicate results of startup and testing requirements. Submit copies of checklists.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For rooftop air conditioners to include in emergency, operation, and maintenance manuals.
- B. Warranties: Special warranties specified in this Section.

1.6 QUALITY ASSURANCE

- A. Factory Engineering: Except where explicitly permitted by these Specifications or the Drawings, no field- or contractor shop-modifications of the factory-engineered equipment package will be acceptable. No modifications that affect the unit's UL listing will be acceptable. No modifications made in a 3rd party factory (i.e. one other than that of the equipment manufacturer) will be acceptable.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance:
 - 1. Comply with UL 1995.
 - 2. Comply with UL 60335-2-40 for refrigerant leak detectors and controls.
- D. Comply with NFPA 70 for components and installation.

- E. NEMA Compliance: Provide motors required as part of air conditioning units that are listed and labeled by UL and comply with applicable NEMA standards.
- F. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- G. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- H. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- I. Comply with NFPA 54 for gas-fired furnace section.
- J. AHRI Certification: Units shall be AHRI certified and listed.
- K. AHRI Compliance:
 - 1. Comply with AHRI 210/240 or AHRI 340/360 for testing and rating energy efficiencies for packaged unitary equipment.
 - 2. Comply with AHRI 270 for testing and rating exterior sound performance.
 - 3. DX cooling and ratings shall be in accordance with AHRI-410.
- L. Comply with AMCA 320 for testing and rating sound performance of airstream fans.
- M. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

1.7 COORDINATION

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- B. Coordinate layout and installation of units with piping, ductwork, and other installations.
- C. Coordinate the controls scope of work between the DDC system supplier and the factory control package specified with the unit.
- D. Coordinate the quantity, supply voltage, amperage, and phase of electrical connections with the Division 26 Contractor.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. The manufacturer shall deliver products to site on a factory-installed base rail or shipping skid and ship units by truck with 10 mil poly shrink wrap enclosing the entire unit (covering unit openings only is not acceptable).
- B. Lift and support units with manufacturer's designated lifting or supporting points.

1.9 WARRANTY

- A. General Warranty: The manufacturer shall warrant all equipment for a period of one (1) year from date of substantial completion. Extended warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Extended Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of rooftop air conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Extended Warranty Period for Compressors: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.
 - 2. Extended Warranty Period for Furnace Heat Exchangers: Manufacturer's standard, but not less than five (5) years from date of Substantial Completion.

1.10 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Belts: One (1) set for each belt-drive fan.
 - 2. Filters: Two (2) sets of filters for each unit.
 - 3. Provide an allowance for one sheave and one belt change for each unit during balancing procedures.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Corp. (BASIS OF DESIGN)
 - 2. Johnson Controls Inc. / York
 - 3. Trane, a Div. of Ingersoll Rand
 - 4. Tempmaster; a Division of Johnson Controls Inc.

2.2 OPERATING CONDITIONS

- A. Outdoor Ambient Temperature Tolerance Range:
 - 1. Construct the units to tolerate operation in an outdoor air temperature as high as 105 deg. F. Provide a high ambient package as required to accommodate this

range. De-rating below the scheduled capacity and efficiency is acceptable at the high ambient temperature.

- a. The outdoor ambient temperature for rating the unit capacity and efficiency shall be as scheduled on the Drawings or 105 deg. F., whichever is higher.

2.3 PACKAGED OUTDOOR UNITARY AIR CONDITIONING UNITS

- A. Provide packaged air conditioning units and control systems for exterior installations as shown and scheduled on the contract documents. The units shall be installed in accordance with this specification and perform at the specified conditions as scheduled.
- B. Units shall consist of insulated weather-tight casing with compressors, air-cooled condenser coil, condenser fans, evaporator coil, air filters, economizer, motors and unit controls and drives, and all other features specified herein or indicated on the Drawings.
 1. Unit shall be 100% factory run tested and fully charged with R-32 or R-454B refrigerant.
 - a. Equipment utilizing Class A2L refrigerants shall be listed and conform to UL 60335-2-40 or ASHRAE 15 (latest editions), whichever is more demanding, and shall include factory-provided, UL listed refrigerant leak detection systems and related controls and output devices (e.g. valves, relays, etc.) to produce the required automatic mitigation response by the system/equipment when a leak above the detection threshold limit value is detected. The Contractor shall field install any detection system control devices, refrigerant sensors, wiring, and conduit that is not factory installed.
 2. Unit shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
 3. Units shall be dedicated down-flow as indicated on the Drawings.
 4. Wiring internal to the unit shall be colored and numbered for identification.
- C. Cabinet: Galvanized steel, phosphatized, and finished with an air-dry paint coating with removable access panels. Structural members shall be 16 gauge with access doors and removable panels of minimum 20 gauge.
 1. Units cabinet surface shall show no visible effects at 600 hours in salt spray test in compliance with ASTM B117.
 2. Cabinet construction shall allow for all service/ maintenance from one side of the unit.
 3. Cabinet top cover shall be one-piece construction or where seams exits, it shall be double-hemmed and gasket-sealed.
 4. Access Panels: Water- and air-tight panels with handles shall provide access to filters, heating section, return air fan section, supply air fan section, evaporator coil section, and unit control section.
 5. Downflow unit's base pans shall have a raised 1 1/8-inch-high lip around the supply and return openings for water integrity.
 6. Insulation: Provide minimum 3/4-inch thick, 1.0 PCF density foil or neoprene faced fiberglass or expanded in place polyurethane foam insulation on side and roof

- panels in contact with the return and conditioned air stream. The unit base shall be insulated with 1/2" thick water impervious, closed cell insulation.
7. Provide openings through the base for power, control and gas connections.
 8. The base of the unit shall have provisions for forklift and crane lifting.
- D. Wind Resistance: The unit and curb assembly shall be factory-engineered and tested to resist wind loads in accordance with the 2018 International Building Code and ASCE Standard 7, as per the project location, Exposure Category B, and a Building Risk Category of III, without the use of supplemental straps or hold downs.
1. Units shall resist the greater of the following:
 - a. 3-Second Gust Design Wind Speed per ASCE Std. 7 - 2016.
 - b. 16 lb./sq. ft. multiplied by maximum area of equipment projected on vertical plane normal to wind direction, and 45 degrees either side of normal.
 2. Units that have been approved for use in Miami-Dade County, with a current NOA number, having successfully passed TAS 202 (Uniform Static Air Pressure Test), are also acceptable for meeting the wind resistance provisions above.
- E. Air Filters: Factory installed filters shall mount integral within the unit and shall be accessible through access panels. Provide two (2) sets of [2]-inch thick, MERV-8 efficient panel type filters in addition to those provided as 'extra materials'. Replace construction phase filters after final clean-up with the 2nd set.
- F. Fans and Motors:
1. Provide evaporator supply fan section with forward curved, double width, double inlet, or backward inclined inle inlet plenum type centrifugal fan.
 2. Provide self-aligning, grease lubricated, ball or sleeve bearings with permanent lubrication fittings.
 3. Provide unit with belt driven, supply fans with adjustable motor sheaves or direct drive supply fans with an ECM motor with an integral, adjustable speed control.
 4. Outdoor and indoor fan motors shall be permanently lubricated and have internal thermal overload protection.
 5. Outdoor condenser coil fans shall be direct drive, statically and dynamically balanced, draw through in the vertical discharge position.
 6. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
 7. Entire fan assemblies shall be mounted on factory installed and engineered spring or rubber-in-shear vibration isolators.
- G. Gas Fired Heating Section:
1. Completely assembled and factory installed heating system shall be integral to unit, UL or CSA approved specifically for outdoor applications for use downstream from refrigerant cooling coils. Threaded connection with plug or cap provided. Provide capability for gas piping through the side of the unit. The furnace shall be designed to operate with gas pressures between 7" w.c. and 14" w.c.
 2. Heating section shall be factory run tested prior to shipment.

3. Gas Burner shall be forced combustion type power burner, negative pressure gas valve, manual shut-off, hot surface ignition, and flame sensing safety control.
4. Gas Burner Safety Controls: Provide safety controls for the proving of combustion air prior to ignition, and continuous flame supervision. Upon a failure to ignite, two attempts of ignition will occur before lockout of the ignition system.
5. Combustion blower shall be centrifugal type fan with built- in thermal overload protection on fan motor.
6. Heat Exchanger: Provide drum and tube heat exchanger of free floating design manufactured from 18-gauge aluminized steel Type 409 stainless steel or Type 321 stainless steel, factory pressure and leak tested.
7. Limit controls: High temperature limit controls will shut off gas flow in the event of excessive temperatures resulting from restricted indoor airflow or loss of indoor airflow.
8. Flue Extension Kit: Factory-furnished to extend furnace combustion gasses no less than 2 feet above the unit outdoor air intake. The termination shall prevent the entry of precipitation and debris.
9. Output Control: Furnace shall be modulating with a minimum 4:1 turndown

H. Evaporator Coil:

1. Provide configured aluminum fin surface mechanically bonded to copper tubing coil.
2. Provide an independent expansion device for each refrigeration circuit. Factory pressure test at 450 psig and leak test at 200 psig.
3. Air Conditioning Condensate Drain Pans: Provide cooling coil drain pan that is sufficient to contain coil condensate. Pans shall be constructed of type 304 stainless steel or plastic or galvanized steel with mastic coating and shall meet the requirements of ASHRAE 62 with no un-sloped surfaces. Pans shall be minimum 2" deep and shall have a threaded nipple drain connection..
 - a. Drain pan shall be double wall with an R-value of 12 hr-ft²-°F/BTU. The entire area of the drain pan shall have this level of thermal performance.
 - b. Provide an intermediate drain pan on stacked cooling coils over 48" tall. Intermediate drain pan shall slope in a minimum of two planes toward a single drain connection. Provide copper tube downspouts to primary pan at the bottom of the unit.
 - c. Drain piping shall be constructed of HDPE pipe with socket fusion type fittings. Terminate piping over a 4-inch thick solid concrete splash block with underlying rubber pad on the roof.

I. Condenser Section:

1. Provide internally finned seamless copper tube mechanically bonded to aluminum fins or aluminum microchannel tube with aluminum fins. Factory pressure test to 450 psig.
2. Provide vertical discharge, direct drive fans with aluminum blades. Fans shall be statically balanced. Motors shall be permanently lubricated, with integral thermal overload protection in a weather tight casing.
3. Provide the manufacturer's factory hail guard accessory. Hail guard shall be fabricated of galvanized steel, and factory finished to match the unit casing.

J. Refrigeration System:

1. Compressors: Provide direct-drive hermetic, scroll type compressors with centrifugal oil pump providing positive lubrication to moving parts, internal suction and discharge valves, and a crankcase heater. Motor shall be suction gas-cooled with internal temperature and current sensitive motor overloads. A pair of service isolation valves, external high pressure cutout and low pressure switches, and phase-loss monitors, shall be provided for each compressor.
 - a. Units sized 15 tons and larger shall have a minimum of two (2) independent refrigerant circuits.
 - b. Minimum Number of Compressors and Temperature Control Stages: Two (2) compressor stages.
 - 1) In addition, also provide hot-gas bypass as the minimum capacity stage on the lead compressor. Hot-gas bypass solenoid valve with a replaceable magnetic coil. Hot gas bypass, shall have a capacity not exceeding the limits prescribed by the International Energy Conservation Code
 - a) Hot gas bypass may be omitted if one of the compressors is either a modulating variable speed type or is a digital-type scroll, and the minimum operating capacity of that compressor is no greater than 25% of the unit's total capacity.
 - 2) One compressor is acceptable if the compressor is either a modulating variable speed type or is a digital-type scroll, and the minimum operating capacity of that compressor is no greater than 20% of the unit's total capacity.
2. Phase monitors shall be a three-phase line monitor module that protects against phase loss, phase reversal and phase unbalance, and shall also protect compressors from reverse rotation. The module shall automatically reset from a fault condition.
3. Provide each unit with refrigerant circuits factory-supplied completely piped with liquid line filter-drier, suction and liquid line pressure ports, sight glass, and thermostatic expansion valves. Capillary tubes in lieu of thermostatic expansion valves are not acceptable.
4. Compressors shall be mounted on factory installed and engineered spring or rubber in shear vibration isolators.
5. Water level sensor complying with UL 508 to provide protection against drain pan overflow by sensing a high condensate level in the drain pan, in conformance with the 2018 International Mechanical Code. The sensor shall de-energize the compressors upon detection of a high water level.

- K. Hot Gas Reheat Coil: Fully modulating condenser reheat coil with stepper valve infinite modulating control to either independent condenser re-heat coil or remote condenser. System shall also include receiver(s), sub-cooling condenser circuit(s) and check valves. The reheat coil shall provide no less than 15 degrees F of reheat, or as scheduled on the Drawings, whichever is larger.

L. Outdoor Air Section:

1. Provide a fully integrated field-installed 100% modulating outside air economizer with motorized outside air and return air dampers, minimum position setting, preset linkage, wiring harness with plug. Unit operation is through primary temperature controls that automatically modulate dampers to maintain space temperature conditions.
2. Relief damper shall be barometric (gravity) or motorized type.
3. Provide economizer with comparative enthalpy control. The economizer controls shall meet the requirements of the 2018 International Energy Conservation Code (IECC), including economizer fault detection and diagnostics.
4. Provide adjustable minimum position controls.
5. Provide spring return motor for outside air damper closure during unit shutdown or power interruption.

M. Electrical:

1. Each unit shall be wired and tested at the factory before shipment. Wiring shall comply with NEC requirements and shall conform to all applicable UL standards. All electrical components shall be labeled according to the electrical diagram and shall be UL recognized where applicable. Each unit shall have a 24-volt circuit transformer and control circuit fuse.
2. The unit shall be wired for a single point connection.
3. A main unit non-fused disconnect switch in a NEMA 3R enclosure shall be provided.

2.4 FACTORY PACKAGE TEMPERATURE CONTROLS

- A. The unit shall be provided with a complete factory controls package to govern all primary unit control functions. The controls package shall utilize microprocessor based digital controls. Control sequences integrated into the factory packaged controls shall comply with the 2018 International Energy Conservation Code (IECC).**
- B. Basic Control Requirements: The unit shall be equipped with a complete microprocessor control system. This system shall consist of temperature and pressure (thermistor and transducer) sensors, printed circuit boards (modules), and a Human Interface Panel. The packaged DDC controller shall have volatile-memory backup. The controls shall be factory-installed and mounted in the main control panel. All factory-installed controls shall be fully commissioned (run tested) at the factory. All microprocessors, boards and sensors shall be factory mounted, wired and tested. Modules (boards) shall be individually replaceable for ease of service. The microprocessor boards shall be stand-alone DDC controls not dependent on communications with the building automation system.**
1. **The unit shall have a Human Interface Panel with a minimum 16-key keypad and 2-line x 40-character clear English display as standard to provide the operator with full adjustment and display of control data functions. Graphics-based displays with touchscreens are also acceptable.**

- a. The Human Interface Panel shall be mounted on the unit.
2. The microprocessors shall be equipped with on-board diagnostics, indicating that all hardware, software and interconnecting wiring are in proper operating condition. The modules (boards) shall be protected to prevent RFI and voltage transients from affecting the board's circuits. All field wiring shall be terminated at separate, clearly marked terminal strip.
3. Pressure transducers shall be provided for the suction pressure and head pressure. Temperature sensor shall be provided for the suction temperature and the refrigerant discharge temperature of the compressors. All of the above devices shall be an input to the unit controller and the values be displayed at the unit controller.

C. Control Programs:

1. **Scheduling:** The DDC controller shall have a built-in time schedule. The schedule shall be programmable from the unit keypad or touchscreen interface. The schedule shall be maintained in nonvolatile memory to insure that it is not lost during a power failure. There shall be one start/stop per day and a separate holiday schedule. The controller shall accept up to sixteen holidays each with up to a 5-day duration.
2. **Unoccupied (Standby) Heating and Cooling Program:** The unit shall operate with a minimum outdoor airflow rate of zero (0) cfm in such modes. Outdoor air shall only be introduced for purposes of economizer cooling.
 - a. For the unoccupied temperature control program, provide a space temperature sensor located where indicated on the Drawings and wired back to the unit controller. The operation of cool-down and warm-up modes that are initiated by optimal start algorithms.
3. **Supply Air Temperature Control for Multiple VAV Terminal Unit Applications:** Provide all necessary controls to operate a VAV unit from the unit discharge supply air temperature, including discharge air microprocessor controller and discharge air sensor wired to the unit controls. The microprocessor controller shall coordinate the comparative enthalpy economizer controls and dampers, and all of the available stages of mechanical cooling and heating output to maintain the discharge air temperature at the supply temperature setpoint.
4. **Economizer Control:** The unit controls shall control the economizer cycle by way of comparative enthalpy. Whenever the return air enthalpy is greater than the outdoor air enthalpy, the unit shall operate in economizer mode. Provide temperature and humidity sensors wired to the unit controller on the outdoor and return airstreams.
 - a. The economizer controls shall meet the requirements of the 2018 International Energy Conservation Code (IECC), including economizer fault detection and diagnostics.
5. **Supply Fan Speed Control (Duct Pressure Control) for Multiple VAV Terminal Unit Applications:** The unit controls shall include factory-installed and

tested variable frequency drive(s) (VFD) to provide supply fan motor speed modulation. The VFD(s) shall receive a 0-10VDC signal from the unit microprocessor based upon remote supply duct static pressure signal, which shall cause the drive to accelerate or decelerate as required to maintain the supply static pressure setpoint.

- a. Provide a duct static pressure sensor for control over the supply fan. Locate where indicated on the Drawings and wire to the unit controls.
6. **Supply Fan Over-Pressure Protection:** Provide high supply duct pressure limit switch and a supply fan suction low-limit switches to de-energize the unit fans in the event of ductwork or unit over-pressurization. Whenever the discharge pressure of the supply fan rises above its setpoint, or whenever the suction pressure of the supply fan exceeds its setpoint, the unit fans shall be de-energized and an alarm issued at the operator's workstation.
 7. **Relief (Exhaust) Fan and Building Pressure Control:** The exhaust discharge/relief dampers and relief fan(s) speed shall be modulated in response to building pressure. A differential pressure control system, (Example: Trane's "Statitrac", or Dakin's "Design Flow" systems), shall use a differential pressure transducer to compare indoor building pressure to outdoor ambient atmospheric pressure. The relief fan(s) shall be energized when required to lower building static pressure setpoint. The control system shall then modulate the discharge/relief dampers and relief fan(s) speed to control the building pressure to within a dead band that shall be adjustable at the Human Interface Panel. It is also acceptable to control the relief fan speed only, and for the discharge/relief damper to be a gravity backdraft damper.
 8. **Outdoor Air Measurement and Control:** Measurement and control of the outdoor airflow rate shall meet requirements of ASHRAE 62.1-2016 and the 2018 International Mechanical Code (IMC). An airflow measurement station shall be provided in the outside air opening to measure airflow. The airflow measurement station shall measure from as low as 40 cfm/nominal ton on up to the unit maximum (supply) airflow rate. The airflow measurement station shall adjust for temperature variations / be temperature compensated. Measurement accuracy shall be +/- 10% of reading throughout the full ventilation range of the unit. The outdoor air and return air dampers shall modulate to maintain the desired outdoor airflow rate, as measured by the airflow station in the outdoor air intake, throughout the entire range of supply fan speeds.
 - a. If an airflow measurement package is not available to be factory-furnished with the unit that meets the above requirements, a field applied airflow station shall be provided to meet this requirement, and this field applied work shall comply with the following:
 - 1) Field-install a DDC system controller to receive outdoor airflow signals and to pilot the unit dampers to maintain the required minimum outdoor airflow rate.
 - 2) The outdoor air rate shall be measured via an outdoor air intake mounted outdoor airflow measuring station. The installation of this station shall require modification of the intake louver or rain hood in order to meet all of the clearance and other installation

requirements of the airflow station manufacturer. Submit the proposed modifications with the rest of the equipment submittal and confirmation that the modifications are acceptable to the unit manufacturer. Submittals lacking this information will be rejected.

- 3) During the occupied mode, the outdoor and return air dampers shall be modulated by the DDC system controller to supply ventilation at a rate no less than the minimum outdoor airflow scheduled in the unit schedule. The desired outdoor airflow rate shall be increased above the minimum during economizer cycles, as governed by the packaged unit's temperature / integrated economizer controls. The fully integrated control of the mixing dampers between operating modes shall be seamless.**
- 4) Outdoor airflow measuring stations shall be a thermal dispersion type, Ebtron 'Advantage 3 Gold' series, Flow Monitor Corp. 'Electra-flo G5' series, Johnson Controls 'AD-1272' series, or Ruskin 'TDP05k' series. Comply with all of the manufacturer's installation and clearance requirements and recommendations to ensure accuracy of the station.**
 - a) Calibrated Velocity Range: 0 to 5000 fpm.**
 - b) Accuracy: $\pm 5\%$ of volumetric flow reading, between 0 and 5,000 feet per minute air velocity, with a NIST traceable certificate. Temperature accuracy shall be $\pm 0.15^\circ$ F.**

2.5 MOTORS

- A. Refer to Division 23 Section "Common Motor Requirements for HVAC Equipment" for general requirements for factory-installed motors, including NEMA designation, temperature rating, service factor, and efficiency requirements.**
 - 1. A shaft grounding ring shall be provided on VFD-driven motors as specified in Division 23 Section "Common Motor Requirements for HVAC Equipment" to provide a conductive discharge path away from the motor bearings to ground.**

2.6 ROOF CURBS

- A. Materials: Minimum 16-gauge galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with National Roofing Contractors Association (NRCA) standards. Gasketing shall be provided for field mounting between the unit base and the roof curb. Curbs shall be assembled on the roof prior to unit shipment. The roof curbs shall be perimeter type with complete perimeter support of the unit. Curbs shall be constructed to accommodate the unit ductwork connections and recognize the roof slope and render the top of the curb flat and plumb in each direction. Curbs shall be laterally stable with internal bracing, and shall be constructed to resist the wind forces exerted on the curb by the supported equipment in a design wind as per the project conditions described in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment". Curbs shall be provided with**

a bottom flange suitable for securing the curb to the roof deck / building structural system in order to resist the design wind loads. Provide manufacturer's standard wind restraint curb clips.

1. Curb Insulation and Adhesive: Comply with NFPA 90A.
 - a. Materials: Fibrous glass duct lining type insulation complying with ASTM C 1071, Type I or II.
 - b. Thickness: 2 inches.
 - c. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - 1) Liner Adhesive: Comply with ASTM C 916, Type I.
 - 2) 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.
 - 3) 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.
 - 4) Liner Adhesive: Comply with ASTM C 916, Type I.
2. Curb Height: Minimum 24 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas and conditions, for compliance with requirements for installation tolerances and other conditions affecting installation of units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Examine equipment supports and roof areas for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- B. Install units level and plumb, maintaining manufacturer's recommended service and airflow clearances.
- C. Install controls and equipment shipped by manufacturer for field installation with units.

- D. Roof Curb: Install on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in applicable Division 07 Sections. Secure units to the curb, and secure the curb base flange to roof framing with anchor bolts and supplemental steel members. The installation shall provide the wind resistance required by the International Building Code and Division 23 Section "Hangers and Supports for HVAC".
1. Install roof curbs in such manner as maintain roof bond.
 2. Provide roof opening, flashing, counter-flashing, sealant, roof insulation and structural framing members.
 3. Secure units to roof curbs with stainless steel hardware.
 4. Provide soft neoprene gasketing between the unit base and the top of the curb.
 5. If building roof insulation has been omitted on the roof deck inside the area surrounded by the curb, provide nominal 6" thick (R-19) fiberglass batt insulation with a vapor retarding foil-scrim-kraft (FSK) facing on the roof deck inside the curb. The FSK facing shall be in contact with the deck and shall be stapled and taped to the inside wall of the curb and sealed / taped to all penetrating items (ducts, piping, conduit, etc.).
- E. Install controls and equipment shipped by manufacturer for field installation with units.
- F. Identify units and connections according to Division 23 Section "Identification for HVAC."

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
1. Gas Piping: Comply with applicable requirements in Division 22 Section "Facility Natural Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- C. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
1. Install ducts to termination in roof curb.
 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 3. Connect ducts to rooftop unit with flexible duct connectors as specified in Division 23 Section "Air Duct Accessories."
- D. Electrical System Connections: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.

- E. Ground equipment according to Division 26 provisions.
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 CLEANING

- A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.
- B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
- C. Prior to startup, provide final cleaning of air handling units to remove road debris from interior and exterior of unit. The interior airstream surfaces of the unit shall be oil and grease free and wiped clean with 50-50 mix of denatured alcohol and water.

3.5 FIELD QUALITY CONTROL

- A. Field Service: Perform the following field quality-control tests and inspections and prepare test reports.
 - 1. After installing rooftop air conditioners 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.
 - 5. Verify that the refrigerant leak detection system affects the required mitigation response per UL 60335-2-40 upon detection of a refrigerant leak at the supply air refrigerant coil in the unit.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.

3.6 STARTUP SERVICE

- A. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to furnace combustion chamber.
 - 3. Inspect for visible damage to compressor, air-cooled outside coil, 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 outside coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Adjust vibration isolators.
13. Inspect operation of barometric dampers.
14. Lubricate bearings on fan.
15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
16. Adjust fan belts to proper alignment and tension.
17. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system in summer only.
 - b. Complete startup sheets and attach copy with Contractor's startup report.
18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency. Adjust pilot to stable flame.
 - a. Measure gas pressure on manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
21. Calibrate thermostats and other sensors.
22. Adjust and inspect high-temperature limits.
23. Inspect outside-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outside-air, dry-bulb temperature.
 - d. Outside-air-coil, discharge-air, dry-bulb temperature.
25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. 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. Outside-air intake volume.

27. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through outside coil or from outside coil to outside-air intake.
28. After startup and performance testing, change filters, vacuum heat exchanger and cooling and outside coils, lubricate bearings, adjust belt tension, and inspect operation of power vents.

3.7 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.
- D. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.8 FUNCTIONAL TESTING AFTER START UP

- A. All testing work described in this Article shall verify that the equipment and controls installation work is complete and fully functional / operational. This work is in addition to any commissioning, testing, and demonstration requirements involving the Commissioning Agent, as specified in Commissioning Sections, and shall be completed by the Division 23 Contractor and his sub-contractors and suppliers prior to beginning the formal commissioning process.
- B. Scope and Involved Parties: After installation, cleaning, start-up, and testing, adjusting, and balancing procedures have been satisfactorily completed, each unit installed shall be functionally tested.
 1. All problems encountered during equipment installation, start-up, and air balancing and water balancing shall be completed and debugged before functional testing may begin.
 2. The functional performance tests conducted shall demonstrate that each unit and system is operating according to the documented design intent, sequence of operations, and Contract Documents.
- C. Functional Testing Procedures: The completed unit shall be tested for correct functionality in all operating modes by the above parties. The functional testing shall consist of an in-unit test of the controller, inputs, outputs, safeties, and all aspects of the sequences of operation. All operating modes (occupied, unoccupied, etc.) shall be tested, as are start-up, shut-down, restart after power failure. Proper response to failure

and alarm conditions (e.g. freeze condition, low oil pressure, no flow, equipment failure, etc.) shall also be tested. Also, part of the functional test will be verification of the operation of compressor(s), fan(s), damper and valve actuators, and associated electrical components.

1. The Contractor shall:
 - a. Lead the functional testing effort as part of the DDC system commissioning specified in Division 23 Section "Instrumentation and Control for HVAC".
 - b. Devise the proposed test procedures in advance of the testing and distribute to involved parties.
 - c. Direct the efforts of the Division 23 Contractor and equipment supplier or manufacturer's representative during testing.
 - d. Compose and submit the functional testing report.
 - e. Review the proposed tests for feasibility, safety, and equipment and warranty protection.
 - f. Provide technicians, instrumentation, and tools to facilitate the tests.
 - g. Operate the equipment and systems they have previously installed during the tests.
 - h. Assist in tests of equipment and systems with which their work interfaces.
 - i. Ensure that the manufacturer's representatives have made all project-specific adjustments and settings during equipment start-up to the factory controllers prior to the joint field-commissioning efforts.

2. The equipment manufacturer or supplier representative shall:
 - a. Make all project-specific adjustments and settings during equipment start-up to the factory controllers prior to the joint field-commissioning efforts.
 - b. Provide a minimum of 8 hours of on-site factory technician time (time exclusive of travel to the site) per unit supplied to assist in functional testing, problem solving, and controls integration. This time shall be allocated as directed by the DDC System Sub-Contractor. The equipment representative shall anticipate that one dedicated site visit per unit installed may be required.
 - c. Refer to Division 23 Section "Instrumentation and Control for HVAC" for requirements regarding control integration responsibilities of the equipment manufacturer to the DDC System Contractor.
- D. Functional Testing Report: Report findings during functional testing. Identify testing procedures, problems encountered, corrective measures taken, and final results.

3.9 DEMONSTRATION

- A. Train owner's maintenance personnel as specified below:
 1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 2. Review data in the maintenance manuals.
 3. Schedule training with Owner, through the Architect, with at least 7 days' advance notice.

END OF SECTION 237439