

University of Houston Master Specification

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SECTION 23 7223 – ENERGY RECOVERY UNITS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

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

This Section uses the term "Engineer." Change this term to match that used to identify the design professional as defined in the General and Supplementary Conditions.

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

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Provide and install a factory-assembled, self-contained, air-to-air no heat energy recovery unit (ERU) manufactured in the U.S.A. The ERU shall consist of, but not be limited to: insulated casing, supply fans, exhaust fans, motorized dampers, filters, **[air to air heat pipe]**, **[energy recovery wheel]**, **[air to air plate heat exchanger]**, **[run-around coils]**, **[cooling coils]**, electrical controls, electrical switched compartment lights completely factory wired, and accessories as specified.
- B. Unit shall be shipped as a single package unless the unit is too large to fit on a standard tractor-trailer.
- C. Perform all Work indicated by the Drawings and Specifications with supplementary items required and necessary for proper unit installation.
- D. In general, all capacities of equipment and motor and starter characteristics are shown on the Drawings. Refer to the Drawings for such information. The capacities shown are minimum capacities. Variations in capacities of scheduled equipment supplied under this Contract will be permitted only with written direction of the Owner.
- E. Insofar as is possible, all items of the same type (i.e., wheel, coils, fans, etc.) shall be by the same manufacturer.

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- F. Motor frame types and horsepower shown on the Drawings are the minimum. Provide motor horsepower to meet performance requirements.
- G. Design entering and leaving air temperature conditions, outside and exhaust air quantities and performance capacity requirements are indicated on the Drawings.

1.3 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.
- C. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
- D. ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.
- E. ASTM A653 – Hot Dipped Galvanized Steel Sheet.
- F. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- G. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- H. AMCA 99 - Standards Handbook.
- I. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
- J. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
- K. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.
- L. AMCA 500 - Test Methods for Louver, Dampers and Shutters.
- M. ARI 410 - Forced-Circulation Air Cooling and Air Heating Coils.
- N. ARI Guideline V – Calculating the Efficiency of Energy Recovery Ventilation and its Effect and Sizing of Building HVAC Systems.
- O. (ANSI) / ARI 1060 - Rating Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment.
- P. NREL/TP-550-26131 - Desiccant Dehumidification Wheel Test Guide.
- Q. NEMA MG1 - Motors and Generators.
- R. NFPA 70 - National Electrical Code.
- S. NFPA 90A Limits for Flame Spread and Smoke Ratings.
- T. UL 900 - Test Performance of Air Filter Units.

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U. (ANSI) ASHRAE 84 - Method of Testing Air-to-Air Heat Exchangers.

V. ASTM C168 - Terminology Relating to Thermal Insulation Materials.

1.4 QUALITY ASSURANCE

A. Energy recovery unit shall be provided by a manufacturing firm with minimum five (5) years of documented experience specializing in the engineering, design, fabrication and testing of energy recovery components.

B. All calculations and efficiencies to meet the performance requirements of this Section are to be processed per the referenced applicable AMCA, ASHRAE 84 Standards, ARI, and NREL guidelines.

C. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.

D. All materials shall have NFPA 90 rating of 25/50 or better.

E. Inspect all ERU components and assemblies prior to shipment to the Project Site. A factory authorized representative shall perform a field inspection of the field assembled components and assemblies, and equipment installation, including all piping, electrical connections, and direct digital controls and instruments that are in the scope of manufacturing and testing of the ERU.

1.5 SUBMITTALS

A. Product Data

1. Provide literature that indicates dimensions, weights, capacities, ratings, fan performance, gages and finishes of materials, electrical characteristics and connection requirements.
2. Provide data for filter media, filter performance data, filter assembly and filter frames as tested and certified per ASHRAE and NFPA 90 flame spread and smoke rating standards.

B. Record Documents

1. Submit under provisions of Division 01.
2. Provide fan curves with specified operating point clearly plotted, as tested and certified per AMCA standards. Ratings to include system effects. Bare fan ratings will not satisfy this requirement but shall be submitted for comparison purposes. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the Drawings. Where two fans are operated in parallel, provide Hagen's Line plots on fan curves, proving fans will not be operating in the unstable region.
3. Submit sound power level data for both fan outlet and casing radiation at rated capacity, as tested and certified per AMCA standards. All fan data shall be generated from specified testing. The fan shall compare favorably with the scheduled data listed in the Drawings. The selected unit will not exceed the scheduled sound power data.

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4. Unit manufacturer shall submit full sound performance data to the Project sound consultant for evaluation. Unit shall be finally configured so as not to exceed sound levels as scheduled on Drawings.
 5. Equipment performance table comparing the performance of the energy recovery system against a conventional (per Specifications using two (2) six-row coils in series) outside air unit. The table should consider peak wet bulb design conditions to winter design condition of 20 degrees F, in 5 degree F wet bulb increments. This table shall also include the following data for every interval:
 - a. Fresh air cfm, dry bulb and wet bulb (before and after the wheel).
 - b. Exhaust air cfm, dry bulb and wet bulb (before and after the wheel).
 - c. Purge section cfm.
 - d. Cross contamination cfm.
 - e. Pressure loss.
 - f. Fan power consumption (kW addition over standard unit).
 - g. Cooling tonnage reduction (sensible and latent).
 - h. Heating BTU added.
 - i. Operating RPM at each point (minimizing supply relative humidity and temperature).
 6. Provide efficiency ratings and performance data on all air-to-air energy recovery equipment being supplied with the ERU in accordance with ARI Guideline V, (ANSI) ARI Standard 1060, and in accordance with independent laboratory test per (ANSI) ASHRAE Standard 84.
 - a. If the ERU supplier does not have ARI certification for air-to-air energy recovery equipment, a letter signed by an engineering officer of the corporation must state that the ERU components meet or exceed the requirements of ARI Guideline V and ANSI Standard 1060, and a list documentation of equivalent performance test and the date of test must be enclosed with the letter.
 - b. Provide performance data on finned tube coils as tested and certified per ARI Standards.
- C. Operation and Maintenance Data:
1. Submit Operating and Maintenance (O&M) Manuals with electrical requirements for power supply wiring including wiring and sequence logic diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring, parts list, with a description of operation and controls, and the required maintenance procedures.
 2. Manufacturer shall prepare a spare parts list with cost per item for items that are necessary to keep the units operational.

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1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect, and handle products to the Project Site under provisions of Division 01 and Section 23 0100 "Mechanical General Provisions."
- B. Deliver materials to the Project Site in original factory packaging, labeled with manufacturer's identification including product thermal ratings and thickness.
- C. Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.
- D. All motors, enthalpy wheel segments, plate-to-plate exchangers, and coils are to be sealed in heavy plastic and stored in a protected area.

1.7 EXTRA MATERIALS

- A. Provide the following items with each shipment of the ERU to the Project Site:
 - 1. Furnish two (2) sets of each filter type specified.
 - 2. Furnish two (2) sets of all types and size of belts for each driven component.

1.8 WARRANTY

- A. Provide a two (2) year warranty on all parts except for filters. Provide a five (5) year warranty on the enthalpy and desiccant wheels. The warranty shall include the repair and replacement of any part that fails during the specified time period. Include labor cost in all warranties.
- B. The warranty shall start on Substantial Completion date.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 MANUFACTURERS

- A. The following manufacturers are approved in principle subject to meeting this Specification:
 - 1. Annexair, Inc.
 - 2. Des Champs Technologies, Inc.
 - 3. Dessicant Rotors International, US, LLC.
 - 4. Semco, Inc.
- B. Manufacturers and representatives are responsible for reviewing dimensional variances between the Contract Documents and the manufacturer's proposed and final dimensioned equipment Drawings. Since this is specialized equipment item, the manufacturer is also responsible for all coordination issues that may arise from design to Commissioning the ERU.

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2.3 ENERGY RECOVERY COMPONENTS

A. Air-to-Air Heat Pipe Heat Exchanger:

1. Comply with UL Standards.
2. Tube and fin material shall be compatible with the air streams.
3. Thermal recovery units shall be capable of operating at temperatures ranging from a minimum of -29 degrees C (-20 degrees F) to a maximum of 49 degrees C (120 degrees F). The heat transfer between air streams shall take place in a counter flow arrangement. The unit shall have no moving parts and shall be one-piece construction.
4. Tube core shall be either 18 mm (5/8 inch) or 25-mm (1 inch) OD seamless aluminum tubing permanently expanded into the fins to form a firm, rigid and complete metal pressure contact between the tube and fin collar of all operating conditions. Provide copper tubes and copper fins for corrosive air streams.
5. Secondary surfaces shall be of continuous plate type aluminum fins, 0.18 mm (0.007 inch) thick, and of corrugated design to produce maximum heat transfer efficiencies.
6. Basic capillary wick shall be an integral part of the inner wall of the tube and provide a completely wetted surface for maximum heat pipe capacity with minimum heat transfer resistance.
7. Refrigerants shall be approved by EPA.
8. Provide a vertical partition to isolate the exhaust and supply airstreams from each other, so that there will be no cross-contamination. Partition shall be a minimum of 1.9 mm (14 gage) galvanized steel. Provide stainless steel casing for corrosive air streams.
9. Casing shall be a minimum of 1.9 mm (14 gage) galvanized steel.
10. End covers shall be a minimum of 1.0 mm (20 gage) galvanized steel.
11. Provide a mechanism so that the unit can be tilted for summer-winter operation. Actuator used to tilt the unit shall be electric. Provide control panels and sensing bulbs as shown on the Drawings.
12. Provide flexible connectors for each side of the unit. The flexible connector shall be fabricated in a manner that will allow the unit to tilt without binding.

B. Rotary Air-to-Air Heat Exchanger

1. Comply with UL Standards.
2. Wheel media for heat transfer such as aluminum, copper, stainless steel, or Monel, shall be compatible with the air streams.
3. Exchanger Rotor or Wheel:
 - a. Rotary enthalpy wheel that will provide the design dry and wet bulb temperatures as shown on the Drawings.
 - b. The wheel shall have a flame spread rating less than 25 and smoke developed rating less than 50 and shall be independently tested in accordance with ASTM standard E-84.
 - c. Rotor media shall be independently tested in accordance with ASHRAE 84. Rotor media shall allow laminar flow (but not radial) at a velocities to reduce leakage, bypassing and cross contamination by cross flow within wheel.

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- d. Size the transfer media to allow passage of 300 micron particles without fouling or clogging. When latent heat transfer is required, treat media with non-degrading desiccant that is bacteriostatic, non-corroding and non-toxic. No asbestos material will be allowed. Wheels constructed with paper substrate or polymer media materials are not acceptable.
 - e. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with this Section.
4. Provide casing seals on periphery of rotor as well as on duct divider and purge section if applicable for this ERU. The face rotor or wheel surface shall be ground and polished to form a smooth surface to achieve long seal life. The seals shall be adjustable, of extended life materials and effective in limiting air bypass leakage.
 5. Rotor or wheel shall be supported by roller bearings and belt driven by a fractional horsepower, totally enclosed; NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction. Bearings should be serviceable and replaceable without having to remove the rotary wheel from the housing. Caster mounted rotor or wheels are not acceptable.
 - a. Where constant speed wheel is indicated on the Drawings provide an AC motor.
 - b. Where variable speed wheel is indicated on the Drawings, exchanger wheel speed and leaving temperature control shall be achieved by means of a variable speed drive. Operation shall be 115/1/60 Volts and by a proportioning temperature controller that varies output voltage of a silicon-controlled rectifier (SCR) to a rectified power motor that will change speed in proportion to changes of voltage to its armature. Include an adjustable thermo switch for automatic changeover for summer-winter operation. Set point of adjustable proportioning temperature controller and thermo switch shall be indicated on visible scale. System shall be capable of speed reduction down to 5 percent of capacity while maintaining adequate torque at any point of operation to rotate wheel.
 - c. System should have an LED type wheel speed indicator, wheel rotation detection device with a local visual alarm on the unit, and an alarm contact to the building automation system (BAS) (flashing red-light) to alert building maintenance.
 6. Purge Section:
 - a. If purge section is required, maintain at minimum percentage of wheel area.
 - b. Provide an automatic, factory built-in, field adjustable purge to limit exhaust air carry-over to less than 5.0 percent of rated volume.
 - c. Purge shall be effective when static pressure difference between supply and exhaust is 125 Pa (one-half, inch w.g.) or greater, and shall have provision for restriction or adjustment to limit purge air volume to not over 4.0 percent of rated air flow when a static pressure difference up to 2.5 kPa (10 inch w.g.) exists.
 7. Accommodations shall be made to ease the cleaning or replacement of rotary wheels or rotary wheel sections.

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8. Unit shall be constructed of heavy gage steel to ensure rigidity and stability. Casing side panels shall be removable to ensure easy access to internal parts. Provide integral flanges for flanged duct connection and provide lifting holes or lugs.

C. Air-to-Air Plate Heat Exchanger

1. Comply with UL Standards.
2. Access plate material shall be compatible with the air streams.
3. Plates: Corrugated 0.53 mm (0.021 inch) diamond embossed aluminum spacing as recommended by the manufacturer.
4. Bedding: Thermosetting reinforced resin. Provide plate seal-off and passage separation at top, bottom and center divider. The resins shall be self-extinguishing type in accordance with ASTM D635.
5. Casing and End Strips: Casing of 1.6 mm (16 gage) galvanized steel in accordance with NFPA. Provide stainless steel casing where corrosive air streams are present. End strips of the same material as exchanger plates. Ends of unit exchanger plates to be sealed with high temperature silicon sealant prior to installation of end strip for corrosive air streams provide welded end strips to avoid cross contaminations.
6. Provide integral flanges for flanged duct connections and provide lifting holes or lugs.
7. Furnish accessories where indicated on the Drawings.
 - a. Face and bypass control dampers shall be constructed with galvanized steel blades and frame, with blade and blade jamb seals for low leakage performance. Dampers shall be provided by the manufacturer complete with electric actuators.
 - b. Provide factory installed controls to operate face and by-pass dampers during summer and winter operation.
 - c. Suspension mounting frame shall be the manufacturer's standard.
 - d. Roof mounting curb for units installed on roofs shall be the manufacturer's standard.
8. **[Provide a factory installed defrost system. The defrost system shall be capable of maintaining at least 85 percent of the non-frosted performance at -29 degrees C (-20 degrees F).]**

D. Run-Around Energy Recovery System

1. Provide a field fabricated system, as shown, containing coils, piping and [_____] percent glycol, pumps, insulation and accessories.
2. Tube and fin material shall be compatible with the exhaust air streams.
 - a. **[Note to Engineer: Pumps for run-around coils must be redundant if the loss of outside air relative humidity and temperature pretreatment could have a major effect on the health and well-being of patients or cause an impact to laboratory animals.]**
3. Provide automatic temperature controls and sequence of operations as shown on the Drawings.

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2.4 CASING AND BASE

A. Unit Casing

1. Panels shall be double wall, reinforced construction with sufficient internal bracing to prevent excessive deflection of the panels.
2. Exterior walls minimum 16-gage G-90 galvanized and interior walls minimum 20-gage G-90 galvanized steel. The interior casing wall of the cooling coil section shall be 20-gage Type 304 stainless steel sheet material.
3. Internal insulation shall be minimum R-value of 12 and fire, mold, and fungus proof.
4. All sheet metal joints throughout the air-handling unit and between panelized sections shall be sealed with closed cell, soft rubber gaskets, fabricated from neoprene, EPDM, or other approved material.
5. Provide airtight enclosure where the air unit casing encloses building columns. Leakage rate shall not exceed that allowed for the unit casing.
6. Maximum deflection at any point on the unit casing shall be limited to 1/200th of the overall panel width or height.
7. Provide a thermal break protection between exterior panel and inner panel construction joints to eliminate all through-metal portions of the unit so that there will be no external condensation.
8. Panel surfaces shall be non-condensing per ASTM D 4230, Measuring Humidity with Cooled Surface Condensation.
9. All surfaces of the ERU casing and base exposed to an outside environment shall have a powder coat finish.

B. Drain Pans

1. Provide IAQ style drain pan under the entire cooling coil section, per compliance with ASHRAE Standard 62.
2. Drain pan shall extend minimum 24 inches downstream of the cooling coil section.
3. Construct drain pan of minimum 14-gage Type 304 stainless steel.
4. Insulate the underside of the entire drain pan with two (2) part sprayed on polyurethane closed cell foam with a minimum of R-8 insulation value. Insulation shall be water impervious rigid type, after curing, and shall occupy all voids and areas between drain pan and outer wall to prevent the occurrence of trapped water, condensation, and microbial growth. Install and seal insulation as appropriate for the equipment construction.
5. Slope drain pan in all planes to the drain connection to prevent accumulation of standing water. On units over ten (10) feet in width, slope pan to drain on both sides of the unit.
6. Condensate from drain pans shall be piped as indicated on the Drawings. The pipe size shall be 1-inch minimum diameter, insulated as specified for chilled water piping. A trap as required to prevent the escape or entry of air through the drain piping shall be provided as indicated on the Drawings.
7. Provide an insulated intermediate drain pan for all coils above another coil, factory piped to main drain pan. Drain pans shall be sloped and constructed of 16 gage Type 304 stainless steel to match the main drain pan and shall extend 6 inches from the coil face.

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C. Base and Floor

1. Construct each unit section on a structural base that supports all major components (i.e., fans, coils, etc.) and is supported with structural steel members. Base and structural members shall be minimum 12 gage G120 galvanized steel.
2. Complete perimeter channel base shall be minimum 6 inch galvanized steel. Base rail height shall be sufficient to meet the lowest coil drain connection to allow for proper condensate drain trap depth in accordance with the Drawings.
3. Fabricate base of electrically welded structural steel members. Use welding procedures and welders certified for structural steel welding according to AWS D1.1 Structural Welding Code - Steel, and AWS D1.3 Structural Welding Code - Sheet Steel.
4. Unit floor panels shall be 16-gage, galvanized steel over expanded foam insulation with a minimum R-value of 8. Hex head zinc coated fasteners shall be used to attach the flooring panels and shall be attached to welded structural frame members. Dow Corning HVAC/R silicon sealant material shall be used to seal the mating surfaces between floor panels and frame members.
5. 20-gage galvanized sheetmetal shall enclose the insulation on the bottom of the unit.
6. All points of contact between the floor, vapor barrier, and structure shall be thermally isolated and sealed with closed-cell soft rubber or EPDM.

D. Access Doors

1. Access doors shall be double wall, insulated the same as wall panels, and the opening framed with thermal break construction.
2. Provide access doors to allow access to both sides (upstream and downstream) of the pre-filter racks, energy recovery components, and cooling coils. Access doors of the fan sections shall be located on the motor side.
3. Door size shall be minimum 18 inches wide and full panel height up to 72-inch tall units. For units above 72 inches tall, provide 72-inch high doors. For panels over 36 inches wide, provide 36-inch wide doors.
4. Access door construction shall equal or exceed the quality of air handler casing materials as specified herein.
5. Each door shall have a minimum 8-inch by 6-inch double glazed view window, capable of withstanding the total developed pressure of the unit.
6. Doors shall be hinged using either heavy-duty adjustable stainless steel butt hinges or a continuous adjustable stainless steel piano hinge, extending along the entire edge of the door, except for a maximum of two inches at each end. If butt hinges are used, provide two (2) per door for up to 36-inch high doors and three (3) per door for longer doors. Provide minimum of two (2) latches on doors longer than 18 inches and three (3) latches on doors over 36 inches long. Latches shall be Ventlok 310, heavy-duty latch.
7. All access doors shall open against air pressure, unless approved by the Owner in writing.
8. All exterior surfaces of the access doors exposed to an outside environment shall be zinc coated galvanized panels with a protective finish (ASTM A653/A) and shall have a baked enamel finish.
9. Intake hoods and exhaust hoods, complete with bird screening over the openings, shall be standard on all outdoor units.

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E. Rigging Performance Requirements

1. Provide lifting lugs suitable for rigging without requiring additional support frames or rails.
2. Provide units that may be lifted without permanent deformation to the housing, base or internal components.
3. Indicate physical balance point on unit bases.

2.5 FANS

- A. Provide fan sections with [double-width double-inlet (DWDI) centrifugal type], [forward curved (FC)], [airfoil (AF)], [backward inclined (BI)], or [single-width single-inlet (SWSI) plug (PF)] fans, minimum class II, constructed of galvanized steel, as scheduled.
1. Higher RPM AF and BI fan casings shall come equipped with additional heavy-duty rectangular angle framework for increased strength and stability.
 2. Fan and unit performance shall be rated and certified in accordance with ARI 430, AMCA300 and ARI 260 as specified elsewhere herein.
 3. Fan wheels shall be keyed to the fan shaft and shall be statically and dynamically balanced at the factory as a complete fan assembly regardless of duty.
 4. Dynamic fan balancing shall be conducted from 16Hz to 66Hz to identify and eliminate critical speeds and to ensure stable operation through the entire operating range of the fan and drive assembly. Forward factory balancing test report upon request of Engineer.
- B. Mount motor drive and fan on integral framework, internally isolated from the casing with factory installed 1-inch deflection spring vibration isolators on units with 8 square feet of coil area or less, and 2-inch deflection on units with coils greater than 8 square feet in area. The fan, drive, and base assembly shall be factory point load tested and balanced with corner isolators selected accordingly for increased stability and to minimize fan assembly noise and vibration and extend bearing life.
- C. Provide internal flexible connection on discharge of fan to isolate fan from casing. Additionally, provide spring loaded fan-shroud-to-casing thrust restraints for all airfoil and backward inclined fans, and on all units with coil face areas greater than 30 square feet.
- D. Fan motors shall be premium high efficiency and VFD compatible. Refer to Division 26 "Variable Frequency Drives."

2.6 BEARINGS AND DRIVES

- A. Bearings: Provide self-aligning grease lubricated, pillow-block ball bearings. Bearings shall be lubricated at the factory and equipped with means for lubrication on the outside of the bearing housing. Bearings shall be designed for an average life (L10) of at least 200,000 hours at the maximum horsepower and operating speed for the classification. Opposite drive side fan bearings shall be sized appropriately to prevent premature wear and bearing skating from uneven loads on bearings to extend bearing life.
- B. Motors shall be in compliance with Division 26 and compatible for use with variable frequency drives.

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- C. Shafts: Solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil. Shafts shall not pass through first critical speed as unit comes up to rated RPM and shall be balanced as part of the fan assembly as described above.
- D. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Variable and adjustable pitch sheaves for motors 15 horsepower and under. Select variable and adjustable pitch sheaves so that required RPM is obtained with sheaves set at mid-position. Provide fixed pitch sheaves for motors equipped with variable speed drives. Provide belts and drive rated for minimum one and one-half times nameplate rating of motor.
- E. Direct Drive: Units with scheduled plug fans shall be direct drive.

2.7 WATER COILS

- A. Provide counterflow chilled water and hot water coils as scheduled. Provide vertical or horizontal coil connection entry to unit casing per the Drawings to maximize maintenance accessibility and minimize coil piping and valve interference. Cooling and heating coils used for outside air pretreatment shall have copper fins in lieu of aluminum fin configuration.
- B. Slide the individual coils into the coil casing through a removable end panel with blank off sheets and sealing collars at connection penetrations. The coil support steel and coil casing is to be made with Type 304 stainless steel for cooling coils and hot dipped galvanized carbon steel for heating coils.
- C. Rate coils in accordance with ARI certified data. Select coil to provide capacity in accordance with water flow and temperatures scheduled on Drawings with maximum water pressure drop through coil as scheduled and a maximum velocity in tubes of 8 feet per second. Provide coil with maximum allowable face velocity as indicated on Drawings.
- D. Provide 1/2-inch or 5/8-inch outside diameter copper tube coils, with a maximum six (6) row depth and a maximum 8 fins per inch spacing supplied with copper headers. Steel pipe water connections shall be welded to copper headers with silica-bronze weld to prevent dielectric corrosion of dissimilar metals, or coil connections shall be provided with isolating devices such as (dielectrically insulated flanges) to extend the life of the coils. If additional rows are required pipe coils in series and provide access section between coils.
- E. Provide coils with plate fin wall thickness of 0.006-inch and tubes of minimum wall thickness of 0.035-inch for 5/8-inch coils and 0.020 for 1/2-inch coils. Connect tubes to header that provides equal flow to all tubes and provide single point connections for supply and return piping per coil. Factory test all coils to 325 psig and forward coil test reports to the Engineer with submittal documentation.

2.8 FILTER SECTIONS

- A. General: Air shall not be allowed to bypass around filters. Provision shall be made to positively lock filters in place to prevent shifting. Provide applicable filter and final filter sections as scheduled on the Drawings. Note: Some units may have multiple filter sections and multiple filter types.

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- B. Angle Filters: Low-velocity angular filter frames with integral, side-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch media. Combine with mixing box where scheduled on Drawings.
- C. Flat Filters: Flat (perpendicular to airflow direction) filter frames with integral, side-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch or 4-inch media (as scheduled).
- D. Open Return Filters: Flat (perpendicular to airflow direction) filter frames with integral, front-access, galvanized steel or extruded aluminum filter frames suitable for 2-inch or 4-inch media (as scheduled).
- E. Cartridge (Rigid) Filters: Flat (perpendicular to airflow direction) filter frames with integral, front or side-access, galvanized steel or extruded aluminum filter frames, with neoprene gasket seal material on the leaving air side of the filter, suitable for a 2-inch pre-filter media and a 12-inch rigid filter media.
- F. HEPA Filters: Flat (perpendicular to airflow direction) filter frames with integral, front-load access, galvanized steel or extruded aluminum filter frames, with leak-free neoprene gasket seal material on the leaving air side of the filter, suitable for a 24-inch high efficiency HEPA filter media.
- G. Filter Gauges: Magnahelic differential pressure gauges shall be installed and mounted on drive side of unit to measure the pressure drop across the filter sections as indicated on the Drawings and/or control schematics.
- H. Refer to Section 23 4000 "Filters and Accessories" for filter media.

2.9 MARINE LIGHTS AND GFI RECEPTACLES

- A. Marine lights shall be provided in access compartments as shown on the Drawings. Access lights shall be wired to a single watertight switch located on the exterior side of unit. A marine GFI receptacle shall be mounted next to the light switch. A separate 120 Volt power connection shall be used for the GFI receptacle. All electrical penetrations through the wall of the ERU shall be sealed by the manufacturer.
 - 1. **[Note to Engineer: Identify access light locations and receptacles on the Drawings.]**
- B. Provide electrical fused-disconnects with units. Units that are exposed to an outdoor environment shall have weatherproof fused-disconnects.

2.10 CONTROLS

- A. Unit shall be provided with manufacturer's control panel and instruments.
- B. Instrumentation and DDC controls furnished with the ERU shall be compatible with the Building Management System (BMS) using a BACnet operating system.

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- C. The DDC controls at a minimum shall consist of a standalone controller, I/O board(s), and instrumentation to provide remote and local indication of entering and leaving relative humidity, and dry and wet bulb temperatures on ventilation air inlet and exhaust air outlet sides of the energy exchange components within the ERU. All filter differential pressures and fan static pressures are to be indicated and monitored by the BMS. The stand-alone controller shall also include functions for purging, speed detection, motor protection, and an alarm.
- D. **[If scheduled on the Drawings, the system should modulate rotor speed between economizer operation down to 0 RPM and maximum heat recovery to 18 RPM when outside air temperature is at peak. Economizer control to reduce rotor speed and prevent discharge air from rising above setpoint.]**
- E. Seal all instrumentation wiring or controls wiring penetrations through the casing of the ERU.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
- B. All installation shall be in accordance with manufacturer's published recommendations.
- C. Follow the equipment manufacturer's instructions for handling and installation, and setting up of ductwork for makeup and exhaust air steamers for maximum efficiency.
- D. Rotary air-to-air exchanger: Adjust seals and adjust purge settings (if used) as recommended by the manufacturer. Verify correct installation of controls.
- E. Seal ductwork connections per the applicable related specification to avoid air leakage.
- F. Provide adequate spacing and access for cleaning and maintenance of heat recovery coils as well as filters.
- G. Secure the energy recovery unit to withstand a wind velocity of [_____] miles per hour, if unit is mounted on a roof or outdoors.
- H. Arrange all water piping to coils so the water circuits are serviceable, without having to dismantle excessive lengths of pipe to remove the coils.
- I. Provide the drain valves and vent cocks for each of the coils.
- J. Provide strainers ahead of recirculation pumps and control valves.
- K. Provide certified wiring schematics to the electrical division for the equipment controls.
- L. Provide all necessary control wiring as recommended by the manufacturer or the ERU.
- M. Provide the correct condensate traps to compensate for blow or draw through pressure characteristics.

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3.2 TESTING

- A. Prior to an integrated test and start-up of this unit, a factory-authorized field service representative shall perform the following:
 - 1. Verify that the unit has specified filtration installed.
 - 2. Perform a full inspection of the assembled unit to confirm the correct rotation of motors.
 - 3. Make seal and/or damper adjustments, test and adjust controls and interlocks.
 - 4. Set and verify initial setpoints on controls and instruments.
 - 5. Perform required final performance leakage test measurements and record for verification by to the Engineer prior to final approval and acceptance of the ERU.

3.3 TRAINING

- A. Provide services of manufacturer's technical representative for four hours to train and instruct Owner about the operation and maintenance requirements of ERU and its energy recovery components.

END OF SECTION 23 7223

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