

HIGH PERFORMANCE ROOFTOP UNIT

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PART 1 GENERAL

1.01 SUMMARY

The Offeror shall provide a detailed description of the rooftop unit (RTU) model offered for sale in response to this Solicitation.

To be considered, models offered must have between 120,000 and 240,000 Btu/h of capacity and meet all of the minimum specification requirements listed below. The models offered must also be supplied as compatible with direct digital control and remote diagnostic systems. Requirements listed in the Specifications (below) include standalone controls, capability to interface with major manufacturer control systems, and availability of specific equipment sensing parameters at a "signal access interface." Offers that do not meet the following minimum technical specifications will be deemed unresponsive and will be automatically rejected. Offers that exceed these specifications, on the other hand, will receive favorable consideration, and offerors are requested to indicate how their products exceed them. In addition to meeting the minimum specifications, the successful Offeror(s) shall be responsible for having complied with all applicable federal and state standards, regulations and laws governing these types of air conditioners. This includes compliance with all applicable safety and environmental standards.

- A. Section Includes:
 - 1. Furnishing of packaged air conditioning equipment by RTU manufacturer
 - a. Cooling-only units 10 to 20 tons
 - b. Cooling and heating units 10 to 20 tons
- B. Providing delivery coordination of RTU equipment to job site by RTU manufacturer.
 - 1. Providing installation support by RTU manufacturer.
 - 2. Providing submittals, operating instruction, service manuals and warranty process by RTU manufacturer
- C. Related Sections:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.02 SYSTEM DESCRIPTION, PERFORMANCE REQUIREMENTS:

- A. Design Requirements: Provide products and systems that have been manufactured to the following criteria:
 - 1. Refrigeration system construction of units shall be in accordance with ASHRAE 15.
 - 2. Units shall be designed, manufactured, and tested and listed in accordance with UL 1995 requirements, and shall bear the UL or ETL label.
 - 3. Gas-fired furnace section construction shall be in accordance with UL/ETL safety standards. Furnace section shall bear the UL/ETL label.
 - 4. Refrigerant must have a global warming potential (gwp) no more than 2100 per ASHRAE Fundamentals 2009.
- B. Electrical Characteristics:
 - 1. 60 Hz
 - 2. 3-phase
- C. Cooling Performance:
 - 1. Unit(s) shall have a minimum IEER of 18.0.
 - 2. Unit(s) shall be in accordance with and independently tested to ANSI/AHRI Standard 340/360.
 - 3. The IEER shall be reported along with the EER and supply air conditions for each of the ANSI/AHRI Standard 340/360 2007 test conditions shown in Appendix A.

4. DOE will conduct tests following the ANSI/AHRI Standard 340/360 with a 30% outdoor air ratio and test conditions shown in Appendix A.
 5. As part of the DOE testing the supply fan will experience 0.7 in H₂O external static pressure at design conditions.
 6. Testing will occur at the manufacturer's or a third-party facility approved by the DOE under observation by a DOE third party representative. Required performance metrics based on the testing will be calculated by a DOE third party representative.
- D. Heating performance:
1. Gas Heating:
 - a. Efficiency:
 - 1) Units ≤ 225 kBtuh shall have a minimum AFUE of 80
 - 2) Units > 225 kBtuh shall have a minimum thermal efficiency of 80%
 - 3) Furnish gas heat units with electronic ignition
 - 4) Gas heat capacity options shall provide the following minimum temperature increase:
 - a) 10 Tons and Over: Low Heat: 25°F rise; High Heat: 50°F rise
 - 5) Gas Input Requirements:
 - a) Natural Gas Supply Pressure: 7 in. w.c. (1.7 kPa).
 - b) LPG/Propane Supply Pressure: 11 in. w.c. (2.7 kPa).
 2. Electric Heating:
 - a. Electric heat capacity options (minimum):
 - 1) 10 Tons and over: Low Heat: 25°F rise High Heat: 50°F rise
 - b. Electrical Requirements:
 - 1) Provide for single connection of power to unit.
- E. Fan performance:
1. The supply air fan shall be tested and rated in accordance with ANSI/AMCA 210.
 2. Fan shall produce the ARI rated air-flow at 0.7 inches water column external static pressure (+/- 10%) without using the required motor service factor.
 3. Fan efficiency shall be a minimum of 60%.
 4. Fan shall be variable volume or multi-stage operation capability with, at minimum, a speed for heating mode, ventilation mode, and each stage of cooling.
 5. Fan motor shall be direct drive and meet NEMA premium efficiency for over 1 hp or an ECM for 1 hp and under.
- F. Economizer and Outdoor Air Damper:
1. Unit(s) shall have differential economizing capability using either dry-bulb or enthalpy with a minimum condition lock out
 2. The economizing function will be capable of actuating from a set minimal outdoor air intake to 100% of ARI rated flow
 3. Outdoor air damper shall be able to fully close switching to 100% recirculation mode and maintain a leakage rate based on section 2.01 E 1 g.
- G. General:
1. Unit(s) shall be a single package air-cooled DX mechanical cooling system with capacity between 120,000 to 240,000 Btu/h.
 2. Unit(s) shall be capable of discharging downward.
 3. The single package unit shall be a product of a firm regularly engaged in the manufacture of heating/cooling equipment.
 4. The manufacturer shall have parts and service available throughout the U.S and Canada.
 5. Unit(s) shall be shipped completely factory assembled, pre-charged, piped and wired internally ready for field connections.
 6. Unit(s) shall be 100% run tested by the manufacturer with a copy of the run test report on file at the manufacturing facility.

PART 2 PRODUCTS

2.01 PACKAGED ROOFTOP UNITS

- A. General:
 - 1. Rooftop unit shall be specifically designed for outdoor application with a fully weatherproof cabinet, fully flashed on 4 sides, and shipped as one piece. (Roof curb can be shipped or supplied separately.)
- B. Manufacturer shall perform all of the following at the factory:
 - 1. Assemble units
 - 2. Wire and pipe units
 - 3. Install unit controller
 - 4. Run test units before shipping
- C. Information plates:
 - 1. Outside Nameplate
 - a. Material shall be durable and weather resistant.
 - b. Located on outside of unit
 - c. Information on the nameplate shall contain:
 - 1) Name of manufacturer
 - 2) Model and serial number
 - 2. Unit shall have tags/decals showing lifting/rigging points, caution areas and refrigerant type.
 - 3. Information in control compartment:
 - a. Unit(s) shall have Installation and Maintenance manuals supplied with each unit in the control access section.
 - b. Unit(s) shall be provided with a durable and weather resistant Wiring Diagram mounted to the control compartment door.
- D. Plastic or rubber bushings or tooled openings to prevent wire abrasion wherever wiring runs through sheet metal
- E. RTU's to include the following equipment:
 - 1. Cabinet: Formed and reinforced insulated panels, hinged to allow access to internal parts and components, with joints between sections sealed.
 - a. Enclosure shall include anti-corrosion coating and shall be capable of withstanding ASTM B117 750 hour Salt Spray Test
 - b. Base rails:
 - 1) Full perimeter
 - 2) To have rigging holes for lifting
 - 3) Shall have forklift slots
 - c. Access Doors and Panels:
 - 1) Provide hinged access doors and removable panels to allow for removal, replacement or repair of all internal components. All doors and removable panels shall be gasketed.
 - 2) Include air/water seals for panels/doors separating conditioned from unconditioned air.
 - 3) Factory supplied latching handles
 - 4) Provide access to:
 - a) Economizer section
 - b) Filter section
 - c) Blower section
 - d) Compressors/control/heat section(s)
 - e) Condenser section
 - d. Condenser section access panel:

- 1) One square foot minimum panel size
- e. Openings:
 - 1) Unit base access for electrical
 - 2) Horizontal access knockouts for electrical and double gas lines
 - 3) ½" Raised edges around duct and power entry openings in the base pan
 - 4) Base pan:
 - a) Provide openings with nonmetallic grommets for the following:
 - (1) Unit power wiring.
 - (2) 120V convenience receptacle wiring.
 - (3) Low voltage network or external device wiring.
 - (4) Low voltage fire alarm wiring.
- f. Insulation:
 - 1) Cabinet shall be thermally and acoustically insulated.
 - 2) Unit base fully insulated to serve as air seal to the roof curb.
 - 3) All panels adjacent to conditioned air including the base shall be fully insulated with a minimum of R=1.0 (higher R value is preferred) fiberglass insulation to prevent condensation and minimize sound transmission.
 - 4) Door liners, top panels, divider panels and mullions shall be fully insulated to meet an R-value of 1.0 (higher R value is preferred).
 - 5) Casing Insulation and Adhesive: Comply with NFPA 90A.
- g. Outdoor- and Return-Air Mixing Dampers:
 - 1) Damper leakage rate no greater than the rate described in ASHRAE/IESNA 90.1 Table 6.4.3.4.4.
 - 2) Damper Motor: Direct-coupled, modulating with adjustable minimum position, plug-in connections.
 - 3) Gear driven preferred, use of rod and linkages is acceptable
 - 4) Outdoor Air Hood furnished with cleanable aluminum mesh outdoor air filters.
 - 5) Relief-Air Damper: Motorized (Direct coupled, gear driven preferred, use of rod and linkages is acceptable) or backdraft gravity (nonmotorized), as required by ASHRAE/IESNA 90.1, with bird screen and hood.
- h. Airstream Surfaces: Surfaces in contact with the air stream shall be protected against erosion and meet NFPA 90 flame retardance requirements (preferably interior panel, but foil faced cleanable insulation encapsulated with panel design or tape edges securing fit is acceptable).

2.02 COOLING SYSTEM:

- A. Operating range of 0°F - 115°F degrees F (-18 - 46°C) outdoor ambient conditions.
- B. Refrigerant Circuits:
 - 1. Each circuit shall have gauge port and connections on high and low pressure side in accessible locations.
 - 2. Refrigerant charging valves and connections shall be provided for each circuit.
- C. Refrigerant:
 - 1. Refrigerant shall not be an HCFC compound.
 - 2. Factory charged with refrigerant and oil
- D. Compressors:
 - 1. Intent is to not restrict technology employed, therefore type of compressor is not specified
 - 2. Safeties will be provided for the following:
 - a. Internal overcurrent and high-temperature protection
 - b. Internal pressure relief and high pressure (manual reset)
 - c. Internal pressure relief and high pressure

- d. Low pressure (automatic reset)
- e. Low charge
- f. Overload protection
- g. Short cycle protection:
 - 1) To allow circuit pressure equalization prior to compressor start
 - 2) To allow minimum run time
- 3. Equip with vibration isolation
- 4. Crankcase heaters
- 5. Compressor(s) shall be easily accessible and removable without disassembling cabinet. Refrigerant piping is to be protected to not leak or be damaged during shipment or unit operation.
- E. Coil Construction:
 - 1. The evaporator coil and condenser coil shall be leak tested to 200 psig and pressure tested to a minimum 450 psig.
- F. Evaporator Coil:
 - 1. Intent is to not restrict technology employed, therefore type and construction of coil is not specified
- G. Condenser Coils:
 - 1. Intent is to not restrict technology employed, therefore type and construction of coil is not specified
- H. Condenser fan(s):
 - 1. Intent is to not restrict technology employed, therefore type of fan is not specified
 - 2. Fan(s) shall be statically balanced
 - 3. Fan(s) and motor(s) shall be suitable for outdoor installation
 - 4. Fan(s) shall have safety guard(s)
- I. Outdoor Coil Fan Motors:
 - 1. Thermal overload protection
 - 2. Totally enclosed
 - 3. Permanently lubricated bearings
- J. Condensate Drain Pan:
 - 1. Unit shall have a non-corroding condensate drain pan under evaporator coil pitched for proper drainage at any orientation on a 1/8"/ft roof slope.

2.03 HEATING SYSTEM:

- A. Gas Furnace
 - 1. Description: Factory assembled, piped, and wired; complying with ANSI Z83.8 and NFPA 54.
 - a. Certified by and bearing label of ULC or CETLus
 - 2. Burners: Stainless steel
 - a. Fuel: Natural gas
 - b. Ignition: Electronically controlled hot-surface or direct spark igniter with flame sensor.
 - c. High-Altitude Model: For Project elevations more than 2000 feet (610 m) above sea level advise derated capacity
 - d. Heat-Exchanger: Aluminized steel or stainless steel.
 - 3. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
 - 4. Gas Controls:
 - a. Gas Control Valve: Two-Stage or Modulating, indicate on submittal documents.
 - b. Gas Train: Single-body, regulated, , 24-V ac gas valve assembly with manual shutoff. (Pressure regulator to be factory or field installed.)
 - c. Gas valve delay
 - d. High temperature limit switches

- e. Electronic switch to lockout gas valve until combustion air flow is proven.
- B. Electric-Resistance Heating:
 - 1. All electric heat specified above 15-kW nominal heat shall have 2 stages.
 - 2. Electric heaters shall meet requirements of NEC, shall be listed by UL for zero clearance to combustible surfaces, and shall be wired for 208/3/60 or 460/3/60 as indicated on Drawings.
 - 3. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
 - 4. Overcurrent Protection: Manual-reset thermal cutouts.
 - 5. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
 - a. Magnetic contactors, one (1) contactor per heating stage, must provide individual contactors for staging electric heat as required by the equipment schedule. All heaters rated above 15-kW shall have two stages.
 - b. Built-in fuses to be included for each heater circuit larger than 40 amps.
 - c. All contactors shall be wired to heating overcurrent device to allow for single-point power connection to the rooftop unit.
 - d. .
 - 6. Internal wiring insulated for operating temperatures.

2.04 INDOOR AIR QUALITY:

- A. Air Filtration: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
 - 1. 2-inch Minimum MERV 7, Factory-Installed for use during construction.
 - 2. 2-inch pleated Replacement Set: Minimum MERV 8.
- B. Filter compartment shall have a hinged, gasketed, access panel on one side of cabinet to allow for easy filter removal.
- C. Supply Air Blower:
 - 1. Intent is to not restrict technology employed, therefore type of fan is not specified.
 - 2. Fan(s), motor(s), and drive(s) shall be entirely self-contained.
 - 3. Each supply-air fan and motor shall be installed on an adjustable fan base.
 - 4. Fan(s) may be direct or belt drive.
 - 5. Motor:
 - a. Overload protected
 - b. Bearings shall be air-handling quality, heavy-duty grease or permanently lubricated ball type. Bearings shall be selected for a Basic Rating Life, (L10) of 100,000 hours at maximum operating speed and horsepower for each construction level
 - c. Ground and polished shafts
 - d. Motor mount base shall permit ease of changeover and belt tension adjustment (if applicable).
 - e. Blowers, drives and motors shall be balanced.
 - f. Shall be "NEMA premium" for motors 1 hp or greater.
 - g. Supply fan motors shall comply with NEMA MG 1

2.05 CONTROLS AND DIAGNOSTICS:

- A. Safety Control Operation:
 - 1. Smoke Detectors Connection:
 - a. Provide Smoke Detector terminals for connection to unit controller or a terminal strip in the electrical compartment for field wiring of the smoke detector(s) to the unit.

2. Smoke Purge: RTU shall have the capability for an EMS, other network application, or external device to start supply fan, deactivate cooling and heating systems, open outside and relief dampers, close return dampers, and activate power exhaust fan(s).
- B. RTU shall have a stand-alone Direct Digital Control (DDC) based unit control system.
1. DDC unit control system shall include all required, input/output boards, main microprocessor, software and operator interface for stand-alone operation and for communication with an external third-party device, network or EMS.
 2. The temperature sensors shall have an accuracy of ± 1 deg F, relative humidity sensors shall have an accuracy of $\pm 5\%$, dew-point sensors shall have an accuracy of ± 1 deg F, pressure transducers shall have an accuracy of $\pm 1\%$ FS and power measurements shall be $\pm 5\%$.
 3. DDC unit control system shall perform all unit control functions including unit safeties and either zone sensor control mode or thermostat control mode
 4. All boards shall be individually replaceable for ease of service. All microprocessors, boards, and sensors shall be factory mounted and tested.
 5. The DDC controller shall be stand-alone, not dependent on communications with any on-site or remote master control panel when operating in either a zone sensor control or a thermostat control mode.
 6. DDC controller shall accept virtual thermostat inputs from an external BACnet third party device or network (e.g., an Energy Management System¹ (EMS)) when operating in zone space temperature control mode. DDC controller shall be capable of switching from external EMS (or other) control mode to zone sensor or thermostat or non-EMS-based zone sensor or thermostat control mode.
 7. DDC controller shall support full communication with external compatible third-party devices, networks, or EMS using standard BACnet open protocol, that is, the DDC controller shall have communication capability with an external BACnet compliant third-party device (e.g. an EMS) to read all sensor data and all signal and status information (damper signal, status of both supply and outdoor fans, status of compressor and any protection limits). If additional sensors are installed to support the diagnostic functions, those sensor values also shall be readable from the external BACnet compliant third-party device or network (e.g. an EMS). In addition, the controller shall allow for reading the fault codes and messages.
- C. The microprocessor memory shall be protected from voltage fluctuations and power failures. All factory and user set control points, control algorithms and schedules shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.
1. Compressor protections and delays shall be no greater than the following:
 - a. Minimum On time of 120 seconds
 - b. Minimum Off time of 300 seconds
 2. Minimum outside air damper position setpoint used during occupied periods if network communications are lost.
- D. The user interface shall consist of a keypad/display device with characters of a size and font that is clearly visible for service personnel on a rooftop. Password protection from changes to writable properties by unauthorized personnel shall be one easily remembered default that is the same for all RTU's. Read only properties shall be available without

1. Some EMS systems are also referred to as Energy Management and Control Systems or Building Automation Systems.

password requirements. The service technician shall be able to scroll through to read the sensor values and fault codes and messages. In addition to the diagnostic fault codes and messages, it shall provide possible cause(s) for each fault condition.

- E. BACnet Communications:
1. A BACnet communications port shall be provided for direct communication to an external third-party network compliant with the BACnet protocol.
 2. All BACnet features shall be implemented per the latest version of the ANSI/ASHRAE 135 industry recognized BACnet standard.
 3. Dip switches or digital display shall be available for setting MAC addresses on individual RTUs in the field.
 4. Dip switches or keypad display shall be capable of setting a unique BACnet Device Instance on each RTU in the field.
 5. BACnet communications hardware and software shall be configured and available when the RTU arrives from the factory with no additional software, hardware, or peripheral (e.g., laptop computer) device connections required to initiate communication between RTU and external third-party network or device (e.g., an EMS).
 6. All required BACnet objects and properties shall be open protocol, non-proprietary type.
 7. BACnet implementation shall include (but not be limited to) the following features to assure satisfactory communication speed:
 - a. BAUD rate shall be BACnet MS/TP 76800 BPS or faster.
 - b. ReadPropertyMultiple service for accessing more than one data point per request message in addition to the ReadProperty service.
 - c. WritePropertyMultiple service for changing more than one data point per request message in addition to the WriteProperty service.
 - d. BACnet MS/TP implementations shall provide the ability to adjust the Max_Masters property of the Device Object through BACnet network communications interface.
 - e. BACnet MS/TP implementations shall not respond with BACnet Reply_Postponed frames to all Confirmed Service Requests.
- F. The DDC unit control system shall have the ability to communicate with an external third-party network or device through a direct wired BACnet communication connection. Multiple units shall communicate on the BACnet communication network. The RTU DDC unit shall enable such external third-party devices to both read and write to properties of the following BACnet objects on the individual rooftop DDC unit controllers:
1. BACnet Binary Inputs Objects:
 - a. Supply Fan (G) Start/stop the supply fan.
 - b. Cool 1 (Y1) Start/stop first stage cooling.
 - c. Cool 2 (Y2): Start/stop second stage cooling. Cool stages shall directly follow these control inputs.
 - d. Cool 3 (Y3): Start/stop third stage cooling on units with three stages. Cool stages shall directly follow these control inputs. Third stage may be defined by combinations of Y1 and Y2.
 - e. Heat 1 (W1) Start/stop first stage heating.
 - f. Heat 2 (W2): Start/stop second stage heating.
 - g. Smoke Alarm: Controller shall allow external BACnet systems (such as EMS) to monitor this BACnet binary input object for alarm purposes.
 - h. Diagnostic Alarm: Controller shall allow external BACnet systems (such as EMS) to monitor this BACnet binary input object for alarm purposes.
 - i. Compressor On/Off Status: Controller shall allow external BACnet systems (such as EMS) to monitor the binary input.

- j. Indoor Fan Status: Controller shall allow external BACnet systems (such as EMS) to monitor this binary input.
 - k. Outdoor Fan Status: Controller shall allow external BACnet systems (such as EMS) to monitor this binary input.
2. BACnet Analog Input Objects:
 - a. Zone Temperature Analog Input. EMS shall monitor and use this value to provide thermostat type staging of RTU heating and cooling.
 - b. Discharge Air Temperature Analog Input EMS shall monitor.
 - c. Return Air Temperature Analog Input for monitoring thru EMS.
 - d. Zone Relative Humidity Analog Input On units with a field mounted zone humidity sensor, EMS shall monitor and provide dehumidification control.
 - e. Carbon Dioxide (CO₂) Analog Input On units with a field-mounted zone CO₂ sensor, EMS shall monitor and vary the OA damper for demand controlled ventilation.
 - f. Energy Recovery Ventilator (ERV) Temperature Analog Input On units with ERV, EMS shall monitor.
 - g. If any additional sensors are installed to support diagnostics, all those sensor values shall be available as BACnet objects for EMS to monitor.
 3. Commandable BACnet Analog Output Objects:
 - a. Outside Air Damper Actuator: The EMS shall write to this output at priority level 9 to achieve direct control of the outside air damper position (overriding the DDC unit controller's ability to control the damper). If damper control resides on an auxiliary control board other than the main processor, the physical analog output of the auxiliary board shall also be directly under EMS control through the same BACnet object.
 4. Commandable BACnet Binary Outputs:
 - a. Power Exhaust 1 Units with economizer shall have this output which the EMS shall write to at priority level 9 when exhaust is required.
 - b. Energy Recovery Ventilator Units with ERV shall have output which the EMS shall write to at priority level 9 when ERV is required..
 5. All fault codes shall be presented to the EMS as BACnet multi-state value object. The state text property shall be implemented and contain English language descriptions of the associated fault codes.
 6. Alarm/Alert Information
 - a. Current alarms and alerts (if these are different from diagnostic information above) shall be presented to the EMS as BACnet multi-state value object. The optional state text property shall be implemented and contain English language descriptions of the associated alarms and alerts.
 7. Remote Alarm Reset
 - a. A commandable BACnet value object shall be available which allows reset of RTU lockouts to be performed over the EMS network. If conditions which caused the lockout still exist, RTU shall again lock out operations. Local alarm reset at the unit shall also be available. After clearing an alarm by setting the present value to "true", the priority array entry used to clear the alarm shall be reset to "auto" by the DDC unit controller so clearing alarms can be done again at any priority (this guarantees local clearing abilities at the unit after remote clearing). Relinquish default property of this object shall equal "false".
 8. The present value property of all BACnet Binary Inputs shall be writable when the object's "out of service" property has been set to true by the EMS.
 9. DDC unit controller shall support the BACnet Time Synchronization service. EMS will automatically set the unit controllers time properties for scheduling purposes.

10. Watchdog Timer (Heartbeat): DDC controller shall accept a watchdog timer signal from EMS network building controller into a BACnet analog value object. EMS will write the value of 300 every 90 seconds at priority level 9. This present value shall be reduced by 1 (at priority level 9) each second by the DDC controller until it reaches zero. If DDC controller's watchdog timer counts down to zero, the DDC controller shall know that EMS network communication has been lost.
 11. On all commandable BACnet objects, the DDC unit controller shall write to the present value property at any priority level higher than 9, preferably 16. Normal EMS control shall override the DDC unit controller at the command priority level 9. Manual EMS control shall write at command priority level 8.
 12. If EMS network communications fail (indicated through the watchdog timer), the DDC unit controller shall assume command in the zone temperature control mode, overriding control of all commandable objects at priority level 8 and 9 from the non-communicating EMS. When communications is restored and the watchdog timer is restored, the controller shall automatically switch back to thermostat control mode. Priority levels less than 8 (manual life safety, automatic life safety, etc) shall not be overridden after communications loss.
- G. RTU controls shall have an available power source to supply loop power through the following optional field installed sensors and back to the associated analog inputs:
1. One Relative Humidity sensor at:
 - a. 18-30 VDC
 - b. 1 VA maximum power
 2. One CO₂ sensor at:
 - a. 18-30 VDC
 - b. 3 VA maximum power
- H. RTU manufacturer shall provide discharge air temperature (DAT), outdoor air temperature, return air temperature (RAT) and humidity sensors wired to DDC unit controller inputs and presented to the external third-party device or network (e.g., an EMS) as BACnet Analog inputs. DAT sensor shall be mounted downstream of the coil, fan and heat source and measure a well mixed air stream. RAT sensor shall be mounted in direct line of sight from the return air duct to the lowest visible spot on the cooling coil. RAT sensor shall not be subjected to air from the OA damper or OA pulled backwards through a closed relief air damper.
- I. In the event of a zone temperature sensor failure (open-circuit, short-circuit, or otherwise defined to have failed by RTU manufacturer), the DDC unit controller shall switch to return air temperature as the control input in zone temperature control mode. The zone temperature sensor failure code shall be set, so an external third-party device or network (e.g., an EMS) can read the code and issue an alarm. This condition, along with the provision to operate the RTU in zone temperature control mode when network communication fails, shall enable units shipped from the factory to condition the space upon startup (before the zone sensor and external third-party devices or network (e.g., EMS) are installed).
- J. DDC unit controller must support enthalpy economizer controls.
- K. DDC unit controller in zone temperature control mode shall provide the following economizer control based on outside air temperature when EMS network communications are lost:
1. Low OA temp lockout = 35 deg F
 2. High OA temp lockout = 65 deg F
 3. DDC controller shall support integrated economizer operation, i.e., the unit shall be able to economize while also providing mechanical cooling, if economizer can't fully satisfy the zone cooling load.

4. If economizer is available, and the zone is in the cooling mode, and no compressors are running, the OA damper shall modulate to supply discharge air temperature control (setpoint = 55 deg F).
 5. If economizer is available and any compressor is running, the OA damper shall be fully (100%) open.
 6. If economizer is not available, the OA damper shall be at Minimum Position during occupied times and fully closed during unoccupied times
- L. DDC unit controller shall provide a service test mode. This operating mode shall allow a service contractor to force RTU into cool, heat, economizer, fan, dehumidification for local troubleshooting control and for independent testing and verification of the unit in the field during start-up commissioning. A BACnet Binary Value object shall indicate to the EMS when the unit is in service test mode.
- M. Communication from unit controller to an external device or network shall use BACnet MS/TP (Master-Slave/Token-Passing) or BACnet/IP.
- N. All operational capabilities described in previous sections A-M shall be automatically executed at equipment start-up to ensure proper operation and assist in commissioning.

2.06 ELECTRICAL:

- A. Single point connection:
1. Provide for single connection of power to unit with non-fused disconnect accessible from outside unit and control-circuit transformer with built-in overcurrent protection.
 2. Electrical power at unit shall be either 208, 460 or 575 volt, three phase, 60 hertz as indicated on Drawings. Provide a 208, 460 or 575 volt to 24 volt transformer (as dictated by unit operating voltage) for integral control of adequate capacity for control wiring and EMS..
 3. Electrical components shall have ETL or UL label where applicable and shall be identified with printed labels.
- B. Circuit Breakers:
1. Factory wired and mounted
 2. Current sensitive
 3. Temperature activated
 4. Manual reset
 5. Only one voltage shall be controlled through the contacts of any particular relay
 6. GFCI receptacles:
 7. Provide a 120 volt, 2-receptacle GFI outlet at the electrical penetration.
 8. The outlet shall be factory-provided with a separate disconnect switch and powered from the line side of the main unit disconnect switch.
 9. Provide label near GFI outlet stating "WARNING: Circuit feeding GFI receptacle is energized when unit disconnect is in OFF position"
- C. All relays, timers, contactors to be located in one compartment
- D. Electric heat contactors located in electric heat compartment, if selected
- E. Wiring:
1. Wiring shall be color-coded or numbered and consistent throughout the unit.
 2. If a wire numbering system is utilized, the numbers shall be located between one and two inches from both ends of each wire.
 3. Wiring shall comply with NEC requirements and with local applicable codes.
 4. Terminal blocks shall be provided for power wiring and external control wiring.
 5. Use wire ties to keep wires grouped together
 6. Orient components such that adequate clearance will remain after common replacement parts are installed.
 7. Wiring, including control wiring, shall have insulation rated at 600 volts.

8. Sheet metal knockouts used for wiring shall have nonmetallic grommets installed to protect wire insulation from abrasion.
 9. If a terminal board is located in another compartment for field terminations, the control systems communication conductors to the transition board shall be in a shielded cable.
- F. Provide a laminated wiring diagram attached to the inside of the compartment door that contains the following:
1. The ladder schematic shall read left to right, top to bottom. The diagram shall accurately reflect the wire numbers or colors used throughout the unit, and shall have a picture of the physical layout of the electrical system of the unit including the unit components and the wiring between them.
 2. Display a fully explained, legible, legend at the bottom.
 3. Provide a diagram of the actual component locations (Acceptable location of layout is in the Installation Manual)
 4. The name of each component inside the compartment shall be labeled on the panel adjacent to it with a sturdy plastic label.
 5. Components shall have labels matching wiring diagram.
- G. Motor control for supply fan motors, each compressor, and each condenser fan motor shall have an ETL or UL label. Provide motors with overload protection in each phase. Separately protect each phase against overcurrent.
- H. Motors:
1. Electrical motors and starter shall comply with AIEE, NEMA, and this specification.
 2. Design motors for supply voltages indicated, sized to develop required brake horsepower and operate satisfactorily with a voltage variation of $\pm 10\%$. Dynamically balance motors and hold to commercial tolerances.
 3. Except for fractional motors, fan motors shall be high efficiency type.
 4. Select motors for satisfactory operation without failure when ambient temperature reaches (104°F) for a period of 2-hours or more.
 5. Provide squirrel-cage type motors, drip-proof enclosure, constant speed, across-the-line normal torque designed for quiet operation. Motor shall operate at proper full load and speed continuously without excessive heating in any part. Size at minimum 115 percent service factor.
 6. Wind motors 1hp and larger for 3-phase, 60 hertz current unless shown otherwise on Drawings.

APPENDIX A: SUMMARY OF PERFORMANCE METRIC TEST PROCEDURES

Table 1. Summary of performance metric test procedures

Test Conditions ¹	OUTDOOR SECTION: Air Entering (Condenser Coil)		Return Air		OA Ratio	INDOOR SECTION : Air Entering (Evaporator Coil)	
	Dry-Bulb	Wet-Bulb	Dry-Bulb	Wet-Bulb		Dry-Bulb	Wet-Bulb
IEER 100% ^{2,3}	95°F	75°F	80°F	67°F	0%	80°F	67°F
IEER 75% ^{2,4}	81.5°F	66.3°F					
IEER 50% ^{2,4}	68.0°F	57.5°F					
IEER 25% ^{2,4}	65°F	52.8°F					
Low Temp Cooling Condition ^{2,4}	67°F	57°F	NA	NA	100%	67°F	57°F
Max Operating Condition ^{2,4}	115°F	75°F	80°F	67°F	0%	80°F	67°F
Condensate Disposal ^{2,4}	80°F	75°F	NA	NA	100%	80°F	75°F
Hot-Dry Annual Average Condition ^{3,4,5}	90°F	64°F	78°F	64°F	30%	82°F	64°F
Hot-Humid Annual Average Condition ^{3,4,5}	80°F	77°F	80°F	67°F	30%	80°F	70°F

Notes

1. All tests shall operate the unit against 0.7 H₂O of external static
2. Based on ANSI/AHRI Standard 340/360 2007
3. Indoor-coil airflow rate not to exceed 37.5 SCFM per 1000 Btu/h of rated capacity
4. Airflow rate should be adjusted to maintain or try to maintain the "IEER 100%" test condition measured leaving air dry-bulb temperature
5. Operate all refrigeration circuits at maximum capacity

APPENDIX B: REFERENCES

- A. American National Standards Institute (ANSI):
 - 1. ASHRAE 33 - 2000 Methods of Testing Forced Circulation Air Cooling and Air Heating Coils
 - 2. ANSI/ASHRAE 15 - 2007 Safety Standard for Refrigeration Systems.
 - 3. ANSI/ASHRAE/IESNA 90.1 - 2007 Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings.
 - 4. ANSI/ASHRAE 135 – 2008 BACnet
 - 5. ANSI/CSA Z83.8-2009 - Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-Fired Duct Furnaces.
 - 6. ANSI/NEMA MG1 - 2009 Motors and Generators
 - 7. ANSI/AMCA 210 - 2007 Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
- B. Air-Conditioning, Heating and Refrigeration Institute (AHRI):
 - 1. ANSI/AHRI 270 - 2009 Sound Rating of Outdoor Unitary Equipment.
 - 2. ANSI/AHRI 210/240 - 2008 Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment
 - 3. ANSI/AHRI 340/360 - 2007 Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
 - 4. ANSI/AHRI 370 - 2010 Sound Rating of Large Outdoor Refrigerating and Air Conditioning Equipment.
- C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE):
 - 1. ASHRAE 52.1 - 1992 Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
 - 2. ASHRAE 52.2 - 2007 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI approved).
 - 3. ASHRAE 62.1 - 2007 Ventilation for Acceptable Indoor Air Quality.
- D. American Society for Testing and Materials (ASTM):
 - 1. ASTM D5894 (2005) Standard Practice for Cyclic Salt Fog/UV Exposure of Painted Metal.
 - 2. ASTM B117 - (2009) Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - 3. ASTM D3359 - (2009) Standard Test Methods for Measuring Adhesion by Tape Test
 - 4. ASTM D2794 (2004) Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
 - 5. ASTM D2485 (2007) Standard Test Methods for Evaluating Coatings for High Temperature Service
 - 6. ASTM D2247 (2002) Standard Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity
 - 7. ASTM D4060 - 2010 Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser
 - 8. ASTM D522 - 2008 Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings
 - 9. ASTM D3363 (2005) Standard Test Method for Film Hardness by Pencil Test
- E. International Code Council (ICC)
 - 1. International Building Code (IBC) – (2009)
 - 2. International Mechanical Code (IMC) – (2009)

- F. U.S. Energy Policy Act of 2005 (EPACT)
- G. U.S. Energy Independence and Security Act of 2007 (EISA)
- H. U.S. National Appliance Energy Conservation Act of 2006 (NAECA):
- I. National Fire Protection Association (NFPA):
 - 1. NFPA 54 (2009) National Fuel Gas Code
 - 2. NFPA 70 (2009) National Electrical Code
 - 3. NFPA 90A (2009) Installation of Air Conditioning and Ventilation Systems.
 - 4. NFPA 90B (2009) Installation of Warm Air Heating and Air-Conditioning Systems.
- J. Underwriters Laboratories, Inc. (UL):
 - 1. UL 1995 Standard for Safety for Heating and Cooling Equipment.

APPENDIX C: DEFINITIONS

- A. DDC: Direct-digital controls.
- B. BMS (or EMS): Building Management System (or Energy Management System).
- C. ECM: Electronically commutated motor.
- D. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
- E. Outdoor-Air Refrigerant-Coil Fan: The fan for circulating outdoor air over the corresponding refrigerant-coil. "Outdoor air" is defined as above.
- F. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
- G. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
- H. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations or reject heat (provide heating) in a heat pump configuration during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

APPENDIX D: SUBMITTALS

- A. General: Submit listed submittals in accordance with Conditions of Contract and Submittal Procedures
- B. Product Data: Submit technical data for each RTU including specifications, capacity ratings, dimensions, required clearances, weights, materials, accessories furnished and installation instructions.
 - 1. Completed data spreadsheets for each unit as described above in Part 1.04, Section C. 3.
 - 2. Gas heating efficiency (AFUE) or combustion efficiency as applicable
 - 3. Maintenance methods, procedures and recommended intervals
 - 4. Equipment, piping and connections, together with valves, strainers, control assemblies, thermostatic controls, auxiliaries and hardware which are mounted, wired and piped ready for final connection to the building system.
 - 5. Dimensions, internal and external construction details, recommended method of installation with proposed structural steel support, mounting curb details, sizes and location of mounting bolt holes; include mass distribution drawings showing point loads.
 - 6. Details of vibration isolation.
- C. Shop Drawings: Submit shop drawings that Indicate:
 - 1. Equipment
 - 2. Piping and connections
 - 3. Recommended accessories
 - 4. External construction
 - 5. Recommended method of installation
 - 6. Mounting curb details, including provisions required for seismic and wind performance
 - 7. Sizes and location of mounting bolt holes
 - 8. Include mass distribution drawings showing point loads.
 - 9. Wiring diagrams for power supply and control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed. Wiring diagrams shall indicate MOCP (maximum overcurrent protection), MCA (minimum circuit ampacity) and FLA (full load amps). Wiring diagrams shall indicate necessary internal protection for equipment fed from RTU single point electrical connection.
 - 10. Fan performance tables or curves
 - 11. Type of refrigerant used
 - 12. Dimensions:
 - a. Plan view
 - b. Front view
 - c. Side view
 - d. Field/factory-installed options
 - e. Service clearances
 - f. Curb detail with dimensions
- D. Certifications:
 - 1. Test Reports: Certified test reports showing compliance with specified performance characteristics and physical properties.
 - 2. Certificates: Product certificates signed by manufacturer certifying materials comply with specified performance characteristics and criteria and physical requirements.

3. Manufacturer's installation instructions
- E. Closeout Submittals: Submit electronic versions of the following:
1. Brief description of unit
 2. Cut-sheets
 3. Warranty documents
 - a. Furnish written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, components with inadequate and defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required, provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period.
 4. Operation and Maintenance Data:
 - a. Include methods for cleaning and maintaining installed products
 - b. Include final sequence of operation
 - c. Methods/cleaning materials detrimental to finishes and performance
 - d. Include names and addresses of spare part suppliers
- F. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified for each wind zone in the International Building Code to include remaining in place when curbs are in use.
- G. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces identified for each seismic zone in the International Building Code to include remaining in place when curbs are in use.

APPENDIX E: QUALITY ASSURANCE

- A. AHRI Compliance:
 - 1. Comply with ANSI/AHRI 210/240 or 340/360 as appropriate for testing and rating energy efficiencies for RTUs.
 - 2. Comply with ANSI/AHRI 270 or 370 for testing and rating sound performance for RTUs.
- B. ASHRAE Compliance:
 - 1. Comply with ASHRAE 15 for refrigeration system safety.
 - 2. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- D. Heating efficiency shall be certified by CSA/ANSI Z83.8.
- E. Unit(s) shall be safety certified, listed and labeled by Underwriters Laboratories (UL), UL of Canada (UL/C), Environmental Testing Laboratories (ETL) a division of Intertek Testing Laboratories, or Canadian Standards Association (CSA) in accordance with UL 1995/CAN/CSA No. 236-M90 and ANSI Z21.47 standards for Central Cooling Air Conditioners.
- F. Unit(s) nameplate shall carry the label of the certification agency.
- G. NFPA Compliance:
 - 1. Comply with NFPA 90A.
 - 2. Comply with NFPA 54.
- H. All wiring shall be in compliance with NEC and CEC
- I. 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. All electrical components shall have UL/C-UL, ETL and CGA listing.
- J. Unit(s) shall be manufactured according to ISO 9002 manufacturing quality control.

APPENDIX F: WARRANTY

- A. Warranty Period begins date of start-up
 - 1. Entire unit: Manufacturer shall warrant units against defective materials, labor and workmanship for a period of one year from date of start-up.
 - 2. Compressor Failure and any leaks in the condenser or evaporator coils: 5 years after date of start-up.
 - 3. Gas Heat Exchanger: Parts 10 years or 20 years (for stainless) after date of startup.
 - 4. Unit Control Module: Parts 3 years after date of start-up
- B. Warranty must be renewable, at the owner's option and expense, each year until the equipment is ten (10) years old.

APPENDIX G: CAPACITIES AND CHARACTERISTICS

- A. Provide submittal data indicating compliance to Equipment Schedule, and provide any additional information as required in the following list.
- B. Supply-Air Fan:
 - 1. Airflow CFM:
 - 2. External Static Pressure INCHES WG:
 - 3. Fan Speed RPM:
 - 4. Motor Horsepower:
 - 5. Motor Speed RPM:
- C. Supply-Air Refrigerant Coil:
 - 1. Total Cooling Capacity Btu/h:
 - 2. Sensible Cooling Capacity Btu/h:
 - 3. Part Load Capacity Btu/h:
 - 4. Entering-Air Dry-Bulb Temperature deg F:
 - 5. Entering-Air Wet-Bulb Temperature deg F:
 - 6. Coil configuration (face-split, row-split, interlaced, etc)
 - 7. Fin per inch count:
 - 8. Coating:
- D. Outdoor-Air Refrigerant Coil:
 - 1. Ambient-Air Temperature deg F:
 - 2. Coating:
 - 3. Fan Motor HP:
 - 4. Number of Fans:
- E. Hot-Gas Reheat Coil:
 - 1. Heating Capacity Btu/h:
 - 2. Entering-Air Temperature deg F:
 - 3. Air-Temperature Rise deg F:
 - 4. Coating:
- F. Electric-Resistance Heating Coil:
 - 1. Capacity kW:
 - 2. Number of Steps (min 2 if >15 kW):
- G. Compressors:
 - 1. Quantity (if not same size, properties required for each)
 - 2. Suction Temperature deg F:
 - 3. Power Input kW:
 - 4. Energy-Efficiency Ratio (EER):
 - 5. Seasonal Energy-Efficiency Ratio (SEER):
 - 6. Coefficient of Performance (COP):
- H. Gas Furnace:
 - 1. Airflow CFM:
 - 2. Minimum AFUE %:
 - 3. Minimum Thermal Efficiency %:
 - 4. Minimum Combustion Efficiency %:
 - 5. Input Btu/h:
 - 6. Output Btu/h:
 - 7. Entering-Air Temperature deg F:
 - 8. Air-Temperature Rise deg F:
- I. Electrical Characteristics for Single-Point Connection:
 - 1. Voltage:

2. Phase:
 3. Hertz:
 4. Full-Load Amperes:
 5. Minimum Circuit Ampacity:
 6. Maximum Overcurrent Protection (indicate Fuse or Circuit Breaker):
- J. Sound Power: Measured per AHRI 270.
- K. Economizer:
1. Single sensor or differential control:
 2. Controller model:
 3. Two-stage thermostat, with first-stage of cooling wired for economizer:
 4. Final changeover temperature or setting:
 5. Minimum outdoor airflow:

APPENDIX H: EXECUTION (INCLUDED FOR HVAC INSTALLATION AND STARTUP)

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 roof for suitable conditions where RTUs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

Installation

- A. 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" and AHRI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in other Sections. Secure RTUs to upper curb rail according to manufacturer's guidelines and using manufacturer supplied anchoring devices to make air and rain tight connection.
- B. Install wind and seismic restraints according to manufacturer's written instructions.
- C. Install prominent external tags/decals showing unit number.

Connections

- A. Install condensate drain per IMC, with trap and indirect connection to nearest roof drain or area drain, or other location as indicated on the drawings.
- B. Install piping adjacent to RTUs to allow service and maintenance.
 1. Gas Piping: Comply with applicable requirements in Division 23 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. Do not block access to any of the unit panels with the gas piping. Install all factory grommets so that all unit piping penetrations are watertight.
- 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 at top of roof curb with a 1-inch minimum duct flange secured to the top of the curb. All duct connections for drop-box diffusers shall be made using bolted transverse connectors. A threaded rod shall be installed from each supporting clip located on each corner of 4-way diffusers and double-nut secured to the bracing supports installed according to the details shown on the Drawings.
 2. The curb shall be installed directly to the joist and the roof decking will be installed by others to be attached to the curb flange.

Field Quality Control

- A. Provide customer selectable option for Manufacturer's Field Service: A factory-authorized service representative shall be included in all equipment pricing to the Owner and shall be present when requested to inspect, test, and adjust components, assemblies, and equipment installations, including connections, and to assist in testing startup. Factory-authorized service reps shall be competent technicians prepared to use refrigerant gauges to report unit performance. Report all results in writing.
- B. Tests and Inspections by installing contractor prior to engaging factory-authorized service rep. (Part 3.05):
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Install 2-inch pleated Replacement Filter Set: Minimum 90 percent arrestance provided to contractor for installation immediately prior to Building Commissioning.

Startup & Commissioning Service

- A. Engage a factory-authorized service representative to perform startup service. The factory technician shall be fully engaged and prepared to record refrigerant pressures and shall coordinate all activity and take direction from the Owner's commissioning agents.
- B. 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, 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. Inspect operation of barometric relief dampers.
 - 14. Verify lubrication on fan and motor bearings.
 - 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.
 - b. Check for proper rotation direction of the compressors
 - c. Do not operate below recommended low-ambient temperature.
 - d. Complete startup sheets and attach copy with Contractor's startup report.
 - 18. Enable the DDC unit controller's automated self-check sequence to provide the following diagnostic checks as a start-up commissioning function:
 - a. Low Evaporator Air Flow
 - b. High Refrigerant Charge
 - c. Low Refrigerant Charge
 - d. Sensor Failure/Fault (including drifting out of calibration)

- e. Equipment Short Cycling
 - f. Dirty Filter
 - g. Efficiency does not meet unit rating
 - h. Capacity does not meet unit rating
 - i. Economizer Faults
 - 1) Damper not modulating (stuck damper)
 - 2) Not economizing when it should
 - 3) Excess outdoor air
 - 4) Low ventilation
19. Inspect and record performance of interlocks and protective devices; verify sequences.
 20. Operate unit for an initial period as recommended or required by manufacturer.
 - a. Gas Heat: Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency. Perform tests with the outside air damper closed.
 - 1) Measure gas pressure on manifold.
 - 2) Inspect operation of power vents.
 - 3) Measure combustion-air temperature at inlet to combustion chamber.
 - 4) Measure flue-gas temperature at furnace discharge.
 - 5) Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - 6) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off.
 - 7) Calculate useful heat to supply air.
 - b. Electric Heat: Perform the following operations for all stages of heating.
 - 1) Measure supply-air temperature and volume for each, and for combined, stages of electric heating.
 21. Calibrate thermostats and temperature sensors
 22. Adjust and inspect high-temperature limits.
 23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
 24. Start refrigeration system and measure and record the following when outdoor ambient is a minimum of 15 deg. F (8 deg. C) above return-air temperature (If outdoor air temperature is too cold, a return trip shall be coordinated to perform these tests at a later date, but proceed with startup without measurements):
 - 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.
 25. Inspect controls for correct setpoints, scheduling, 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. Outdoor-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 condenser coil or from condenser fans to outdoor-air intake.