CSI Specification

PRODUCT SPECIFICATION GUIDE DN SERIES
RENEWAIRE MODEL ERV — AIR-TO-AIR ENERGY RECOVERY VENTILATOR
FOR OUTDOOR OR INDOOR INSTALLATION
CSI MASTERFORMAT CATEGORY 23 74 33

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To view RenewAire product data to include unit description, catalog and instruction manuals, go to www.renewaire.com/our-ervs/

This product is available in multiple different configurations. The unit is typically installed as an element of a building HVAC system.

Questions regarding this product should be directed to your local RenewAire authorized representative. To locate your local rep, go to www.renewaire.com/how-to-buy/find-a-dealer/ and select your region.

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SECTION 237433 - DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

- Section includes factory assembled and manufactured [non-packaged split] [packaged] dedicated outside air units (DOAS) with static plate air-to-air energy recovery capable of supplying up to 100 percent outdoor air and providing [cooling only] [heating only] [cooling and heating].
- The [non-packaged] [packaged] split DOAS unit with static plate air-to air energy recovery shall be for [indoor] [outdoor] installation.

1.2 RELATED DOCUMENTS

- Drawing and general provisions of the contract, including General Requirements Division 01, Division 23, Division 23 Specifications Sections, and common work requirements for HVAC apply to work specified in this section.
    - Section 23 05 00 (15050) – Common Work Results for HVAC
    - Section 23 05 13 (15090) – Common Motor Requirements for HVAC Equipment

- Section 23 05 48 (15070) – Vibration Control for HVAC Piping and Equipment
- Section 23 05 53 (15075) – Identification for HVAC Piping and Equipment
- Section 23 05 93 (15950) – Testing, Adjusting and Balancing for HVAC
- Section 23 09 00 (15900) – Instrumentation and Control for HVAC
- Section 23 09 93 (15940) – Sequence of Operation for HVAC Controls
- Division 23 11 23 (15194) – Facility Natural-Gas Piping
- Division 26 (16) Sections for electrical connections.

1.3 REFERENCES

- Air-Conditioning, Heating and Refrigeration Institute (AHRI) Publications:
  - 410 "Forced Circulation Air-Cooling and Air-Heating Coils”
  - 1060 "Performance of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment”
  - [ANSI/AHRI 920 “Performance Rating of DX-Dedicated Outdoor Air System Units”]
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Publications:
  - 62.1 “Ventilation for Acceptable Indoor Air Quality (ANSI Approved)”
  - 90.1 “Energy Code for Commercial and High-Rise Residential Buildings”
- 52.2 “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.”
  - 84 “Method of Testing Air to Air Heat/Energy Exchangers.”
- ASTM International (ASTM) Publications: (Former American Society for Testing and Materials)
  - B117 "Standard Practice for Operating Salt Spray (Fog) Apparatus"
- National Fire Protection Association (NFPA) Publications:
  - 70 "National Electric Code"
  - 90A “Standard for the Installation of Air Conditioning and Ventilating Systems”
- Air Movement and Control Association (AMCA) publications:
  - AMCA 500-D - Laboratory Methods of Testing Dampers for Rating

1.4 SUBMITTALS

- Product Data: For each type of product. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- Product data: For each [non-packaged split] [packaged] DOAS unit with static plate air-to air energy recovery, include the following:
  - Unit performance data for both Supply Air and Exhaust Air, with system operating conditions indicated.
  - Cooling and heating coil performance data.
  - [Packaged DX performance data]
  - Enthalpy plate performance data for both summer and winter operation.
  - Motor ratings and unit electrical characteristics.

    - Dimensioned drawings for each type of installation, and plan views, to include location of attached ductwork and service clearance requirements.
    - Estimated gross weight of each installed unit.
    - Filter types, quantities, and sizes
    - Installation, Operating and Maintenance manual (IOM) for each model
- LEED Submittals: For each [non-packaged split] [packaged] DOAS unit with static plate air-to air energy recovery, include the following:
    - Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1.
    - Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
    - Product Data for Credit IEQ 1: Documentation indicating that units are equipped with a direct outdoor airflow-measuring device capable of measuring the minimum outdoor airflow with accuracy within 15 percent of the design minimum airflow rate, as defined by ASHRAE 62.1.
    - Product Data for Credit IEQ 5: Documentation indicating that units include MERV 13 filters rated according to ASHRAE 52.2.
- Shop Drawings: For each [non-packaged split] [packaged] DOAS unit with static plate air-to air energy recovery, include the following:
    - Include plans, elevations, sections, and attachment details.
    - Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
    - Wiring Diagrams detailing wiring for power, signal, and control systems. Clearly differentiate between manufacturer-installed and field-installed wiring.
    - [Refrigeration diagram]
    - Commissioning report, including pre-functional testing checklists, indicating the results of unit startup, testing and commissioning requirements.
    - Prepare the following by or under the supervision of a qualified professional engineer:
        - Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
        - Include diagrams for power, signal, and control wiring.
- Delegated-Design Submittal (Optional): For design of [vibration isolation] [seismic restraints] [and] [wind restraints], including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
    - Unit fabrication and assembly details.
    - Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
    - Design Calculations:
        - Calculate requirements for selecting vibration isolators [and seismic restraints] [and wind restraints] and for designing vibration isolation bases.

1.5 CLOSEOUT SUBMITTALS

- Operation and Maintenance Data: For each [non-packaged split] [packaged] DOAS unit with static plate air-to air energy recovery, provide operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- Source Limitations: Obtain the [non-packaged split] [packaged] DOAS unit with static plate air-to air energy recovery with all appurtenant components or accessories from a single manufacturer.
- For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.
- The energy recovery core shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of ten (10) years from the date of purchase. The balance-of-unit shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of two (2) years from the date of installation.
- Manufacturer shall be able to provide evidence of independent testing of the core by Underwriters Laboratory (UL), verifying a maximum flame spread index (FSI) of 25 and a maximum smoke developed index (SDI) of 50 thereby meeting NFPA90A and NFPA 90B requirements for materials in a compartment handling air intended for circulation through a duct system. The method of test shall be UL Standard 723.
- Certifications:
    - The energy recovery cores used in these products shall be third party Certified by AHRI under its Standard 1060 for Energy Recovery Ventilators. AHRI published certifications shall confirm manufacturer’s published performance for airflow, static pressure, temperature and total effectiveness, purge air (OACF) and exhaust air leakage (EATR). Products that are not currently AHRI certified will not be accepted. OACF shall be no more than 1.02 and EATR shall be at 0% against balanced airflow.
    - AHRI 410, "Forced Circulation Air-Cooling and Air-Heating Coils," and shall be listed and bear the label of the Air-Conditioning, Heating and Refrigeration Institute (AHRI).
    - UL and NEMA Compliance: Provide motors required as part of air-handling units that are listed and labeled by UL and comply with applicable NEMA standards.
    - Units intended for outdoor use shall have a minimum IPX4 rating per EN 60529.
    - Units to be safety certified to UL 60335.
- Every unit to be factory tested prior to shipping: Unit to undergo the following factory tests.
    - Unit to be dielectric voltage tested per UL/ETL.
    - Grounding Continuity Test
    - Raw Material and Component Test
    - [Refrigeration circuits fully charged and tested]
    - Functional run test of entire unit

1.7 DELIVERY, STORAGE AND HANDLING

- Deliver units as factory-assembled units with protective covering.
- Coordinate delivery of units in sufficient time to allow movement into building.
- Handle rooftop units to comply with manufacturer's written rigging and installation instructions for unloading and moving to final location.

1.8 COORDINATION

- Coordinate size and location of all building penetrations required for installation of each DOAS unit and associated plumbing and electrical systems.
- Coordinate sequencing of construction for associated plumbing, HVAC, electrical supply.
- Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- Basis-of-Design Product: Subject to compliance with requirements, provide product as indicated on drawings, RenewAire DN Series Dedicated Outside Air Units.
- Manufacturer should be in business for minimum 10 years manufacturing non-packaged dedicated outside air units with static plate air-to air energy recovery.
- [Split non-packaged] [Packed] [indoor] [outdoor] unit using 100% outside air, with cooling coil and/or heat, enthalpic plate energy recovery unit of capacities and characteristics as scheduled on the drawings.
- Each unit shall be completely factory assembled, wired, tested and shipped in one piece.
- Unit shall be capable of varying the amount of outside air delivered to the space based on occupancy, humidity, and indoor air quality.

2.2 PERFORMANCE REQUIREMENTS

- General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- Cabinet Thermal Performance:
    - Maximum Overall U-Value: Comply with requirements in ASHRAE/IESNA 90.1.
    - Insulation R-Value: [1”-R6.5] [2”-R13.0]
    - Include effects of metal-to-metal contact and thermal bridges in the calculations.
- Cabinet Deflection Performance:
    - Walls and roof deflection shall be within L/240 of the span when subjected to a 15 in-w.g. pressure. Deflection limits shall be measured at any point on the surface.
- Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET

- Construction: [1” double] [2” double] wall with injected foam insulation.
- Exterior Casing Material: [Unpainted 20-gauge G90 galvanized steel] [Painted exterior casing shall be capable of withstanding at least 2500-Hrs with no visible corrosive effects when tested in a salt spray and fog atmosphere with ASTM B117-95 test procedure. The unit shall be painted on 5 sides, base unpainted.]
- Interior Casing Material: Unpainted 20-gauge G90 galvanized steel.
- Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.
- Base Rails: G90 galvanized steel rails for mounting on roof curb or pad as indicated.

- Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
    - Service Doors:
        - Access doors to filters and cores shall be hinged and gasketed.
        - All other access doors shall be removeable type with door handles.
        - Material and construction of doors shall match material and construction of cabinet in which doors are installed.
- Roof of Rooftop Units: Standing seam; sloped to drain water.
- Outdoor units shall be specifically designed for outdoor rooftop application with a fully weatherproof cabinet.
- Outdoor unit base shall overhang the roof curb for water run-off.
- Floor: Reinforced, metal surface; reinforced to limit deflection when walked on by service personnel. Insulation shall be below metal walking surface.
- Unit nameplates shall be fixed on the unit.

- Cabinet Insulation:
    - Type: Injected foam insulation using Ecomate® an environmentally friendly foam blowing agent (or expansion agent) and family of polyurethane foam systems with no global warming potential (GWP), no ozone depletion potential (ODP) and no volatile organic compounds (VOCs) as the expansion agent.
    - Insulation Thickness: [1 inch] [2 inches].
    - The R-value of the insulation shall be R6.5 for 1” of insulation and R-13 for 2” of insulation.
    - Insulation Adhesive: Comply with ASTM C 916, Type I.
- Condensate Drain Pans:
    - Shape: Rectangular, with one (1) percent slope in at least two planes to direct water toward drain connection.
    - Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.
        - Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
        - Depth: 2 inches deep.
    - Material: Stainless-steel.
    - Drain Connection:
        - Located on one end of pan, at lowest point of pan.
        - Terminated with threaded nipple.
        - Minimum Connection Size: ¾” NPS
- Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.
- Roof Curb: Full-perimeter curb of sheet metal, minimum 14 inches high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
    - Comply with requirements in "The NRCA Roofing Manual."

- Curbs are to be knock down construction providing full perimeter support, cross structure support and air seal for the unit.
- Curb shall be as described on the drawings.

2.4 SUPPLY AND EXHAUST FANS

- Fan Type: Direct Drive Type
- Variable Flow Type: [Electronically Commutated Motors] [Variable Frequency Drive]
- Vibration Isolation: [Elastomeric (VFD only)] [spring (VFD only)]
- Plenum Fan Type: Single width, non-overloading, with backward-curved motorized impellers.
  - Fan Wheel Material: Plastic attached directly to motor shaft. Impeller made of high-strength composite material ZAmid in ultramarine blue for EC fans. Impellers made of powder-coated carbon steel for fans with VFDs.
  - Fan Wheel Drive and Arrangement: Direct drive.
  - Fan Balance: Precision balance fan at G6.3 (6.3mm/sec) per ISO 1940-1.
- Motors:
  - Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors.
  - EC fan motor to have an IP54 rating.
  - Enclosure: Totally enclosed.
  - Motor Bearings: L10 lifetime rated bearing life and shall exceed 30,000 hours.
  - EC Motor Efficiency: Super premium efficient per NEMA Standard.
  - EC Motor Service Factor: 1.00
- Mounting: For units with VFD only, fan wheel, motor, and drives to be mounted to fan casing with restrained elastomeric isolators and spring isolators as an option.Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

2.5 COOLING COILS

- Capacity Ratings: Coil rated in accordance with ARI 410 – Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
- Coil Casing Material: [Galvanized steel] [Stainless steel].
- Tube Material: Copper.
- Tube Header Material: Copper.
- Fin Material: Aluminum.
- Fin and Tube Joints: Mechanical bond.
- Leak Test: Coils shall be leak tested with air underwater.
- Refrigerant Coil Capacity Reduction (optional): Circuit coils for interlaced control.
- Refrigerant Coil Suction and Distributor Header Materials: Seamless copper tube with brazed joints.
- Coating (optional): Phenolic epoxy corrosion-protection coating after assembly.

2.6 REFRIGERANT REHEAT COILS

- Capacity Ratings: Coil rated in accordance with ARI 410 – Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
- Coil Casing Material: [Galvanized steel] [Stainless steel].
- Tube Material: Copper.
- Tube Header Material: Copper.
- Fin Material: Aluminum.
- Fin and Tube Joints: Mechanical bond.
- Leak Test: Coils shall be leak tested with air underwater.
- Coating (Optional): Phenolic epoxy corrosion-protection coating after assembly.

2.7 ELECTRIC-RESISTANCE HEATING COIL

- UL Compliance: Comply with requirements in UL 1996, "Heating and Cooling Equipment."
- Electric-Resistance Heating Elements:
    - Open-Coil Resistance Wire: [60 percent nickel, 20 percent chromium and 20 percent iron] [80 percent nickel, 20 percent chromium].
    - Supports and Insulation: Floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
    - Heating Capacity: Low density 30 W per sq. in. factory wired for single-point wiring connection; with time delay for element staging and overcurrent- and overheat-protection devices.
    - Silicon Controlled Rectifier (SCR) control for modulating the electric heater.
    - Safety Controls:
        - Blower-motor interlock.
        - Automatic high-limit switch for primary over-temperature protection.
        - Manual reset high-limit switch for secondary over-temperature protection.
        - Integral, non-fused power disconnect switch.

2.8 INDIRECT-FIRED GAS FURNACE HEATING

- Furnace Assembly:
    - Factory assembled, piped, and wired.
    - Comply with requirements in NFPA 54, "National Fuel Gas Code," and ANSI Z83.8, "Gas Unit Heaters, Gas Packaged Heaters, Gas Utility Heaters and Gas-Fired duct furnaces."
- Burners:
    - Heat-Exchanger Material: Stainless steel with a minimum thermal efficiency of 80 percent.
    - Fuel: [Natural] [Propane] gas.
        - [5.0” w.c. Minimum Inlet Pressure – Natural Gas]
        - [11.0” w.c. Minimum Inlet Pressure – Propane Gas]
        - 13.5” w.c. (1/2 PSI) Maximum Inlet Pressure

    - Ignition: Electronically controlled electric spark with flame sensor.
    - High-Altitude Correction Capability: For Project elevations more than 2000 feet above sea level.
- Heat-Exchanger shall have an integral condensate drainpipe to drain condensate.
- Type of Venting: An induced-draft combustion air blower to provide for positive venting of flue gases. Fan interlocked with gas valve.
- Safety Controls:
    - Gas Control Valve: Electronic modulating.
    - Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly, and manual shutoff.

2.9 HOT-WATER HEATING COIL

- Capacity Ratings: Coil rated in accordance with ARI 410 – Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
- Coil Casing Material: [Galvanized steel] [Stainless steel].
- Tube Material: Copper.
- Tube Header Material: Copper.
- Fin Material: Aluminum.
- Fin and Tube Joints: Mechanical bond.
- Leak Test: Coils shall be leak tested with air underwater.
- Provide adequate clearance for accessing, cleaning, servicing and maintaining the coil per coil manufacturer's recommendation.
- Ensure that the coil can be removed and replaced in the field with ease.
- Coating (Optional): Phenolic epoxy corrosion-protection coating as an option.

2.10 STEAM HEATING COIL

- Capacity Ratings: Coil rated in accordance with ARI 410 – Standard for Forced-Circulation Air-Cooling and Air-Heating Coils
- Coil Type: Non-freeze, horizontal or vertical, tube arrangement.
- Coil Casing Material: [Galvanized steel] [Stainless steel].
- Tube Material: Copper.
- Tube Header Material: Copper.
- Fin Material: Aluminum.
- Fin and Tube Joints: Mechanical bond.
- Leak Test: Coils shall be leak tested with air underwater.
- Provide adequate clearance for accessing, cleaning, servicing and maintaining the coil per coil manufacturer's recommendation.
- Ensure that the coil can be removed and replaced in the field with ease.
- Coating (Optional): Phenolic epoxy corrosion-protection coating after assembly.

2.11 OUTDOOR-AIR INTAKE HOOD

- Type: Downturned and louvered intake hood
- [Optional 3/8-inch mist eliminating aluminum mesh filters].
- Materials: Match cabinet.
- Bird Screen: Comply with requirements in ASHRAE 62.1.
- Configuration: Designed to inhibit wind-driven rain and snow from entering unit.
- Inlet velocity at the outdoor air intake screen to be less than 400 fpm.
- Comply with Outdoor Air Hood requirements of ASHRAE 62.1

2.12 FILTERS

- Filters: [2 inch] [4 inch] thick disposable pleated filter.
- MERV Rating: [MERV 8] [MERV13] [MERV14]
- Extended-Surface, Disposable Panel Filters:
    - Comply with NFPA 90A.
    - Factory-fabricated, dry, extended-surface type.
    - Thickness: [2 inches] [4 inches].
    - Initial Resistance for MERV8: Less than 0.29 inches w.g. at unit design maximum airflow.
    - Recommended Final Resistance: 1.0 inches w.c. above initial resistance.
    - Minimum Arrestance: 90, according to ASHRAE 52.1.
    - Minimum MERV 8, in accordance with ASHRAE 52.2.
    - Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
- Mounting Frames:
    - Panel filters arranged for flat or angular orientation, Filters to be removable from one side.

2.13 Packaged DX System

- Unit shall have [an] integral compressor[s] and an evaporator coil located within the weather-tight unit housing. The [lead] compressor must be a BLDC variable speed type with a minimum turn down of 6:1 and a dedicated VFD to modulate based on demand. Fixed speed compressors, hot gas bypass, and digital scroll compressors are not acceptable. [The second circuit shall be a staged compressor with a maximum capacity of 75% of the lead compressor to provide an even transition between stages.] All compressors shall be mounted on vibration isolators to minimize sound and vibration transmission.
- Variable speed compressors will utilize internal heating to evaporate liquid during the compressor off state. [Staged compressors will utilize crank case heaters.]
- All refrigeration circuits must include electronic expansion valves, sight glasses, filter driers, manual-reset high pressure safety switches, and service ports. Each circuit will include suction and discharge temperature and pressure sensors to allow a dedicated refrigeration controller to operate the compressors within their design envelope.
- [Refrigeration circuits with HGRH must include a suction accumulator to accommodate the varying refrigerant circuit volume.]

- Condenser fans shall be modulating [ECM][AC with VFD (575 VAC only)] to control head pressure. Condenser fans shall be high-efficiency and low sound ZA type, encased for weatherization protection.
- Condenser fans shall have removeable hinged hail guards.
- All refrigeration circuits shall be factory piped, evacuated, and charged with R-410A refrigerant.

2.14 ELECTRICAL POWER CONNECTIONS

- General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.
- The units shall have an electrical connection box to connect all high and low voltage connections. The electrical shall be constructed to permit single-point high voltage power supply connections.
- [DOAS unit shall be equipped with a Unit Disconnect Switch]
- Power Interface: Field power interface shall be UL 508 listed, nonfused disconnect switch.
- Factory Wiring: Branch power circuit to each motor and motor control with means for disconnecting.
- Factory-Mounted, Overcurrent-Protection Service: Optional for unit and each motor.
- Transformer: Factory mounted with integral circuit breaker and sized with enough capacity to operate electrical load plus spare capacity.
- Controls: Factory wired unit-mounted microprocessor controls, sensors and sequences of operations.
- [Service Receptacle: 120 VAC GFCI service outlet shall be factory unit-mounted to the exterior of the unit, ground fault interrupt (GFI) duplex receptacle option for outdoor. The service outlet requires a dedicated 120 V single phase electric circuit by others] [120 VAC GFCI service outlet shall be factory-provided and installed [by this contractor in a location designated by the A/E. The service outlet requires a dedicated 120 V single phase electric circuit by others].

2.15 CONTROLS

- Control equipment and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC."
- Control Valves: Comply with requirements in Section 230900 "Instrumentation and Control for HVAC."
- Control Wiring: Factory wire connection for controls' power supply.
- Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.
- Unit-Mounted Controller Display:
    - Cooling/Off/Heating Controls: Control operational mode.
    - Damper Position: Indicate open/closed position of the outdoor-air damper.
    - Status Data:
        - Filter dirty.
        - Fan operating.
        - Cooling operating.
        - Heating operating.
        - Fan alarm.

        - General alarm.
        - [Drain Pan Overflow]
    - Digital Numeric Display:
        - [Suction Temperature]
        - [Suction Pressure]
        - [Discharge Temperature]
        - [Discharge Pressure]
        - Outdoor airflow.
        - Exhaust airflow.
        - Outdoor dry-bulb temperature.
        - Outdoor humidity
        - Exhaust temperature.
        - Supply temperature.
        - [Space Temperature.]
        - [Space relative humidity.]
        - [Space carbon dioxide level.]
        - Return Air Temperature.
        - Return Air Humidity

- Control Dampers:
    - Damper Location: OA and EA dampers are factory installed and wired on the outside of the unit.
    - Damper Leakage: The dampers for outside air and exhaust air to be low leak galvanized steel dampers for the commercial heating and air conditioning industry that meet most energy codes including California's Title 24, IECC 2015, and ASHRAE 90.1 requirements. The dampers to leak less than 4 cfm/sq. ft. at 1" w.c. (static pressure), and are AMCA licensed as a Class 1A damper at 1" w.c.
    - Damper Rating: AMCA Class 1A rated dampers.
    - Damper Label: Bear the AMCA seal for both air leakage and performance.
    - Blade Configuration: Unless otherwise indicated, use parallel blade configuration for two-position control and equipment isolation service. For other applications, use an opposed-blade configuration.
    - Damper Frame Material: galvanized steel.
    - Blade Type: Non-insulated, Single-thickness metal reinforced with multiple V-grooves or hollow-shaped airfoil.
    - Blade Material: Galvanized steel.
    - Maximum Blade Width: 6 inches.
    - Maximum Blade Length: 48 inches.
    - Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression-type seals.

- End-Switch(es): As required to satisfy the sequence of operations under all operating conditions and modes.

- Damper Actuators:
  - Factory-installed electric actuator for each damper assembly with one actuator for each damper assembly mounted to the damper frame.
  - Actuator capable of shutoff against fan pressure and able to operate the damper with sufficient reserve power to achieve smooth modulating action and proper speed of response at the velocity and pressure conditions to which the damper is subjected.
  - Maximum Operating Time: Open or close damper 90 degrees in 60 seconds.
  - Adjustable Stops: For both maximum and minimum positions.
  - Spring-return actuator to fail-safe; either closed or open as required by application.
  - Actuator Type: Direct coupled, designed for minimum 60,000 full-stroke cycles at rated torque.
  - Position feedback Signal: For remote monitoring of damper position.
  - Coupling: V-bolt and V-shaped, toothed cradle.
  - Circuitry: Electronic overload or digital rotation-sensing circuitry.
- Chilled-Water Coil Controls:
  - Factory-mounted sensor in unit discharge with sensor adjustment located in control panel to modulate third party furnished and installed coil control valve to maintain temperature.
  - Temperature sensor with temperature adjustment or unit-mounted temperature adjustment or adjustment on remote-control panel to modulate field furnished and installed coil control valve to maintain temperature.
- Furnace Controls:
  - Factory-supplied sensor in supply outlet with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.
  - Wall-mounted, space-temperature sensor with temperature adjustment or unit-mounted temperature adjustment or adjustment on remote-control panel to modulate gas furnace burner to maintain space temperature.
  - Staged Burner Control: [5:1] [10:1] Electronic Modulation
- Electric-Resistance Heat Controls:
  - Factory-supplied sensor in supply outlet with sensor adjustment located in control panel to control electric coil to maintain temperature.
  - Wall-mounted, space-temperature sensor with temperature adjustment or unit-mounted temperature adjustment or adjustment on remote-control panel to control electric coil to maintain temperature.
  - Capacity Controls: Modulating SCR.
- [Hot-Water] [and] [Steam] Coil Controls:
  - Factory-mounted sensor in supply outlet with sensor adjustment located in control panel to modulate third party furnished and installed coil control valve to maintain temperature.
  - Temperature sensor with temperature adjustment or unit-mounted temperature adjustment or adjustment on remote-control panel to modulate field furnished and installed coil control valve to maintain temperature.

- BACnet Factory Activation (optional): Factory programmed and tested BACnet activation on the microprocessor controller that allows for communication to a BAS via BACnet
- Integrated Web Pages for advanced diagnostics
- Recirculation Damper (optional): – Factory Installed low leakage galvanized steel damper
- Drain Overflow (optional): – Factory installed switch installed on condensate drain pan to shut down fans if water level rises to unacceptable level.
- Smoke Alarm (optional): 24V smoke detector is shipped loose and to be field installed and wired back to the unit in [supply][return] air duct. The air duct smoke detector housing shall be UL listed per UL 268A specifically for use in air handling systems. The air duct smoke detector housing shall be suitable for mounting indoors. The detector shall operate at air velocities of 100 feet per minute to 4000 feet per minute.
- WARNING: Duct smoke detectors are NOT a substitute for open area smoke detectors; NOT a substitute for early warning detection; NOT a replacement for a building's regular fire detection system. Refer to NFPA 72 and 90A for additional information].
- DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with control system specified in Section 230900 "Instrumentation and Control for HVAC." Links shall include the following:
    - Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
    - Hardware interface or additional sensors for the following:
        - Room temperature.
        - Discharge-air temperature.
        - Refrigeration system operating.
        - Furnace operating.
        - Constant and variable motor loads.
        - Variable-frequency-controller operation.
        - Cooling load.
        - Economizer status.
        - Air-distribution static pressure and ventilation-air volumes.
- Refrigeration Control: Dedicated refrigeration controller allows either demand signal or temperature and setpoint from remote controller to stage on compressor[s] as required. Functions shall include:
    - Suction temperature and pressure monitoring
    - Discharge temperature and pressure monitoring
    - Envelope control and alarming
    - Oil management control
    - Head pressure control
    - Electronic expansion valve control for each refrigeration circuit
    - Control sequencing for multiple compressors, including startup and shutdown
- BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.
    - Hardwired Points:

        - Monitoring: On-off status, [common trouble alarm].
        - Control: On-off operation, [space temperature set-point adjustment] [supply temperature set-point adjustment] [space humidity set-point adjustment] [space pressure set-point adjustment].
    - [ASHRAE 135 (BACnet)] [Modbus] communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

2.16 ACCESSORIES

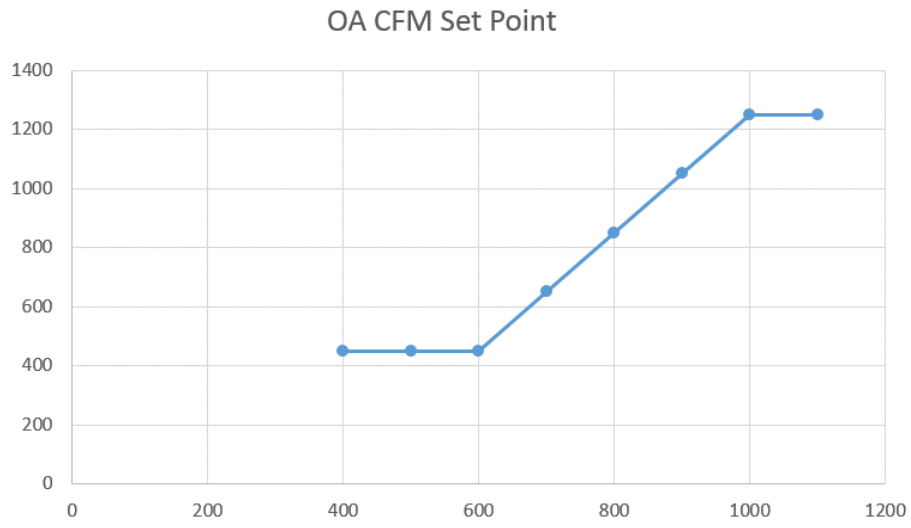
- Carbon Dioxide Sensor: [Duct][Wall] mounted Carbon Dioxide Sensor for installation in the field and connected to the terminal block for the unit.
- Indoor Air Quality Sensor: [Duct][Wall] mounted Indoor Air Quality Sensor for installation in the field and connected to the terminal block for the unit.
- Smoke Detector: Duct Mounted Smoke Detector that are shipped loose for installation in the field and connected to the terminal block for the unit.
- Pressure Sensors (Room/Static): [Duct][Room] mounted pressure sensor for installation in the field and connected to the terminal block for the unit.
- Occupancy Sensor: Room mounted pressure sensor for installation in the field and connected to the terminal block for the unit
- Room Temperature and Humidity Sensor: Cross-linked bulk polymer capacitive sensing element with hydrophobic and oleophobic ePTFE filter to protect the sensing element from condensation, fog, salt air, pollutants and other contaminants.
- Controller Remote Display: Handheld/wall mount LED display with keypad for easy programing.
- Pressure Sensors: [Duct][Room] [with display] [without display] differential pressure transmitter with 4-20mA or field selectable 0-10V & 0-5V output signal.
- Temperature Sensor Kit: Duct temperature sensors with hermetically sealed 304SS probe with easy installation integral mounting plate and operating range -40F to 210F that can be connected to the unit microprocessor controller.
- Hurricane or Seismic Rated curbs.
- Curb Clip Kit: Sets of 10-gauge galvanized G90 steel clips designed to keep unit and roof curb attached together.
- Waterless trap negative pressure: Condensate drain trap with cleanout port. Installs horizontally and rated to 12 in w.c.
- Waterless trap positive pressure: Condensate drain trap with cleanout port. Installs vertically and rated to 12 in w.c.

2.17 SEQUENCE OF OPERATION

- **Unit shall be tested and shipped with the standard default factory sequence of operation setpoints. This shall include all the possible operating modes of the controls. For project specific and area specific setpoints, conditions and capacities, please refer to the project schedule as located on the drawings.**
- SUPPLY FAN OPERATION
    - The supply fan can control can be set for fixed speed, supply air flow control, supply duct static pressure control, CO2/VOC control, or CO2/VOC Flow control.

- The unit will attempt to start the supply fan when the supply fan delay timer expires. When the supply fan starts the supply fan adjustable current switch should close and remain closed until the fan is turned off.
- Supply Fan Status
  - Once the supply fan current switch closes heating and/or cooling operation, if applicable, are allowed. After a delay of 90 seconds (adjustable) from supply fan start signal, if the supply fan current switch is still open the supply fan alarm should be set to true and heating and cooling operation shall be prohibited. The supply fan status shall be set to true only when the supply fan output is on and supply fan current switch is closed. The supply fan status shall be false in all other circumstances.
- Fixed Fan Speed Option
  - The analog voltage command to the supply fan VFD or ECM can be set from the unit controller display or by the BMS. The adjustable range of 0% to 100% correspond to the minimum and maximum fan operating speed. This supply fan operational mode can be used to field balance the supply air flow rate. This mode can also be used when the BMS is performing a control loop and the BMS will provide a supply fan command.
- Supply Air Flow Control Option
  - The controller will adjust the supply fan VFD or ECM command to maintain the supply air flow rate at a set point. The supply air flow rate set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for supply air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air flow to the air flow rate set point and adjust the fan speed. If the measured supply air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) a supply air flow rate alarm will be set to true. This supply fan operation mode can be used to provide a constant supply air flow rate as the unit filters become loaded.
- Supply Duct Static Pressure Control Option
  - The controller will adjust the supply fan VFD or ECM command to maintain the supply duct static pressure at a set point. The supply air duct static pressure set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the supply air duct static pressure set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured supply air duct static pressure to the static pressure set point and adjust the fan speed. If the measured static pressure varies from the desired static pressure by more than 0.05 inches water gauge (adjustable) for more than 60 seconds (adjustable) a supply air static pressure alarm will be set to true. This supply fan operation mode can be used to provide a constant supply duct pressure for VAV systems.
- CO2/VOC Control Option
  - The controller will adjust the supply fan VFD or ECM command to maintain the room or return air CO2 or VOC level at a set point. The CO2/VOC set point is entered and adjusted from the unit controller display or provided by the BMS. An adjustable PI (proportional & integral) loop will compare the measured CO2/VOC level to the set point and adjust the fan speed. The minimum and maximum fan speed commands are adjustable. If the measured CO2/VOC level exceeds 1000 ppm (adjustable) for more than 60 seconds (adjustable) a CO2/VOC alarm will be set to true. This supply fan operation mode can be used to provide demand-controlled ventilation of a space. The minimum fan speed will provide the required minimum outdoor air when the CO2/VOC level is at or below the set point.
- CO2/VOC Flow Control Option
  - The controller will adjust the supply fan VFD or ECM command based on the measured room or return air CO2/VOC level. The supply air flow set point is derived from the user entered minimum and maximum CO2/VOC levels and minimum and maximum desired air flow rates. When the CO2/VOC level is at or below the minimum CO2/VOC level the air flow set point is at the minimum and when the CO2/VOC level is at or above the maximum

CO2/VOC level the air flow set point is at the maximum. Between the minimum and maximum CO2/VOC levels the air flow set point is linearly scaled. If the measured CO2/VOC level exceeds 1000 ppm (adjustable) for more than 60 seconds (adjustable) a CO2/VOC alarm will be set to true. This supply fan operation mode can be used to provide demand-controlled ventilation of a space. The minimum flow rate will provide the required minimum outdoor air when the CO2 level is at or below the CO2 set point.



- Exhaust Fan Operation
    - The exhaust fan control can be set for fixed speed, exhaust air flow control, supply fan command tracking control, supply fan flow rate tracking control, or return duct static pressure control.
    - The unit will attempt to start the exhaust fan when the exhaust fan delay timer expires. When the exhaust fan starts the exhaust fan adjustable current switch should close and remain closed until the fan is turned off.
    - Exhaust Fan Status
        - After a delay of 90 seconds (adjustable) from exhaust fan start signal, if exhaust fan current switch is still open the exhaust fan alarm should be set to true. The exhaust fan status shall be set to true only when the exhaust fan output is on and exhaust fan current switch is closed. The exhaust fan status shall be false in all other circumstances.
    - Fixed Fan Speed Option
        - The analog voltage command to the exhaust fan VFD or ECM can be set from the unit controller display or by the BMS. The adjustable range of 0% to 100% correspond to the minimum and maximum fan operating speed. This exhaust fan operational mode can be used to field balance the exhaust air flow rate. This mode can also be used when the BMS is performing a control loop and the BMS will provide an exhaust fan command.
    - Exhaust Air Flow Control Option
        - The controller will adjust the exhaust fan VFD or ECM command to maintain the exhaust air flow rate at a set point. The exhaust air flow rate set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the exhaust air flow rate set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by

more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to provide a constant exhaust air flow rate as the unit filters become loaded.

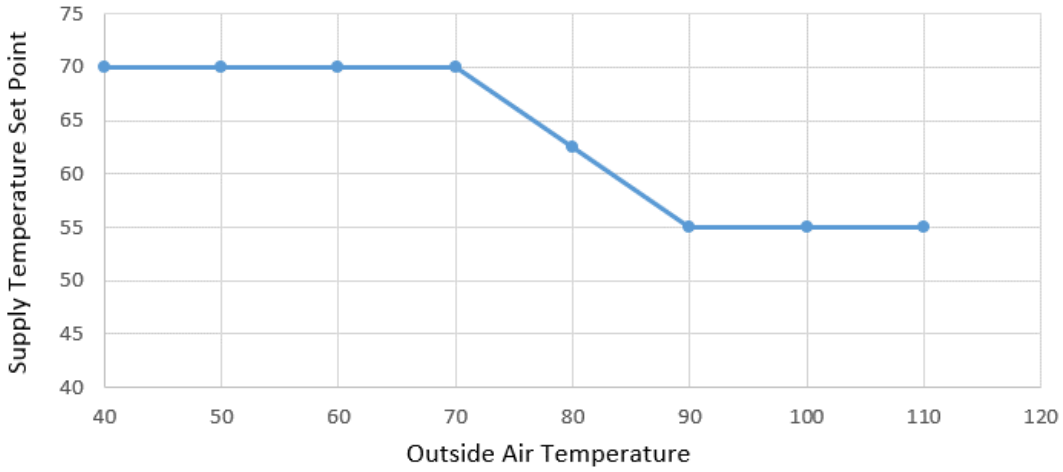
- Supply Fan Command Tracking Control Option
  - The controller will adjust the exhaust fan VFD or ECM command to track the supply fan VFD or ECM command. The minimum (50%) and maximum (200%) tracking rates are adjustable. This exhaust fan operation mode can be used to maintain proportional supply and exhaust fan commands as the supply fan modulates.
- Supply Fan Flow Tracking Control Option
  - The controller will adjust the exhaust fan VFD or ECM command to track the supply fan air flow rate. The scaling of the exhaust flow rate set point from the measured supply air flow rate is adjustable from 50% to 200%. An adjustable PI (proportional & integral) loop will compare the measured exhaust air flow to the air flow rate set point and adjust the fan speed. If the measured exhaust air flow rate varies from the desired air flow rate by more than 10% (adjustable) for more than 60 seconds (adjustable) an exhaust air flow rate alarm will be set to true. This exhaust fan operation mode can be used to maintain proportional supply and exhaust air flows as the supply fan modulates and as the unit filters become loaded.
- Return Duct Static Pressure Control Option
  - The controller will adjust the exhaust fan VFD or ECM command to maintain the return duct static pressure at a set point. This mode cannot be used if the supply fan mode is duct static control. The return duct static pressure measurement is typically a negative pressure value. The return duct static pressure set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the return air duct static pressure set point are unit dependent. An adjustable PI (proportional & integral) loop will compare the measured return air duct static pressure to the static pressure set point and adjust the exhaust fan speed. If the measured static pressure varies from the desired static pressure by more than 0.05 inches water gauge (adjustable) for more than 60 seconds (adjustable) a return air static pressure alarm will be set to true. This exhaust fan operation mode can be used to provide a constant return duct pressure for variable exhaust systems.

- Cooling Operation
  - Economizer (Bypass/Free Cooling)
    - If the application requires that the unit be in economizer (bypass) mode, the controller may enter the economizer state. During normal operation the bypass damper shall remain closed and the face damper open to allow full energy recovery. During economizer operation the bypass damper will modulate open and the face damper will modulate closed to bypass up to 100% of the outside air around the energy recovery core. The economizer state can be controlled by temperature or enthalpy and is utilized as the first stage of cooling.

      The economizer will be locked out when:

      - The outside air temperature is less than the economizer adjustable low lockout.
      - The return air temperature is below the adjustable low lockout
      - Heating is enabled
    - Temperature:
      When the outside air temperature is below the return air temperature the economizer will modulate the face and bypass dampers to control the unit supply air temperature
    - Enthalpy:
      When the outside air enthalpy is below the return air enthalpy the economizer will modulate the face and bypass dampers to control the unit supply air temperature.
  - Active Cooling

        - When the economizer alone cannot provide the required amount of cooling additional active cooling will be enabled. Active cooling will be locked out if the outdoor air temperature is below 70 degrees F (adjustable) or if heating is enabled. The temperature control set point can be configured as constant (adjustable) or can be reset by the outside air temperature. The constant temperature control can be for the supply air temperature or the return air (room) temperature (selectable).
        - [Compressors will have a minimum 5 minute On time (adjustable) and a 5 minute minimum Off time (adjustable)]
    - Constant Supply Air Temperature Option
        - The controller will adjust the cooling device to maintain the supply air temperature at a set point. The supply air temperature set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the supply air temperature set point are unit dependent.
    - Reset Supply Air Temperature Option
        - The controller will adjust the cooling device to maintain the supply air temperature at a set point. The supply air temperature set point is calculated based on the outdoor air temperature. The air set point is adjusted between the 70-degree F maximum (adjustable) and the 55-degree F minimum (adjustable) as the measured temperature varies from the 70-degree F minimum (adjustable) to the 90-degree F maximum (adjustable). These values are entered and adjusted from the unit controller display or provided by the BMS.



    - Constant Return Air Temperature Option
        - The controller will adjust the cooling device to maintain the return (room) air temperature at a set point. The return air temperature set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the return air temperature set point are unit dependent.
    - Dehumidification (Reheat) Option
        - When the return (room) air dew point exceeds the 55 degrees F (adjustable) the dehumidification mode will be enabled. The controller will adjust the cooling device to maintain the cooling coil leaving air temperature at a 55 degrees F (adjustable). The modulating hot gas reheat valve will provide warm refrigerant to the reheat coil to control the supply or return air temperature at the set point. An adjustable PI (proportional & integral) loop will compare the measured air temperature to the air temperature set point and adjust the analog output to the valve.

- Active Cooling Modes

- Single Stage/On-Off:
    - When the measure air temperature exceeds the set point by 3.6 degrees F (adjustable) the cooling stage is enabled. When the measured air temperature decreases below the set point the cooling stage is disabled.
- Two Stage:
    - A proportional band of 4 degrees F (adjustable) is used to create a cooling demand. If the measured temperature exceeds the temperature set point by the proportional band amount a demand of 100% is created. When the demand reaches 25% (adjustable) the first stage of cooling is enabled. If the demand reaches 75% (adjustable) the second stage of cooling is enabled. When the demand reduces to the first stage level (25% above) the second stage is disabled and when the demand falls to 0% the first stage is disabled.
- Modulating:
    - An adjustable PI (proportional & integral) loop compares the measured air temperature to the air temperature set point and adjusts the 0 to 10 VDC analog output. A digital output that indicates a call for cooling will also be provided.
- Compressors Timers:
    - When compressors are used for staged cooling minimum run timers of 3 minutes (adjustable) and minimum off timers of 5 minutes (adjustable) are utilized.

- Heating Operation

  Heating will be locked out if the outdoor air temperature is above 65 degrees F (adjustable). The temperature set point can be configured as constant (adjustable) or can be reset by the outside air temperature. The temperature control can be for the supply air temperature or the return air (room) temperature (selectable).
    - Constant Supply Temperature Option
        - The controller will adjust the heating device to maintain the supply air temperature at a set point. The supply air temperature set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the supply air temperature set point are unit dependent.
    - Reset Supply Air Temperature Option
        - The controller will adjust the heating device to maintain the supply air temperature at a set point. The supply air temperature set point is calculated based on the outdoor air temperature. The supply air set point is adjusted between the 100-degree F maximum (adjustable) and the 70-degree F minimum (adjustable) as the measured temperature varies from the 20-degree F minimum (adjustable) to the 70-degree F maximum (adjustable). These values are entered and adjusted from the unit controller display or provided by the BMS.
    - Constant Return Temperature Option
        - The controller will adjust the heating device to maintain the return (room) air temperature at a set point. The return air temperature set point is entered and adjusted from the unit controller display or provided by the BMS. The minimum and maximum values for the return air temperature set point are unit dependent.
- Heating Modes
    - Modulating:
        - An adjustable PI (proportional & integral) loop compares the measured air temperature to the air temperature set point and adjusts the 0 to 10 VDC or 10 to 0 VDC (selectable) analog output. A digital output that indicates a call for heating will also be provided.
    - Tempering Modes

        - A digital output indicates the current tempering mode. The relay output is open for heating and closed for cooling. This output can be used for changing the mode of a heat pump. If a heat pump is selected the heating will be disabled if the outdoor air temperature falls below the adjustable low temperature limit.

- Occupied/Unoccupied Mode
    - The integral schedule or a BMS signal can be used to place the unit in occupied or unoccupied mode. During occupied mode the outside air and exhaust dampers will open, and the unit will perform energy recovery and tempering of fresh air as described above. During unoccupied mode operation the outside air damper and exhaust air dampers will be closed, the face/bypass damper will modulate to full bypass, and the recirculation damper will open. The exhaust air fan will be off, and the supply air fan will be on. When the unit is commanded to run the return, air will be tempered and supplied back to the space, there will be no outside air used.
- Alarms
    - The microprocessor controller includes a digital output for remote indication of an alarm condition. Possible alarms include:
    - Supply and Exhaust Air Proving Alarm: Microprocessor controller monitors the current switch on each blower and displays an alarm in case of blower failure.
    - An exhaust fan alarm will disable the unit. The supply fan alarm can be set to disable the unit (factory default) or to keep the unit operating (desired for bathroom exhaust).
    - Dirty Filter Alarm: If the outside air or return air filter differential pressure rises above the differential pressure switch set point (adjustable), the microprocessor controller will activate an alarm.
    - Airflow Alarm
    - Static Pressure Alarm
    - CO2/VOC Alarm
    - Sensor Alarm: Microprocessor controller will send an alarm if a failed sensor is detected (temperature, pressure, relative humidity).
    - Low Discharge Temperature Alarm

PART 3 - EXECUTION

3.1 EXAMINATION

- Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation. See unit IOM.
- Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- Install units in accordance with these written specifications, project drawings, manufacturer’s installation instructions as documented in manufacturer’s IOM, Best Practices and all applicable building codes.
- Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

- Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."
    - Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
    - Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
    - Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.
- Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."
- Equipment Mounting:
    - Install air units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in [Section 033000 "Cast-in-Place Concrete."] [Section 033053 "Miscellaneous Cast-in-Place Concrete."]
    - Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
    - Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- Suspended Units: Suspend [and brace] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in [Section 230548 "Vibration and Seismic Controls for HVAC."] [Section 230548.13 "Vibration Controls for HVAC."]
- Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.
- Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."
- Install separate devices furnished by manufacturer and not factory installed.
- Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- Install drainpipes from unit drain pans to sanitary drain.
    - Drain Piping: Drawn-temper copper water tubing complying with [ASTM B 88, Type L] [ASTM B 88M, Type B], with soldered joints.
    - Drain Piping: Schedule 40 PVC pipe complying with ASTM D 1785, with solvent-welded fittings.
        - PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
        - Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
        - Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
    - Pipe Size: Same size as condensate drain pan connection.

3.3 CONNECTIONS

- Where installing piping adjacent to units, allow space for service and maintenance.
- Gas Piping Connections:

    - Comply with requirements in [Section 231123 "Facility Natural-Gas Piping."] [Section 231126 "Facility Liquefied-Petroleum Gas Piping."]
    - Connect gas piping to furnace, full size of gas train inlet, and connect with union, [pressure regulator,] and shutoff valve with sufficient clearance for burner removal and service.
    - Install AGA-approved flexible connectors.
- Hydronic Piping Connections:
    - Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."
    - Install shutoff valve and union or flange on each supply connection and install balancing valve and union or flange on each return connection.
- Steam Piping Connections:
    - Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 Steam and Condensate Piping Specialties."
    - Install shutoff valve and union or flange on each supply connection.
    - Install, starting from the coil connection, union or flange, strainer, union, float and thermostatic trap, union, and shutoff valve.
- Duct Connections:
    - Comply with requirements in Section 233113 "Metal Ducts."
    - Drawings indicate the general arrangement of ducts.
    - Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."
- Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.
    - Install electrical devices furnished by unit manufacturer but not factory mounted.

3.4 STARTUP SERVICE

- [Engage a factory-authorized service representative to perform] [Perform] startup service.
    - Complete installation and startup checks according to manufacturer's written instructions.
    - Inspect units for visible damage to furnace combustion chamber.
    - Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
        - Measure gas pressure at manifold.
        - Measure combustion-air temperature at inlet to combustion chamber.
        - Measure flue-gas temperature at furnace discharge.
        - Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
        - Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
    - Verify operation of remote panel failure modes. Inspect the following:
        - High-limit heat exchanger.

        - Alarms.
    - Inspect units for visible damage to evaporator coils, and fans.
    - Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:
        - Cooling coil leaving-air, dry- and wet-bulb temperatures.
        - Cooling coil entering-air, dry- and wet-bulb temperatures.
        - Condenser coil entering-air dry-bulb temperature.
        - Condenser coil leaving-air dry-bulb temperature.
        - Subcooling and superheat of each circuit
    - Simulate maximum cooling demand and inspect the following:
        - Compressor refrigerant suction and hot-gas pressures.
        - Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.
    - Verify that clearances have been provided for servicing.
    - Verify that controls are connected and operable.
    - Verify that filters are installed.
    - Verify sight glass for charge and dryness.
    - Clean coils and inspect for construction debris.
    - Clean furnace flue and inspect for construction debris.
    - Inspect operation of power vents.
    - Purge gas line.
    - Inspect and adjust vibration isolators and seismic restraints.
    - Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
    - Start unit.
    - Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
    - Operate unit for run-in period.
    - Calibrate controls.
    - Adjust and inspect high-temperature limits.
    - Inspect outdoor-air dampers for proper stroke.
    - Verify operational sequence of controls.
    - Measure and record the following airflows. Plot fan volumes on fan curve.
        - Supply-air volume.
        - Return-air flow.
        - Outdoor-air flow.
- After startup, change filters.

- Remove and replace components that do not properly operate and repeat startup procedures as specified above.
- Prepare written report of the results of startup services.

3.5 ADJUSTING

- Adjust initial temperature and humidity set points.
- Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- Occupancy Adjustments: When requested within [12] months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain units.
- [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
- Review data in the maintenance manuals.

END OF SECTION 237433