

## SECTION 237200 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

**TIPS:**

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

## 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.

## 1.2 SUMMARY

- A. Section Includes:
  - 1. Heat wheels.
  - 2. Heat-pipe heat exchangers.
  - 3. Fixed-plate sensible heat exchangers.
  - 4. Fixed-plate total heat exchangers.
  - 5. Packaged energy recovery units.

## 1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7] **<Insert requirement>**.
  - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[ **and the unit will be fully operational after the seismic event**]."

## 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

D. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy recovery equipment.
2. 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.
3. Design Calculations: Calculate requirements for selecting vibration isolators[ **and seismic restraints**] and for designing vibration isolation bases.

## 1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment or suspension systems will be attached.

B. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

## 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Filters: **[One]** <Insert number> set(s) of each type of filter specified.
  - 2. Fan Belts: **[One]** <Insert number> set(s) of belts for each belt-driven fan in energy recovery units.
  - 3. Wheel Belts: **[One]** <Insert number> set(s) of belts for each heat wheel.

## 1.8 QUALITY ASSURANCE

- A. 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.
- B. ARI Compliance:
  - 1. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
  - 2. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."
- C. ASHRAE Compliance:
  - 1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
  - 2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
- D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
- E. UL Compliance:
  - 1. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
  - 2. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

## 1.9 COORDINATION

- A. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

## 1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period for Packaged Energy Recovery Units: [Two] <Insert number> years.
  - 2. Warranty Period for Fixed-Plate Total Heat Exchangers: [10] <Insert number> years.
  - 3. <Insert components requiring extended warranty>.

## PART 2 - PRODUCTS

### 2.1 HEAT WHEELS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Casing:
  - 1. Steel with standard factory-painted finish.
  - 2. Integral purge section limiting carryover of exhaust air to between [0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa)] <Insert value> differential pressure.
  - 3. Casing seals on periphery of rotor and on duct divider and purge section.
  - 4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings[ or permanently lubricated bearings]. Support horizontal rotors on tapered roller bearing.
- C. Rotor: Aluminum segmented wheel strengthened with radial spokes[, with nontoxic, noncorrosive, silica-gel desiccant coating].
  - 1. Maximum Solid Size for Media to Pass: [500] [800] [1200] micrometer.
- D. Rotor: [Glass-fiber] [Polymer] segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
  - 1. Maximum Solid Size for Media to Pass: [800] [1200] micrometer.

- E. Drive: Fractional horsepower motor and gear reducer[, **with speed changed by variable frequency controller**] and self-adjusting multilink belt around outside of rotor.
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- F. Controls:
1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
  2. Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.
  3. Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
  4. Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain[ **exhaust temperature above freezing and**] air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
  5. Pilot-Light Indicator: Display rotor rotation and speed.
  6. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
- G. Disposable Panel Filters:
1. Comply with NFPA 90A.
  2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  3. Factory-fabricated, viscous-coated, flat-panel type.
  4. Thickness: [1 inch (25 mm)] [2 inches (50 mm)].
  5. Dust-Holding Capacity: <Insert lb (kg)>.
  6. Initial Resistance: <Insert inches wg (Pa)>.
  7. Recommended Final Resistance: <Insert inches wg (Pa)>.
  8. Minimum Arrestance: [80] <Insert value>, according to ASHRAE 52.1.
  9. MERV: [5] <Insert value>, according to ASHRAE 52.2.
  10. Media: Interlaced glass fibers sprayed with nonflammable adhesive[ **and antimicrobial agent**].
  11. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
- H. Extended-Surface, Disposable Panel Filters:
1. Comply with NFPA 90A.
  2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  3. Factory-fabricated, dry, extended-surface type.
  4. Thickness: [1 inch (25 mm)] [2 inches (50 mm)] [4 inches (100 mm)].
  5. Dust-Holding Capacity: <Insert lb (kg)>.
  6. Initial Resistance: <Insert inches wg (Pa)>.
  7. Recommended Final Resistance: <Insert inches wg (Pa)>.

8. Minimum Arrestance: [90] <Insert value>, according to ASHRAE 52.1.
9. MERV: [7] <Insert value>, according to ASHRAE 52.2.
10. Media: Fibrous material formed into deep-V-shaped pleats[ **with antimicrobial agent**] and held by self-supporting wire grid.
11. Media-Grid Frame: [**Nonflammable cardboard**] [**Galvanized steel**] [**Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets**].
12. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

I. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface, self-supporting type.
4. Dust-Holding Capacity: <Insert lb (kg)>.
5. Initial Resistance: <Insert inches wg (Pa)>.
6. Recommended Final Resistance: <Insert inches wg (Pa)>.
7. Minimum Arrestance: [95] <Insert value>, according to ASHRAE 52.1.
8. MERV: [13] <Insert value>, according to ASHRAE 52.2.
9. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions[ **and antimicrobial agent**].
10. Filter-Media Frame: [**Galvanized steel**] [**Hard polyurethane foam**].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks[ **with space for prefilter**].

## 2.2 HEAT-PIPE HEAT EXCHANGERS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Casing: Galvanized-steel flanged casing, with airtight partition between airstreams.
- C. Refrigerant: ASHRAE 15, Group 1. <Insert requirements>.
- D. Tubes: [**5/8-inch- (16-mm-)**] [**1-inch- (25-mm-)**] diameter, [**aluminum**] [**copper**] <Insert material>.
- E. Fins: [**Aluminum**] [**Integral aluminum**] [**Copper**].
  1. Fin Spacing: [**0.125 inch (3.18 mm)**] [**0.091 inch (2.31 mm)**] [**0.071 inch (1.80 mm)**] [**0.067 inch (1.70 mm)**] [**0.056 inch (1.42 mm)**] [**0.0075 inch (0.19 mm)**] <Insert fins per inch (mm)>.
  2. Fin and Tube Joint: [**Mechanical bond**] [**Silver brazed**].
- F. Coating: [**Thermoplastic vinyl**] [**Epoxy**] [**Synthetic resin**] [**Phenolic**] [**Polytetrafluoroethylene**] [**Vinyl ester**] <Insert coating>; apply to supply and exhaust.
- G. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.

- H. Control: Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.

## 2.3 FIXED-PLATE SENSIBLE HEAT EXCHANGERS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Casing: **[Aluminum]** **[Galvanized steel]** **[Enameled steel, with galvanized-steel liner]** **[Enameled steel]** with duct collars.
- D. Casing Insulation: **[1/2-inch- (13-mm-) thick, foil-faced glass fiber]** **[1-inch- (25-mm-) thick, foil-faced glass fiber]** **[1 inch (25 mm) thick, ASTM C 1071 with coated surface]** **[1 inch (25 mm) thick, fiber free]**.
- E. Drain Pan: **[Same material as casing, with drain connections on exhaust and supply side]** **[Molded ABS covering bottom of case, with drain connections on exhaust and supply side]**.
  - 1. Comply with requirements in ASHRAE 62.1.
- F. Plates: Evenly spaced and sealed and arranged for counter airflow.
  - 1. Plate Material: **[Embossed aluminum]** **[Stainless steel]** **[Polypropylene copolymer (high-density plastic)]**.
  - 2. Plate Coating: **[Epoxy]** **[Air-dried phenolic]**.
- G. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
- H. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock[, **with detergent injection]**.
- I. Disposable Panel Filters:
  - 1. Comply with NFPA 90A.
  - 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - 3. Factory-fabricated, viscous-coated, flat-panel type.
  - 4. Thickness: **[1 inch (25 mm)]** **[2 inches (50 mm)]**.
  - 5. Initial Resistance: **<Insert inches wg (Pa)>**.
  - 6. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
  - 7. Minimum Arrestance: **[80]** **<Insert value>**, according to ASHRAE 52.1.
  - 8. MERV: **[5]** **<Insert value>**, according to ASHRAE 52.2.
  - 9. Media: Interlaced glass fibers sprayed with nonflammable adhesive[ **and antimicrobial agent**].

10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

J. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface type.
4. Thickness: [1 inch (25 mm)] [2 inches (50 mm)] [4 inches (100 mm)].
5. Initial Resistance: <Insert inches wg (Pa)>.
6. Recommended Final Resistance: <Insert inches wg (Pa)>.
7. Minimum Arrestance: [90] <Insert value>, according to ASHRAE 52.1.
8. MERV: [7] <Insert value>, according to ASHRAE 52.2.
9. Media: Fibrous material formed into deep-V-shaped pleats[ with antimicrobial agent] and held by self-supporting wire grid.
10. Media-Grid Frame: [Nonflammable cardboard] [Galvanized steel] [Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

K. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface, self-supporting type.
4. Initial Resistance: <Insert inches wg (Pa)>.
5. Recommended Final Resistance: <Insert inches wg (Pa)>.
6. Minimum Arrestance: [95] <Insert value>, according to ASHRAE 52.1.
7. MERV: [13] <Insert value>, according to ASHRAE 52.2.
8. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions[ and antimicrobial agent].
9. Filter-Media Frame: [Galvanized steel] [Hard polyurethane foam].
10. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks[ with space for prefilter].

## 2.4 FIXED-PLATE TOTAL HEAT EXCHANGERS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Casing: Galvanized steel.
- C. Plates: Evenly spaced and sealed and arranged for counter airflow.
  1. Plate Material: Chemically treated paper with selective hydroscopicity and moisture permeability, and gas barrier properties.
- D. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.



## E. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, viscous-coated, flat-panel type.
4. Thickness: [1 inch (25 mm)] [2 inches (50 mm)].
5. Initial Resistance: <Insert inches wg (Pa)>.
6. Recommended Final Resistance: <Insert inches wg (Pa)>.
7. Minimum Arrestance: [80] <Insert value>, according to ASHRAE 52.1.
8. MERV: [5] <Insert value>, according to ASHRAE 52.2.
9. Media: Interlaced glass fibers sprayed with nonflammable adhesive[ and antimicrobial agent].
10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

## F. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface type.
4. Thickness: [1 inch (25 mm)] [2 inches (50 mm)] [4 inches (100 mm)].
5. Initial Resistance: <Insert inches wg (Pa)>.
6. Recommended Final Resistance: <Insert inches wg (Pa)>.
7. Minimum Arrestance: [90] <Insert value>, according to ASHRAE 52.1.
8. MERV: [7] <Insert value>, according to ASHRAE 52.2.
9. Media: Fibrous material formed into deep-V-shaped pleats[ with antimicrobial agent] and held by self-supporting wire grid.
10. Media-Grid Frame: [Nonflammable cardboard] [Galvanized steel] [Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

## 2.5 PACKAGED ENERGY RECOVERY UNITS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, [gasketed and calked weathertight,] [hinged access doors] [removable panels] with neoprene gaskets for inspection and access to internal parts, minimum [1-inch- (25-mm-)] [2-inch- (50-mm-)] <Insert thickness> thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
  1. Inlet: Weatherproof [hood] [louver], with damper for exhaust and supply.
    - a. Exhaust: [Gravity backdraft damper] [Spring-return, two-position, motor-operated damper].

- b. Supply: **[Gravity backdraft damper] [Spring-return, two-position, motor-operated damper]**.
- 2. Roof Curb: Refer to Section 077200 "Roof Accessories" for roof curbs and equipment supports.
- D. Heat Recovery Device: **[Heat wheel] [Heat-pipe heat exchanger] [Fixed-plate heat exchanger]**.
- E. Supply and Exhaust Fans: **[Forward-curved, centrifugal] [Propeller] [Backward-inclined, SWSI centrifugal] [Backward-inclined, plenum centrifugal]** fan with **[spring isolators] [restrained, spring isolators] [spring hangers] [spring hangers with vertical-limit stops] [and] [insulated]** flexible duct connections.
  - 1. Motor and Drive: **[Direct driven] [Belt driven with adjustable sheaves, motor mounted on adjustable base] [Drive type indicated on Drawings]**.
  - 2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
  - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 4. Spring isolators on each fan having **[1-inch (25-mm)] <Insert deflection>** static deflection.
- F. Disposable Panel Filters:
  - 1. Comply with NFPA 90A.
  - 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - 3. Factory-fabricated, viscous-coated, flat-panel type.
  - 4. Thickness: **[1 inch (25 mm)] [2 inches (50 mm)]**.
  - 5. Initial Resistance: **<Insert inches wg (Pa)>**.
  - 6. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
  - 7. Minimum Arrestance: **[80] <Insert value>**, according to ASHRAE 52.1.
  - 8. MERV: **[5] <Insert value>**, according to ASHRAE 52.2.
  - 9. Media: Interlaced glass fibers sprayed with nonflammable adhesive **[and antimicrobial agent]**.
  - 10. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
- G. Extended-Surface, Disposable Panel Filters:
  - 1. Comply with NFPA 90A.
  - 2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - 3. Factory-fabricated, dry, extended-surface type.
  - 4. Thickness: **[1 inch (25 mm)] [2 inches (50 mm)] [4 inches (100 mm)]**.
  - 5. Initial Resistance: **<Insert inches wg (Pa)>**.
  - 6. Recommended Final Resistance: **<Insert inches wg (Pa)>**.
  - 7. Minimum Arrestance: **[90] <Insert value>**, according to ASHRAE 52.1.
  - 8. MERV: **[7] <Insert value>**, according to ASHRAE 52.2.

9. Media: Fibrous material formed into deep-V-shaped pleats[ **with antimicrobial agent**] and held by self-supporting wire grid.
10. Media-Grid Frame: [**Nonflammable cardboard**] [**Galvanized steel**] [**Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets**].
11. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

H. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
3. Factory-fabricated, dry, extended-surface, self-supporting type.
4. Initial Resistance: <Insert inches wg (Pa)>.
5. Recommended Final Resistance: <Insert inches wg (Pa)>.
6. Minimum Arrestance: [**95**] <Insert value>, according to ASHRAE 52.1.
7. MERV: [**13**] <Insert value>, according to ASHRAE 52.2.
8. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions[ **and antimicrobial agent**].
9. Filter-Media Frame: [**Galvanized steel**] [**Hard polyurethane foam**].
10. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks[ **with space for prefilter**].

I. Cooling Coils: Rated according to ARI 410 and ASHRAE 33[, **and bearing the ARI label**].

1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
2. Casing: [**Manufacturer's standard material**] [**Aluminum**] [**Galvanized steel**] [**Stainless steel**] <Insert material>.
3. Tubes: [**Copper**] <Insert material>.
4. Tube Headers: [**Manufacturer's standard material**] [**Copper**] [**Carbon steel**] [**Red brass**] <Insert material>.
5. Fins: [**Aluminum**] [**Copper**] <Insert material>.
6. Fin and Tube Joint: Mechanical bond.
7. Leak Test: Coils shall be leak tested with air under water.
8. Refrigerant Coils:
  - a. Capacity Reduction: Circuit coils for [**face**] [**row**] [**interleaved**] control.
  - b. Suction and Distributor: Seamless copper tube with brazed joints.
9. Coating: Phenolic epoxy corrosion-protection coating after assembly.

J. Cooling-Coil Condensate Drain Pans:

1. Fabricated from [**galvanized**] [**stainless**]-steel sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
2. Complying with requirements in ASHRAE 62.1.
3. Drain Connections: At low point of pan with minimum <Insert size> threaded nipple.
4. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.

- K. Hot-Water Coils: Rated according to ARI 410 and ASHRAE 33[, and bearing the ARI label].
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
  2. Casing: [**Manufacturer's standard material**] [**Aluminum**] [**Galvanized steel**] [**Stainless steel**] <Insert material>.
  3. Tubes: [**Copper**] <Insert material>.
  4. Tube Headers: [**Manufacturer's standard material**] [**Copper**] [**Carbon steel**] [**Red brass**] <Insert material>.
  5. Fins: [**Aluminum**] [**Copper**] <Insert material>.
  6. Fin and Tube Joint: Mechanical bond.
  7. Leak Test: Coils shall be leak tested with air under water.
  8. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- L. [**Nonfreeze Type**] Steam Coils: Rated according to ARI 410 and ASHRAE 33[, and bearing the ARI label].
1. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
  2. Casing: [**Manufacturer's standard material**] [**Aluminum**] [**Galvanized steel**] [**Stainless steel**] <Insert material>.
  3. Tubes: [**Copper**] <Insert material>.
  4. Tube Headers: [**Manufacturer's standard material**] [**Copper**] [**Carbon steel**] [**Red brass**] <Insert material>.
  5. Fins: [**Aluminum**] [**Copper**] <Insert material>.
  6. Fin and Tube Joint: Mechanical bond.
  7. Leak Test: Coils shall be leak tested with air under water.
  8. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- M. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
1. Casing Assembly: [**Slip-in**] [**Flanged**] type with galvanized-steel frame.
  2. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
  3. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
  4. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
  5. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
  6. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
  7. Control Panel: [**Unit**] [**Remote**] mounted with disconnecting means and overcurrent protection.
    - a. [**Magnetic**] [**Mercury**] contactor.
    - b. Solid-state, stepless pulse controller.
    - c. Toggle switches, one per step.
    - d. Step controller.

- e. Time-delay relay.
- f. Pilot lights, one per step.
- g. Airflow proving switch.

N. Indirect-Fired Gas Furnaces:

1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
  - a. AGA Approval: Furnace shall bear label of AGA.
2. Burners: [**Aluminized steel with stainless-steel inserts**] [**Stainless steel**].
  - a. Ignition: Electronically controlled electric spark with flame sensor.
  - b. High-Altitude [**Model**] [**Kit**]: For Project at elevations more than **2000 feet (610 m)** above sea level.
3. Heat-Exchanger Drain Pan: Stainless steel.
4. Venting: Gravity vented.
5. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
6. Gas Control Valve: [**Single stage**] [**Two stage**] [**Electronic modulating**].
7. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff. Control devices and control sequence shall comply with requirements of [**FMG**] [**IRI**] **<Insert agency>**.
8. Access: Fabricate section to allow removal and replacement of furnace and to allow in-place access for service.

O. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.

1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
3. Include [**fused**] [**nonfused**] disconnect switches.
4. Variable-speed controller to vary fan capacity from 100 to approximately [**50**] **<Insert number>** percent.

P. Accessories:

1. Roof Curb: [**Steel**] [**Galvanized steel**] [**Aluminum**] with gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of [**14 inches (350 mm)**] [**24 inches (600 mm)**] **<Insert height>**.
2. Intake weather hood with **2-inch- (50-mm-)** thick filters.
3. Louvered intake weather hood with **2-inch- (50-mm-)** thick filters in V-bank configuration.
4. Exhaust weather hood with birdscreen.
5. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, [**galvanized-steel**] [**aluminum**] [**extruded-aluminum**] dampers with compressible jamb seals and extruded-vinyl blade edge seals, in [**opposed**] [**parallel**]-blade arrangement with [**cadmium-**

- plated**] steel operating rods rotating in [**stainless-steel sleeve**] [**sintered bronze or nylon**] bearings mounted in a single [**galvanized-steel**] [**aluminum**] [**extruded-aluminum**] frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed **5 cfm/sq. ft. (0.22 L/s per sq. m)** at **1-inch wg (250 Pa)** and **9 cfm/sq. ft. (0.4 L/s per sq. m)** at **4-inch wg (1.0 MPa)**.
6. Isolation Dampers: Opposed-blade, [**galvanized-steel**] [**aluminum**] [**extruded-aluminum**] dampers with [**cadmium-plated**] steel operating rods rotating in sintered bronze or nylon bearings mounted in a single [**galvanized-steel**] [**aluminum**] [**extruded-aluminum**] frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
  7. Duct flanges.
  8. Rubber-in-shear isolators for ceiling-mounted units.
  9. Hinged access doors with quarter-turn latches.
  10. Drain pans for condensate removal[ **complying with ASHRAE 62.1**].
  11. Automatic, in-place, spray-wash system.
  12. Weatherproofing for tilt-control system.

## 2.6 CONTROLS

- A. Time Clock: Solid-state, programmable, microprocessor-based unit for [**wall mounting**] [**mounting in outdoor NEMA 250, Type 3R enclosure**] with up to eight on/off cycles per day and battery backup protection of program settings against power failure to energize unit.
- B. Motion (Occupancy) Sensor: Passive infrared sensor for [**wall**] [**ceiling**] mounting with adjustable time-off delay of up to 30 minutes to energize unit.
- C. Carbon Monoxide Sensor: Adjustable control from 600 to 2000 ppm for [**wall**] [**duct**] mounting with digital display and computer/building management system interface to energize unit.
- D. Humidistat: Adjustable, wall-mounted instrument to energize unit when space relative humidity exceeds [**50 percent**] <**Insert relative humidity**>.
- E. Chilled-Water-Cooling-Coils Controls:
  1. [**Factory-mounted sensor in unit discharge**] [**Remote-mounted sensor for field installation in supply-air duct**] with sensor adjustment located in control panel to modulate factory-**[mounted]** [**furnished**] coil-control valve to maintain temperature.
  2. Wall-mounted, space-temperature sensor with [**temperature adjustment**] [**unit-mounted temperature adjustment**] [**adjustment on remote-control panel**] to modulate factory-**[mounted]** [**furnished**] coil-control valve to maintain temperature.
- F. Refrigerant-Cooling-Coils Controls:
  1. [**Factory-mounted sensor in unit discharge**] [**Remote-mounted sensor for field installation in supply-air duct**] with sensor adjustment located in control panel to control remote condensing unit to maintain temperature.
  2. Wall-mounted, space-temperature sensor with [**temperature adjustment**] [**unit-mounted temperature adjustment**] [**adjustment on remote-control panel**] controls remote condensing unit to maintain temperature.

3. Cooling Capacity Control: **[On/off]** **[Multiple steps]** **<Insert type>**.

G. **[Hot-Water-]** **[and]** **[Steam-]**Coils Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to modulate factory-**[mounted]** **[furnished]** coil-control valve to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to modulate factory-**[mounted]** **[furnished]** coil-control valve to maintain temperature.

H. Electric-Coils Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control electric coil to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to control electric coil to maintain temperature.
3. Coil Controls: **[On/off]** **[Multiple steps]** **[Modulating SCR]** **<Insert type>**.

I. Indirect-Fired-Gas-Furnaces Controls:

1. **[Factory-mounted sensor in unit discharge]** **[Remote-mounted sensor for field installation in supply-air duct]** with sensor adjustment located in control panel to control gas furnace burner to maintain temperature.
2. Wall-mounted, space-temperature sensor with **[temperature adjustment]** **[unit-mounted temperature adjustment]** **[adjustment on remote-control panel]** to control gas furnace burner to maintain temperature.
3. Burner Controls: **[On/off]** **[Multiple steps]** **[Modulating]** **<Insert type>**.

## 2.7 CAPACITIES AND CHARACTERISTICS

A. Exhaust Air:

1. Airflow: **<Insert cfm (L/s)>**.
2. Face Velocity: **<Insert fpm (m/s)>**.
3. Summer:
  - a. Entering-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
  - b. Entering-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
  - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
  - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
4. Winter:
  - a. Entering-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
  - b. Entering-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.
  - c. Leaving-Air Temperature, Dry Bulb: **<Insert deg F (deg C)>**.
  - d. Leaving-Air Temperature, Wet Bulb: **<Insert deg F (deg C)>**.



5. Air Pressure Drop: <Insert **inches wg (Pa)**>.
6. Fan Motor Size: <Insert **horsepower**>.
7. Fan Motor Electrical Characteristics:
  - a. Volts: [120] [208] [230] <Insert **value**>.
  - b. Phase: [Single] [Three].
  - c. Hertz: 60.

B. Supply Air:

1. Airflow: <Insert **cfm (L/s)**>.
2. Face Velocity: <Insert **fpm (m/s)**>.
3. Summer:
  - a. Entering-Air Temperature, Dry Bulb: <Insert **deg F (deg C)**>.
  - b. Entering-Air Temperature, Wet Bulb: <Insert **deg F (deg C)**>.
  - c. Leaving-Air Temperature, Dry Bulb: <Insert **deg F (deg C)**>.
  - d. Leaving-Air Temperature, Wet Bulb: <Insert **deg F (deg C)**>.
4. Winter:
  - a. Entering-Air Temperature, Dry Bulb: <Insert **deg F (deg C)**>.
  - b. Entering-Air Temperature, Wet Bulb: <Insert **deg F (deg C)**>.
  - c. Leaving-Air Temperature, Dry Bulb: <Insert **deg F (deg C)**>.
  - d. Leaving-Air Temperature, Wet Bulb: <Insert **deg F (deg C)**>.
5. Air Pressure Drop: <Insert **inches wg (Pa)**>.
6. Fan Motor Size: <Insert **horsepower**>.
7. Fan Motor Electrical Characteristics:
  - a. Volts: [120] [208] [230] <Insert **value**>.
  - b. Phase: [Single] [Three].
  - c. Hertz: 60.

C. Wheel Drive:

1. Motor Size: <Insert **horsepower**>.
2. Motor Electrical Characteristics:
  - a. Volts: [120] [208] [230] <Insert **value**>.
  - b. Phase: [Single] [Three].
  - c. Hertz: 60.

D. Effectiveness: <Insert **percent**>.

E. Cooling Coil:

1. Fluid: [Chilled water] [Refrigerant] <Insert **fluid**>.
2. Sensible Heat-Transfer Rate: <Insert **Btu/h (kW)**>.
3. Total Heat-Transfer Rate: <Insert **Btu/h (kW)**>.
4. Entering-Air, Dry-Bulb Temperature: <Insert **deg F (deg C)**>.



5. Entering-Air, Wet-Bulb Temperature: <Insert **deg F (deg C)**>.
6. Leaving-Air, Dry-Bulb Temperature: <Insert **deg F (deg C)**>.
7. Leaving-Air, Wet-Bulb Temperature: <Insert **deg F (deg C)**>.
8. Face Area: <Insert **sq. ft. (sq. m)**>.
9. Maximum Face Velocity: <Insert **fpm (m/s)**>.
10. Maximum Air-Side, Static-Pressure Drop: <Insert **inches wg (Pa)**>.
11. Coil Type: [Continuous circuit] [Self-draining] [Cleanable].
12. Piping Connections: [Threaded] [Flanged], [same end] [opposite ends] of coil.
13. Tube Thickness: <Insert **inches (mm)**>.
14. Fin Spacing: <Insert **fins per inch (cm)**>.
15. Fin Thickness: <Insert **inches (mm)**>.
16. Number of Rows: <Insert **number**>.
17. Coil Working-Pressure Ratings: [200 psig (1380 kPa), 325 deg F (163 deg C)] <Insert **value**>.
18. Fluid:
  - a. Fluid Flow: <Insert **gpm (L/s)**>.
  - b. Maximum Fluid Pressure Drop: <Insert **feet of head (kPa)**>.
  - c. Entering-Fluid Temperature: <Insert **deg F (deg C)**>.
  - d. Leaving-Fluid Temperature: <Insert **deg F (deg C)**>.
  - e. Tube velocity: <Insert **fpm (L/s)**>.

F. [Hot-Water] [Steam] Coils:

1. Heat-Transfer Rate: <Insert **Btu/h (kW)**>.
2. Entering-Air Temperature: <Insert **deg F (deg C)**>.
3. Leaving-Air Temperature: <Insert **deg F (deg C)**>.
4. Face Area: <Insert **sq. ft. (sq. m)**>.
5. Maximum Face Velocity: <Insert **fpm (m/s)**>.
6. Maximum Air-Side, Static-Pressure Drop: <Insert **inches wg (Pa)**>.
7. Coil Type: [Continuous circuit] [Self-draining] [Cleanable].
8. Piping Connections: [Threaded] [Flanged], [same end] [opposite ends] of coil.
9. Tube Thickness: <Insert **inches (mm)**>.
10. Fin Spacing: <Insert **fins per inch (cm)**>.
11. Fin Thickness: <Insert **inches (mm)**>.
12. Number of Rows: <Insert **number**>.
13. Coil Working-Pressure Ratings: [200 psig (1380 kPa), 325 deg F (163 deg C)] <Insert **value**>.
14. Fluid:
  - a. Fluid Flow: <Insert **gpm (L/s)**>.
  - b. Maximum Fluid Pressure Drop: <Insert **feet of head (kPa)**>.
  - c. Entering-Fluid Temperature: <Insert **deg F (deg C)**>.
  - d. Leaving-Fluid Temperature: <Insert **deg F (deg C)**>.
  - e. Tube velocity: <Insert **fpm (L/s)**>.
15. Steam Coils:
  - a. Heat-Transfer Rate: <Insert **Btu/h (kW)**>.
  - b. Steam Flow: <Insert **lb/h (g/s)**>.
  - c. Inlet Steam Pressure: <Insert **psig (kPa)**>.

- d. Coil Working-Pressure Ratings: [**200 psig (1380 kPa)**, **325 deg F (163 deg C)**] **<Insert value>**.

G. Electric Heating Coils:

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Power Input: **<Insert kilowatts>**.
5. Volts: [**208**] [**230**] [**480**] **<Insert value>**.
6. Phase: [**Single**] [**Three**].
7. Hertz: 60.
8. Full-Load Amperes: **<Insert value>**.
9. Maximum Overcurrent Protection: **<Insert amperage>**.
10. Capacity Control Number of Steps: **<Insert number>**.

H. Indirect-Fired Gas Furnace:

1. Heat-Transfer Rate: **<Insert Btu/h (kW)>**.
2. Entering-Air Temperature: **<Insert deg F (deg C)>**.
3. Leaving-Air Temperature: **<Insert deg F (deg C)>**.
4. Efficiency: [**80**] **<Insert number>** percent.
5. Fuel: [**Natural**] [**Propane**] gas.
6. Gas Heating Value: **<Insert Btu/cu. ft. (kJ/L)>**.
7. Gas Input: **<Insert cfh (mL/s)>**.
8. Power Input: **<Insert kilowatts>**.
9. Volts: [**120**] [**208**] [**230**] [**480**] **<Insert value>**.
10. Phase: [**Single**] [**Three**].
11. Hertz: 60.
12. Full-Load Amperes: **<Insert value>**.
13. Minimum Circuit Ampacity: **<Insert value>**.
14. Maximum Overcurrent Protection: **<Insert amperage>**.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
  - 1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
  - 2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
  - 3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
- B. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.
  - 1. Install heat exchanger with clearance space for heat-pipe coil removal.
  - 2. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
  - 3. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.
- C. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
  - 1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
- D. Install gas-fired furnaces according to NFPA 54, "National Fuel Gas Code."
- E. Install floor-mounted units on ~~4-inch-~~ (100-mm-) high concrete base[ **designed to withstand, without damage to equipment, seismic force required by code**].
- F. Equipment Mounting:
  - 1. Install air-to-air energy recovery equipment 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."]
- G. Roof Curb: Install on roof structure or concrete base, level and secure, according to [The NRCA "Roofing and Waterproofing Manual - Volume 4: Construction Details - Low-Slope Roofing," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts."] [ARI Guideline B.] Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- H. Unit Support: Install unit level on structural [curbs] [pilings]. Coordinate wall penetrations and flashing with wall construction. Secure air-to-air energy recovery equipment to structural support with anchor bolts.

- I. Install wind and seismic restraints according to manufacturers' written instructions.[ **Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 230548 "Vibration and Seismic Controls for HVAC."**]
- J. 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."
- K. Install units with clearances for service and maintenance.
- L. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
- M. Pipe drains from drain pans to nearest floor drain; use **ASTM B 88, Type L (ASTM B 88M, Type B)**, drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.
- N. Pipe drains from drain pans to nearest floor drain; use ASTM D 1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.
  - 1. Requirements for Low-Emitting Materials:
    - a. 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).
    - b. 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).
  - 2. Requirements for Low-Emitting Materials: 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."

### 3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
- E. [**Chilled**] [**and**] [**Hot**] Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

- F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 Steam and Condensate Piping Specialties." Install shutoff valve at steam coil connections, float and thermostatic trap, and union or flange at each coil return connection.
- G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping."
- H. Gas Piping: Comply with requirements in [Section 231123 "Facility Natural-Gas Piping."] [Section 231126 "Facility Liquefied-Petroleum Gas Piping."] Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make connection with AGA-approved flexible connectors.
- I. Comply with requirements for ductwork specified in Section 233113 "Metal Ducts."
- J. Indirect-Fired Furnace Vent Connections: Comply with Section 235123 "Gas Vents."
- K. Install electrical devices furnished with units but not factory mounted.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - 2. Adjust seals and purge.
  - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 4. Set initial temperature and humidity set points.
  - 5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

### 3.5 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 237200