

**SECTION 23 72 00**  
**AIR-TO-AIR RECOVERY EQUIPMENT**

**PART 1 – GENERAL**

**1.1 RELATED DOCUMENTS**

- A. The general provisions of the contract, including the conditions of the contract (General, Supplementary and other Conditions, if any) and Division 1 as appropriate, apply to the work specified in this section.
- B. Refer to Section 23 00 00 for HVAC General Provisions
- C. Refer to Section 23 05 00 for HVAC Basic Materials & Methods.
- D. Refer to Section 23 23 00 for Refrigeration Piping.

**1.2 DESCRIPTION OF WORK**

- A. This Section includes work necessary and/or required and materials and equipment for construction of a complete system. Such work includes, but is not limited to the following:
  - 1. Heating and Ventilating Units
  - 2. Packaged Air-to-Air Energy Recovery Unit
  - 3. Single Packaged, Gas-Fired Rooftop Air Conditioning Unit
  - 4. Packaged Gas-Fired Rooftop Unit (Kitchen Ventilation)

**1.3 REFERENCE STANDARDS**

- A. Refer to Section 23 00 00 for a general description of requirements applying to this section.
- B. AMCA Standards 210 and 300 for fans.
- C. ARI Standard 410, ASHRAE Standard 33 for Heating and Cooling Coils.
- D. ASHRAE Standard 52.2 and U.L. Standard 900 for media type air filters.
- E. AMCA Standard 511 and 500D for Air Control Dampers.
- F. AMCA Standard 611 and 610 for air flow measurement stations.
- G. ARI Standard 1060 and ASHRAE Standard 84 for Air-to-Air Energy Recovery Equipment.
- H. ARI Standard 260 and 430 for Air Handling Units.

**1.4 QUALITY ASSURANCE**

- A. Refer to Section 23 05 00 for a general description of requirements applying to this Section.
- B. Whenever a variable frequency PWM drive is installed to control an AC motor, a maintenance-free, circumferential, conductive micro fiber shaft grounding ring shall be installed on the AC motor drive end to discharge shaft currents to ground. Recommended part: AEGIS SGR™ Bearing Protection Ring, as made by Electro Static Technology. Install in accordance with the manufacturer's written instructions.

**1.5 SUBMITTALS**

- A. Submit shop drawings in accordance with Section 23 00 00.
- B. Submit shop drawings and descriptive data for all equipment specified in this section.

**1.6 SUBSTITUTIONS**

- A. The listed equivalent or substituted manufacturers along with the bidding related contractor shall be completely responsible to comply with all requirements on all contract documents. This shall include, but not limited to, space requirements, code clearances, the type, horsepower, capacities, number and

size of services required from other trades, including all required ancillary items provided by other trades. If the manufacturer or related bidding contractor does not comply with these requirements, this Contractor shall be responsible for any and all additional costs associated with the changes required by other trades.

#### 1.7 WARRANTY/GUARANTEE

- A. All work and materials are subject to the general warranty as described in the General Conditions of the Contract and in Division 1, General Requirements. In addition, the following special guarantee applies:
1. Each compressor unit shall be provided with manufacturer's five (5) year parts and labor warranty.

### **PART 2 – PRODUCTS**

#### 2.1 HEATING AND VENTILATING UNITS

- A. The air handling units for heating and ventilating shall be sectional component type. Components shall include fan section, gas-fired heat exchanger, and air filters.
- B. The fan section shall consist of a rectangular steel cabinet, incorporating single or multiple centrifugal fans mounted on a cold rolled steel shaft which shall rotate in grease lubricated ball bearings. The fan wheels shall be multi-blade forward, backward inclined or air foil as required by conditions listed on schedule. Fan ratings shall be based on AMCA Standards 210 and 300. Fans shall bear the AMCA seal.
1. Fan and fan motor shall be internally mounted and isolated on a full width isolator support channel using 1” springs. The fan discharge shall be connected to the fan cabinet using a flexible connection to ensure vibration-free operation. The isolator support rail shall be structurally supported from the unit base.
  2. Fan motors shall be NEMA design ball bearing type with electrical characteristics and horsepower as specified on the schedule. Motors shall be 1750 RPM, open dripproof type. All motors shall be high efficiency.
  3. The motor shall be mounted on the same isolation base as the fan. The motor shall be on an adjustable base.
  4. Fan bearings shall be self-aligning, pillow block or flanged type regreaseable ball bearings and shall be designed for an average life (AFBMA L50) of at least 200,000 hours. All bearings shall be factory lubricated and equipped with standard hydraulic grease fittings and lube lines extended to the motor side of the fan.
  5. Fan drives shall be selected for a 1.5 service factor and anti-static belts shall be furnished. All drives shall be adjustable pitch.
  6. Fan shafts shall be selected to operate well below the first critical speed and each shaft shall be factory coated after assembly with an anticorrosion coating.
- C. The fan shaft shall be motor driven through a Vee-belt drive. The drive assembly shall be designed for not less than 150% of the motor ampere rating. Adjustment of belt tension shall be by means of an adjustable motor base. The drive assembly shall conform to A.R.I. Standard 435-78. The drive sheave shall be variable pitch type where it falls between limits of A.R.I. Standard 435-78. Outside the established limits an initial and a final set of fixed drives shall be required. Fan motors shall have copper windings.
- D. Air filters shall be 2 inches thick arranged in modular sizes to be readily removable through a hinged access door. Air filters shall be MERV 8.
- E. The exterior and interior of the casing shall receive a rust and corrosion resistant finish.

F. The heating and ventilating units shall be manufactured by Trane Co., York/Johnson Controls, American Air Filter, Carrier.

1. Any listed equivalent manufacturer and the Mechanical Contractor shall be completely responsible to comply with all requirements on the contract documents. This shall include, but not be limited to, space requirements, code clearances, the type, horsepower, capacities, number and size of services required from other trades.

## 2.2 PACKAGED AIR-TO-AIR ENERGY RECOVERY UNIT

A. Factory fabricated and assembled unit consisting of constant volume fans, motors, and drive assemblies, coils, plenum casing, filters, energy recovery wheel (with motor and drive), flat plate energy recovery heat exchanger, motor-operated outside air and exhaust air dampers, access doors and operating controls.

B. Casing:

1. Casing panels shall consist of dual wall, minimum 18-gauge galvanized solid exterior skins and 22-gauge galvanized steel solid interior skins enclosing 2" thick 1.5 pcf fiberglass insulation with a minimum R-value of 10 which meets NFPA 90A and UL181 test standards. All metal-to-metal surfaces exposed to the weather shall be sealed airtight with maximum leakage not-to-exceed 2% at external static pressure of 3" W.C.
2. Removable panels shall be provided for energy recovery wheels, and fans. The housing shall be supported by an all-welded epoxy-painted structural base. Lifting lugs shall be welded to the base. All frame and panel members shall be G90 galvanized steel.
3. Access to all internal devices and sections shall be provided through hinged, sealed doors. Access doors shall be constructed of the same materials as the unit casing. Each door shall be provided with two cam type handles and two heavy duty hinges to achieve maximum sealing. Handles are to be internal and external for opening from the inside or outside of the unit.
4. The unit's duct connections shall be arranged to require only minor ductwork offsets or transitions to the packaged heating/cooling unit.
5. Unit features and casing shall be of weatherized construction including:
  - a. Continuous 18 gauge galvanized steel, pitched watertight roof with standing seams.
  - b. Gasketed sections requiring no caulking at the job site.
  - c. Internal galvanized steel drain pans in each section.

C. Fans:

1. Fan ratings are based on tests made in accordance with AMCA Standard 210 and shall bear the AMCA Seal. Fans shall be of the centrifugal type, designed with a scroll type housing. Fans shall incorporate a wheel, structural steel frame and shaft and bearings in the AMCA Arrangement 3 configuration to form a heavy-duty integral unit. All fan wheels shall provide stable flow and high rigidity. The wheels shall be non-overloading type. The blades shall be continuously welded, die-formed backward curved type, designed for maximum efficiency and quiet operation. Impellers shall be statically and dynamically balanced and the complete fan assembly shall be test balanced at the operating speed prior to shipment.
2. Shafts shall be AISI hot rolled steel accurately turned, ground, polished, and ring gauged for accuracy. Shafts shall be sized for first critical speed of at least 1.43 times the maximum speed for the class.
3. Bearings shall be heavy duty, grease lubricated, anti-friction ball or roller, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-10) in excess of 100,000 hours at the maximum class RPM.

4. Fans shall be mounted on vibration bases with adjustable motor bases, V-belt drives, minimum 1” static deflection spring isolators, and flexible connections. Belts shall be designed for a minimum 1.5 service factor. Drives for motors shall be variable pitch.
  5. Motors shall be standard NEMA frame, design B high efficiency, with 1.15 service factor and open drip-proof enclosures. Motor selections shall be non-overloading over the fan curve from 0 to 150% of design flow, and the design BHP shall not be above 90% of motor horsepower at design condition.
- D. Total Energy (Enthalpy) Recovery Wheel:
1. The rotor media shall be made of aluminum which is coated to prohibit corrosion. All media surfaces shall be light weight polymer coated with a permanently bonded Silica gel desiccant prior to being formed into the honeycomb media structure to ensure that all surfaces are coated and that adequate latent capacity is provided. Desiccant coatings that must be reapplied over time are not acceptable.
  2. Sensible and latent recovery efficiencies shall be clearly documented through a certification program conducted in accordance with ASHRAE 84-1991 and the results shall be presented in accordance with ARI 1060-2000 Standards. The certification shall have been conducted by the unit manufacturer.
  3. Wheel testing to document that the desiccant material utilized does not transfer pollutants typically encountered in the indoor air environment shall be provided. The cross-contamination and performance certification reports shall be provided for as part of the submittals for this project.
  4. The media shall be cleanable with low temperature steam, hot water or light detergent, without degrading the latent recovery. Dry particles up to 650 microns shall pass freely through the media.
  5. Rotor System:
    - a. Seals: The rotor shall be supplied with diameter and perimeter seals which shall not make contact with any rotating surface of the exchanger rotor face.
    - b. Rotor Support System: The rotor media shall be provided in segmented fashion to allow for field erection or replacement of one section at a time without requiring side access. The media shall be rigidly held by a structural spoke system made of stainless steel.
    - c. Rotor Housing: The rotor housing shall be a structural framework which limits the deflection of the rotor due to air pressure loss to less than 1/32". The housing shall be made of galvanized steel to prevent corrosion. The rotor shall be supported by two pillow block bearings which can be maintained or replaced without the removal of the rotor from its casing or the media from its spoke system. Bearings shall be selected for an L-10 life in excess of 30 years.
    - d. Drive System: The rotor shall be driven by a self-adjusting flexible, circumferential belt system. A/C motors shall be utilized.
    - e. Assembled system shall incorporate the complete wheel assembly, seals, drive motor and belts in an insulated cassette frame within a slide-out track.
- E. Filters:
1. Provide filters for both inlet air streams, outside air and return air.
  2. Filters shall be disposable 2" thick, MERV 8. The filter shall be listed by Underwriters' Laboratories as Class 2.
  3. Provide a bank of galvanized universal holding frames arranged for upstream access.
- F. Electrical: 460-volt, 3 phase, 60 Hz; electrical features shall include single point power feed

termination, unit-mounted lockable disconnect, internal circuit breaker type overload protection, starters, 24 VAC control transformer and fusing.

- G. Connections: System field connections shall be limited to:
  - 1. Supply air duct connection from the packaged unit.
  - 2. Return air duct connection to the packaged unit.
  - 3. Field supplied power source.
  - 4. Coil piping connections for condensate drain.
- H. BAS Controller: Provided by ATC, field mounted and wired.
- I. Basic Safety/Operating Controls: Unit manufacturer shall supply the following safety/operating control features:
  - 1. A thermostat to deenergize the compressors when the suction line temperature drops below 22°F.
  - 2. A five-minute timer to prevent the compressor from short cycling.
  - 3. A lock-out circuit to prevent the compressors from cycling on one of their safety controls.
  - 4. A cutout to protect the compressors during abnormally low voltage conditions.
- J. Roof Curb: Prefabricated galvanized steel mounting curb shall be provided for field assembly on the roof decking prior to unit placement. The roof curb shall be a perimeter type with complete perimeter support of the air handler unit. The curb shall be a minimum of 12" high. Gasketing shall be provided for field mounting between the unit base and roof curb. Curb shall include a 2" x 4" wood nailer.
- J. Manufacturers: Basis of design, Greenheck. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work are limited to one of the following:
  - Addison
  - Annexaire
  - CanFab, Inc.
  - Desert Aire
  - Greenheck
  - Innovent
  - Loren Cook
  - Temtrol
  - Thybar Corp.
  - Valent
  - VenMar
  - 1. Any listed equivalent manufacturer and the Mechanical Contractor shall be completely responsible to comply with all requirements on the contract documents. This shall include, but not be limited to, space requirements, code clearances, the type, horsepower, capacities, number and size of services required from other trades.

2.3 SINGLE PACKAGED, GAS-FIRED ROOFTOP AIR CONDITIONING UNIT

- A. Refrigeration System:
  - 1. One independent refrigeration circuit with hermetic compressor, crankcase heater, strainer, high and low pressure control, compressor motor protection, and access valves.

2. A direct expansion, draw-thru evaporator coil shall be circuited so that its entire fin surface will be active during part load operation.
  3. Draw-thru condenser coils with a separate sub-cooling circuit for each refrigeration system shall provide at least 15 F of sub-cooling at design conditions.
  4. Outdoor air thermostats shall cycle the condenser fan motors to maintain stable operation at ambient temperature down to 35 deg. F. Condenser fan motors shall have inherent protection.
- B. 100% Outdoor Air (Economizer Package):
1. Outdoor and return air dampers shall be interlocked in position by a fully modulating damper actuator. Actuator shall be spring return so that the outdoor air intake dampers will close when power to the unit is interrupted.
  2. Maximum leakage rate for the outdoor air intake dampers shall not exceed 2% when fully closed and operating against a pressure differential of 0.5" WC.
  3. A unit-mounted potentiometer shall be provided to adjust the outdoor and return air damper assembly to take in minimum scheduled or 10% CFM of outdoor air.
  4. During economizer operation, a mixed air temperature control shall modulate the outdoor and return air damper assembly to prevent the supply air temperature from dropping below 55 deg. F.
  5. Changeover from mechanical refrigeration to economizer operation shall be provided by enthalpy control.
  6. The outdoor intake opening shall be covered with a birdscreen and a rain-hood that matches the exterior of the unit.
- C. Exhaust Air Relief Dampers:
1. Economizer shall be equipped with barometric dampers that will open to exhaust return air as more outdoor air is supplied to the conditioned space during economizer operation. This relief shall prevent the conditioned space from over-pressurizing during economizer operation.
  2. Exhaust air opening shall be covered with a birdscreen and a rain hood that matches the exterior of the unit.
- D. Filters shall be 2" thick replaceable type MERV 8 and internal metal frame work.
- E. A 1,750-rpm single supply air blower motor shall have a 1.15 service factor, solid base, Class B insulation and ball bearings with permanent lubrication. All belts and pulleys shall be treated with permanent lubrication. All belts and pulleys shall be rated at least 25% above the nominal drive horsepower. The fan shaft ball bearings shall have minimum average bearing life (AFBMA L-10) in excess of 100,000 hours at the maximum class RPM.
- F. Roof Curb:
1. Roof curb shall be supplied by the unit manufacturer to provide a watertight seal between the roof and the unit.
  2. Roof curb shall be approved by the National Roofing Contractor's Association.
  3. Roof curb shall be full perimeter with all utility and duct connections within the perimeter of the curb eliminating the need for other roof penetrations.
- G. Unit Construction:
1. All sheet metal parts shall be constructed of a zinc coated, commercial grade galvanized steel. All external surfaces shall be finished with a UL approved coating system.
  2. Removable side panel shall provide easy access for maintenance, service and adjustment.

3. Unit shall be single wall construction with foil faced insulation such that insulation is not exposed to the air stream.
  4. Unit shall have lifting lugs on each of the four upper corners.
  5. Condenser coils and fan discharge shall be protected by heavy duty wire guards.
- H. Basic Safety/Operating Controls - Unit manufacturer shall supply the following safety/operating control features:
1. A firestat to deenergize the unit if the temperature of the air returning to the unit rises to 145 deg. F.
  2. A thermostat to deenergize the compressors when the suction line temperature drops below 22 deg. F.
  3. A five-minute timer to prevent the compressor from short cycling.
  4. A lock out circuit to prevent the compressors from cycling on one of their safety controls.
  5. A cutout to protect the compressors during abnormally low voltage conditions.
- I. Unit shall be complete BAS Controller: DDC controller shall be provided by ATC, field mounted and wired.
- J. Gas Heating Section:
1. Manufacturer shall furnish a natural gas furnace constructed of 20-gauge aluminized steel tubes.
  2. Furnace shall include the following controls and safety devices:
    - a. Intermittent spark ignition with two stage gas valve with pressure regulator.
    - b. Centrifugal blower to maintain positive flue pressure with air pressure safety switch.
    - c. Electronic ignition with flame sensor and lockout safety valve.
    - d. High temperature limit thermostat with automatic reset.
- K. Manufacturer: Trane, York/Johnson Controls, Carrier, Daikin McQuay.
- L. Manufacturer shall furnish start-up.
1. Any listed equivalent manufacturer and the Mechanical Contractor shall be completely responsible to comply with all requirements on the contract documents. This shall include, but not be limited to, space requirements, code clearances, the type, horsepower, capacities, number and size of services required from other trades.
- 2.4 PACKAGED GAS-FIRED ROOFTOP UNIT (KITCHEN VENTILATION)
- A. Unit Construction:
1. All sheet metal parts shall be constructed of 18-gauge commercial grade galvanized steel. All external surfaces shall be finished with manufacturer's standard color enamel coating system.
  2. Removable side panel shall provide easy access for maintenance, service and adjustment of components within the supply fan section and filter/damper section.
  3. Unit shall be single wall construction with foil faced insulation minimum 1" thick fiberglass pinned to housing and designed for NPFA 90A requirements.
  4. Unit shall have lifting lugs on each of the corners, factory assembled, except where larger units require two-piece shipment.
  5. Modular sections shall include insulated downturn supply plenum, gas-fired heater section, supply fan, filter/damper section and air intake section.
  6. All modules shall be of weatherproof design, joined with Ductmate connectors.

- B. Outdoor Air/Filter/Damper Section:
1. Outdoor air damper shall be controlled by a factory mounted and wired damper actuator. Actuator shall be spring return so that the outdoor air intake damper will close when power to the unit is interrupted. Damper actuator shall be mounted inside housing.
  2. Maximum leakage rate for the outdoor air intake dampers shall not exceed 2% when fully closed and operating against a pressure differential of 0.5" W.C.
  3. The outdoor intake opening shall be covered with a removable inlet birdscreen and a rain hood that matches the exterior of the unit.
  4. Filters shall be 2" thick replaceable type MERV 8 and internal metal frame work.
- C. A 1,750-rpm single supply air blower motor shall have a 1.15 service factor, solid base, Class B insulation and ball bearings with permanent lubrication. All belts and pulleys shall be treated with permanent lubrication. All belts and pulleys shall be rated at least 65% above the nominal drive horsepower. The fan shaft ball bearings shall have an average life rating of 100,000 hours of operation. Fan shaft shall be machined from SAE 1020 cold rolled steel. Fans shall be FC Type, DWDI design. Fan and drive assembly shall be mounted on rubber isolators with adjustable motor base.
- D. Roof Curb:
1. Roof curb shall be supplied by the unit manufacturer to provide a watertight seal between the roof and the unit.
  2. Roof curb shall be approved by the National Roofing Contractor's Association.
  3. Roof curb shall be full perimeter with all duct connections within the perimeter of the curb eliminating the need for other roof penetrations.
- E. Gas Heating Section:
1. Manufacturer shall furnish a natural gas furnace AGA labeled and constructed of 20-gauge Type 409 stainless steel tubes. Provide Type 409 stainless steel flue collector and side vent with cap.
  2. Furnace shall be as manufactured by Sterling and include the following controls and safety devices:
    - a. Intermittent spark ignition with two stage gas valves with pilot gas valve pressure regulator.
    - b. Centrifugal blower to maintain positive flue pressure with air pressure safety switch.
    - c. Electronic ignition with flame sensor and lockout safety valve.
    - d. High temperature limit thermostat with automatic reset.
    - e. 24-volt control voltage.
- F. Unit shall be completely factory wired, piped and tested by the manufacturer before shipment.
- G. Unit-mounted motor control center shall be factory installed, wired and include the following components:
1. Single point power connections within NEMA 3R enclosures for fused disconnect switch and motor controls.
  2. Magnetic contactors with overload protection in all legs.
  3. Resets for supply and exhaust fans, with interlocking contactor, additional contactor for motor-operated outside air damper.
  4. Fused transformer to provide secondary 24 VAC control voltage for heater section control and control panel on face of kitchen hood. Electronic modulating discharge temperature control with internal setpoint selector.



5. All components U.L. listed or classified and wired per N.E.C.
- H. Exhaust fan section shall be factory mounted and wired. Fan shall be as scheduled on drawings and as specified in Section 23 34 00.
- I. Accessories:
  1. Remote discharge air temperature setpoint controller for field mounting. Control interface with unit-packaged control center shall be part of the work of Division 23- Mechanical.
  2. Provide 24VAC control voltage relays for interface between unit packaged control center and heat detectors furnished with the kitchen type I ventilator package for automatic operation of the makeup air unit and its associated ventilator exhaust fan.
- J. Manufacturer: Kees, Inc., Greenheck, Captive Aire, Weather-Rite.
  1. Any listed equivalent manufacturer and the Mechanical Contractor shall be completely responsible to comply with all requirements on the contract documents. This shall include, but not be limited to, space requirements, code clearances, the type, horsepower, capacities, number and size of services required from other trades.

### **PART 3 – EXECUTION**

#### **3.1 INSTALLATION**

- A. Verify that coils, filters, motors, drives and other components are matched with the proper unit.
- B. Assemble unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas, and paint in accordance with manufacturer's written recommendations.
- C. Vacuum clean interior of units prior to operation.
- D. Repair air leaks from or into casing that can be heard or felt during normal operation.
- E. Install rooftop units in accordance with manufacturer's installation instructions. Install units plumb and level, firmly anchored in locations indicated, and maintain manufacturer's recommended clearances.
- F. Support: Install and secure roof curb to roof structure, in accordance with National Roofing Contractors Association (NRCA) installation recommendations and shop drawings. Install and secure rooftop units on curbs and coordinate roof penetrations and flashing.
- G. Perform field mechanical balancing in accordance with Section 23 05 93.
- H. The Mechanical Contractor shall own as part of his work, the following:

Provide one (1) additional drive set, if necessary, to obtain final design balancing requirements. The Mechanical Contractor shall coordinate with Balancing Firm and equipment manufacturer for drive selection, including belts and pulleys.
- I. Provide certified factory start-up and written report on all units.

#### **3.2 AUTOMATIC TEMPERATURE CONTROLS**

- A. Coordination of control work with the BAS shall include, but not be limited to, the following items as described in Section 23 09 00.
- B. Constant volume rooftop units:
  1. The following items shall be provided by the equipment manufacturer:
    - a. Motor starters and overload protection.
    - b. Control transformers.

- c. Energy wheel motor, speed controller, defrost controller, rotation failure contact, and status contact.
  - d. Dampers and damper motors.
  - e. Terminal blocks for all wiring connections between equipment and control devices.
  - f. Analog air filter differential pressure sensor.
  - g. Manual reset freeze stat.
  - h. Variable frequency drives as scheduled.
  - i. Run status dry contact for each VFD.
2. The following items will be furnished by the BAS Contractor and installed by the equipment manufacturer:
- a. DDC Controller
  - b. Discharge air temperature sensor.
  - c. Discharge humidity sensor.
  - d. Return air temperature sensor.
  - e. Return air humidity sensor.
  - f. Temperature sensor at exhaust air outlet.
  - g. Current sensor for one phase of power feeding the supply fan, and/or unit exhaust fan.
  - h. Mixed air average temperature sensor.
  - i. Heating coil discharge air temperature.
3. The following items shall be field mounted and wired by the BAS Contractor:
- a. Discharge air temperature sensor.
  - b. Discharge humidity sensor.
  - c. Heating coil discharge air temperature sensor.
  - d. Manual reset freezestat (supplied by ATC).
- C. Variable Volume Rooftop Units:
1. The following items shall be provided by the equipment manufacturer:
    - a. Motor starters and overload protection.
    - b. Control transformers.
    - c. Energy wheel motor, speed controller, defrost controller and rotation failure contact.
    - d. Dampers and damper motors.
    - e. Terminal blocks for all wiring connections between equipment and control devices.
    - f. Analog air filter differential pressure sensor.
    - g. Variable frequency drives with status/alarm feedback signal for monitoring via the BAS.
    - h. Manual reset freeze stat.
  2. The following items will be furnished by the BAS Contractor and installed by the equipment manufacturer:
    - a. DDC Controller.
    - b. Discharge air temperature sensor.
    - c. Discharge humidity sensor.

- d. Return air temperature sensor.
  - e. Return air humidity sensor.
  - f. Temperature sensor at exhaust air outlet.
  - g. Mixed air average temperature sensor.
3. The following items shall be field mounted and wired by the BAS Contractor:
    - a. Discharge air temperature sensor.
    - b. Discharge humidity sensor.
    - c. Heating coil discharge air temperature sensor.
    - d. Manual reset freezestat (supplied by ATC).
- D. Rooftop Energy Recovery Units:
1. The following items shall be provided by the equipment manufacturer:
    - a. Motor starters and overload protection.
    - b. Control transformers.
    - c. Energy wheel motor, speed controller, defrost controller and rotation failure contact.
    - d. Dampers and damper motors.
    - e. Terminal blocks for all wiring connections between equipment and control devices.
    - f. Analog air filter differential pressure sensor, each filter bank.
    - g. Manual reset freeze stat.
  2. The following items will be furnished by the BAS Contractor and installed by the equipment manufacturer:
    - a. DDC Controller.
    - b. Unit discharge air temperature sensor.
    - c. Heating and cooling coil discharge air temperature sensors.
    - d. Discharge humidity sensor.
    - e. Return air temperature sensor.
    - f. Return air humidity sensor.
    - g. Temperature sensor at exhaust air outlet.
    - h. Current sensor for one phase of power feeding the supply and exhaust fans.
  3. The following items shall be field mounted and wired by the BAS Contractor:
    - a. Discharge air temperature sensor.
    - b. Discharge humidity sensor.
    - c. Heating coil discharge air temperature sensor.
    - d. Manual reset freezestat (supplied by ATC).
- E. The factory mounted DDC controllers shall be fully programmed with factory approved applications. Any modifications to these programs shall be done by factory trained personal or as approved by the DDC controls and unit equipment manufacturer.

The unit equipment manufacturer shall provide coordination for start-up, check-out, and test of the factory mounted DDC controllers and network devices including the protocol translator. Any hardware and software necessary including labor shall be provided by the unit equipment manufacturer.

The unit DDC controllers shall be networked to a standard protocol translator or gateway so system points shall be available for communications and control from the Building Automation System (BAS)/Automatic Temperature Controls (ATC) System. The protocols available from the protocol translator to the BAS/ATC System shall be BACNET (MSTP), LON or N2.

System points shall be configured to the BAS/ATC System by the BAS/ATC System Contractor. The mapping of points to the BAS/ATC front-end/PC shall be done by the BAS/ATC Contractor. Any software or hardware necessary including labor to accomplish this work shall be provided by the BAS/ATC System Contractor.

END OF SECTION