

## MILLER-PICKING CUSTOM AIR HANDLING UNITS - GUIDE SPECIFICATION

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Indoor and outdoor air handling units and components as scheduled and shown on drawings.
- B. Motor disconnects, motor starters, and variable frequency drives.

#### 1.02 RELATED SECTIONS

- A. The requirements of the General Conditions, Supplementary Conditions, Division 1, equipment schedules, and drawings apply.

#### 1.03 REFERENCES

- A. AMCA 99 – Standard Handbook
- B. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes
- C. AMCA 500 – Test Methods for Louvers, Dampers, and Shutters
- D. AMCA 611-95 – Methods of Testing Airflow Measurement Stations for Rating
- E. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
- F. ANSI/UL 900 – Test Performance of Air Filter Units
- G. AHRI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment
- H. AHRI 410 – Forced-Circulation Air Cooling and Air Heating Coils
- I. ANSI/AHRI 430 – Performance Rating of Central-Station Air Handling Units
- J. ASHRAE 52.1/52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
- K. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality
- L. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
- M. ASTM-C 1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.
- N. NFPA 70 – National Electric Code (conductors, equipment and raceways)
- O. NFPA 90A – Installation of Air Conditioning and Ventilation Systems
- P. SMACNA – HVAC Duct Construction Standards

- Q. UL-181 – Mold Growth and Humidity Test
- R. UL-1995 – Standard for Safety for Heating and Cooling Equipment

#### 1.04 QUALITY ASSURANCE

- A. Manufacturer shall have a minimum of 25 years of experience in designing, manufacturing, and servicing air-handling units.
- B. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers are acceptable if equipment meets scheduled performance requirements and dimensional requirements.

#### 1.05 COORDINATION

- A. If equipment is supplied by a manufacturer other than the one named, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This coordination shall include (but is not limited to) the following:
  - 1. Structural supports for units.
  - 2. Size and location of concrete bases/housekeeping pads
  - 3. Location of roof curbs, unit supports and roof penetrations
  - 4. Ductwork sizes and connection locations
  - 5. Piping size and connection/header locations
  - 6. Interference with existing or planned ductwork, piping and wiring
  - 7. Electrical power requirements and wire/conduit and over current protection sizes.
  - 8. Trap height requirements
- B. The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.

#### 1.06 RATINGS AND CERTIFICATIONS

- A. Air Handling Unit safety: ETL or UL 1995
- B. Air Handling Unit energy use: ASHRAE 90.1
- C. Fans: AMCA 210
- D. Air Coils: AHRI 410
- E. Air Handling Unit certification program: ANSI/AHRI 430
- F. Filter media: ANSI/UL 900 listed Class I or Class II
- G. Control wiring: NEC codes & ETL requirements
- H. Motors: Federally mandated Energy Policy Act (EPACT).
- I. Airflow Monitoring Stations: AMCA 611-95

## 1.07 SUBMITTAL DOCUMENTATION REQUIRED

- A. Furnish fan performance ratings and fan curves with specified operating point clearly plotted.
- B. Furnish drawings indicating unit dimensions, required clearances, field connection locations, wiring diagrams, shipping drawings, and curb drawings.
- C. Furnish performance report showing unit level performance data including: fan(s), motor(s), coil(s) and other functional components. Performance report shall also include unit casing performance.
- D. Furnish operation and maintenance data, including instructions for lubrication, filter replacement, motor and drive replacement, and condensate pan cleaning; spare parts lists, and wiring diagrams.
- E. Adjust and report performance ratings for the proper altitude of operation.
- F. Report air-handling unit performance ratings in accordance with ANSI/AHRI-430 (static pressure, airflow, fan speed, and fan brake horsepower).
- G. Report static pressure profiles by component section.
- H. Report coil ratings in accordance with AHRI-410 (capacities and pressure drops).
- I. Report unweighted octave band AHU sound power for inlets and outlets rated in accordance with AHRI Standard 260. Provide eight data points, the first for the octave centered at 63 Hz, and the eighth centered at 8,000 Hz. Manufacturer shall not use sound estimates based on bare fan data (AMCA ratings), nor use calculations like the substitution method based on AHRI 260 tests of other AHU products. Provide data for inlets and outlets as scheduled. Report unweighted casing radiated sound power over the same 8 octave bands in accordance with ISO 9614 Parts 1&2 and ANSI S12.12.
- J. Airflow measuring device performance shall be certified and rated in accordance with AMCA-611. Report data in accordance with AMCA-611. Provide AMCA Certified Rating Seal for Airflow Measurement Performance.
- K. Report panel deflection at +/-10" [12"] w.g., stated in terms of 'L/X' where 'L' is the casing panel length and 'X' is a constant provided by the AHU manufacturer.
- L. Report casing leakage rate at +/-10" [12"] w.g., specified in terms of percentage of design airflow.
- M. Report weight loads and distributions by component section.
- N. Report product data for filter media, filter performance data, filter assembly, and filter frames.
- O. Report electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- P. Report motor electrical characteristics.

#### 1.08 DELIVERY, STORAGE and handling

- A. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).
- B. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from moisture by appropriate in-transit and on-site procedures.
- C. Follow manufacturer's recommendations for handling, unloading and storage.
- D. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.
- E. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.
- F. Enclose and protect control panels, electronic or pneumatic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.
- G. Seal openings to protect against damage during shipping, handling and storage.
- H. Wrap indoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively AHU must be tarped for shipment and storage.
- I. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.
- J. Tarp outdoor units to protect against rain and road debris during shipping.
- K. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

#### 1.09 EXTRA MATERIALS

- A. Provide one set of filters for balancing, and one additional set for final turnover to owner.
- B. Provide one extra set of belts, in addition to the factory-installed set.

#### 1.10 WARRANTY

- A. Provide warranty for 18 months from date of shipment. Warranty shall cover manufacturer defects. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician.
- B. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

#### 1.11 SYSTEM STARTUP

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

- B. Comply with manufacturer's start-up requirements to ensure safe and correct operation and integrity of warranty.

## PART 2 - PRODUCTS

### 2.01 ACCEPTABLE MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on schedule as **Miller-Picking** or comparable product by one of the following:
  - 1. Temtrol, div. of Nortek Air Solutions
  - 2. Haakon Industries
  - 3. Air Enterprises, Inc.
  - 4. Airtherm; a Mestek company.
  - 5. Buffalo Air Handling.
  - 6. Carrier Custom; a member of the United Technologies Corporation Family.
  - 7. Dunham-Bush, Inc.
  - 8. Engineered Air.
  - 9. Mammoth Inc.
  - 10. Scott Springfield Mfg. Inc.
  - 11. Trane Custom TCFS, div of Ingersoll Rand Inc.
  - 12. **<Insert manufacturer's name>**.

### 2.02 UNIT CASINGS

- A. Unit Casing Performance
  - 1. Leakage shall be no more than 1/2% of rated unit CFM at +/- 10" static pressure. Manufacturer shall perform a factory leakage test on at least one unit. Customer shall select which unit to test. Perform test at 10" static pressure. If unit fails at the factory, manufacturer shall seal and retest unit until it meets specified performance.
  - 2. Deflection shall be no more than L/240 of panel length at +/- 10" static pressure. Manufacturer shall perform a factory deflection test on at least one unit. Customer shall select which unit to test. Measure deflection on the largest wall panel. Perform test at 10" static pressure. If unit fails, manufacturer shall add structural support required to achieve specified performance.
  - 3. Thermal performance:
    - a. Unit wall shall not sweat with interior air temperature of XX°F and exterior air at XX/XX db/wb
    - b. R-value of wall shall be R-13[R19] [R25] at the center of panel.
- B. [2" foam injected [thermal break] walls] [3" foam injected thermal break [UTB™ ultra thermal break] walls] [4" foam injected [thermal break] walls]: Construct walls with interior and exterior sheet metal surfaces, welded internal post structure, and [2"] [3"] [4'] of injected foam insulation. Foam board or fiberglass insulation is not acceptable.
  - 1. Interior Liner:

- a. Galvanized Steel, G90 shall be 22 ga [**20 ga, 18 ga**].
  - b. Stainless Steel, 304 shall be 20 ga [**18 ga, 16 ga**].
  - c. Stainless Steel, 316L shall be 22 ga.
  - d. Pre-painted galvanized steel shall be 18 ga [**16 ga**].
  - e. Aluminum, 3003 shall be 0.05” thick (0.05” thickness is equivalent to 16 ga. Aluminum).
2. Exterior surface
    - a. Galvanized Steel, G90 shall be 20 ga [**18 ga, 16 ga, 14 ga**].
    - b. Stainless Steel, 304 shall be 20 ga [**18 ga, 16 ga**].
    - c. Stainless Steel, 316L shall be 16 ga.
    - d. Pre-painted galvanized steel shall be 18 ga [**16 ga**].
    - e. Aluminum, 3003 shall be 0.04” thick, textured (0.04” thickness is equivalent to 18 ga. Aluminum).
  3. Internal Post Structure: Formed galvanized 16 ga steel C-channel. Structure shall be fully welded. Post spacing shall be designed to provide L/240 wall deflection at +/- 10” w.g. Maximum post spacing shall be 24” on centers.
  4. Fasteners
    - a. Exterior Fasteners
      - 1) For outdoor units, units with stainless steel or aluminum exterior walls use self tapping series 400 stainless steel sheet metal screws to fasten exterior sheet metal walls to post frame structure on 18” centers
      - 2) For indoor units use self-tapping rust inhibited sheet metal screws to fasten exterior sheet metal walls to post frame structure on 18” centers.
    - b. Interior Fasteners
      - 1) For Galvanized interior liner: use self tapping rust inhibited sheet metal screws to fasten interior and exterior sheet metal walls to post frame structure on 27” centers.
      - 2) For Stainless steel or aluminum interior liner: use self tapping series 400 stainless steel sheet metal screws to fasten exterior sheet metal walls to post frame structure on 27” centers
  5. Casing Joints: Joints shall be mechanically fastened. Fasteners shall not extend from the outside to the inside of the unit. Use angle to fasten and seal walls at corners, floors, and roofs.
  6. Sealing: Seal joints with polyurethane water resistant sealant.
  7. No additional coating
  8. Mill Finish for galvanized steel casings: Immediately after cleaning and pre-treating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of polyurethane prime coat and polyester thermosetting topcoat. Coating shall pass ASTM B-117 1,000 hour salt spray test. Color shall be manufacturer’s standard champagne.
  9. Factory applied high build (3 to 5 mils) alkyd enamel. Coating shall pass ASTM B-117 500 hour salt spray test. Color shall be manufacturer’s standard champagne, or Architect shall specify color.
  10. Factory applied single coat industrial 2-part epoxy shall be 3 – 4 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer’s standard champagne, or Architect shall specify color.
  11. Factory applied double coat industrial 2-part epoxy shall be 6 – 8 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer’s standard champagne, or Architect shall specify color.
  12. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.

C. Roofs

1. Construction of the roof shall be identical to the wall construction specified.  
(Use 2 through 9 for outdoor units only)
2. Unit roof for outdoor units are to be sloped a minimum pitch of ¼” per foot.
3. The roof shall overhang all side and end panels to prevent precipitation drainage from streaming down the unit wall panels. Gutter systems are not acceptable.
4. Roofs less than 12’ wide shall be sloped to the non-door side of the unit; roofs 12’ wide and wider shall be peaked in the center and sloped to both sides of the unit.
5. Roof construction shall accommodate a minimum snow-load of 30 lb/ft<sup>2</sup>.
6. Roof shall be designed to hold a 300lb load for service and maintenance.
7. The roofing system shall consist of a white (or custom color) 100% acrylic elastomeric coating with mildewcide. Coating shall be a minimum 20 mils thick. Coating shall meet the following requirements:
  - a. CRRC Solar Index Rating of 112 per ASTM E1980-01
  - b. CRRC Initial Solar Reflectance of 0.89; 0.81 after 3 years
  - c. CRRC Initial Thermal Emittance of 0.89; 0.87 after 3 years
  - d. Fungi Resistance per ASTM G21 of zero growth
8. Outdoor roofs supplied with non-sloped roofs or standing seam roof systems are not acceptable.
9. For all outdoor roof duct connections provide a minimum 1.5” duct flange.

D. Casing Insulation and Adhesive:a

1. Materials: ASTM C 1071, [**Type I**] [**Type II**].
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.
  - a. Liner Adhesive: Comply with ASTM C 916, Type I.
  - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
  - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.
3. Location and Application: Encased between outside and inside casing.

E. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall, [**2-inch, 3-inch, 4-inch**] insulated panels of same material type [**and thickness**] as unit casing.
2. Inspection and Access Panels:
  - a. Fasteners: Attached to unit casing with tek screws with EPDM washers on maximum 9-inch centers.
  - b. Gasket: 3/4” wide x 1/8” thick PVC gasket applied around entire perimeters of panel frames [**and the access opening**].

- c. **Construction: Factory shall provide double sided tape where liner is attached to internal supports.**
3. Access Doors:
- a. Frames: Type 6063-T6 aluminum extrusion, **[with thermal break for "no through metal" construction]**, welded at the corners and attached to the unit casing with **[plated, stainless steel]** hardware.
  - b. Hinges: A full height stainless-steel piano hinge with minimum two roller cam latches per door, operable from inside and outside. Rotating knife-edge or "paw" latches are not acceptable. **[Provide galvanized, Z-type safety latch for all outward opening access doors opening with unit pressure.]**
  - c. Handles: Glass fiber reinforced, UV rated, padlockable, nylon polyamide as manufactured by Allegis Corporation.
  - d. Gasket: EPDM-sponge, applied around entire perimeters of panel frames. **[Provide one set of spare door gaskets for each access door.]**
  - e. Viewports: Provide **[8"x8", 12"x12"]**, **[single pane, thermal pane]** viewing window centered in each access door with wire-reinforced safety glass.
  - f. Test Ports: Ventlok No. 699 instrument test holes installed in door locations as required to measure pressure drops across unit.
  - g. Rain Lip: Provide rain lip of same material type as unit casing attached with tek screws above all access doors.
  - h. Interlock Switch: Provide Nema 3R, plunger type interlock switch mounted on doors as noted on submittal drawing.
- F. Service Vestibule (recommended on outdoor units with at least six (6) ft. of interior clearance): Air handling unit(s) shall be provided with a service vestibule equivalent to the unit casing, having a minimum thermal conductivity R of 12 /hr-ft<sup>2</sup>-°F/BTU.
- 1. Service vestibule shall be a minimum six (6) ft. wide by full height and length of the unit.
  - 2. Service vestibule floor construction shall be the same as the unit floor.
  - 3. Selected access doors are provided as indicated in door section of this specification.
  - 4. Selected lighting and outlets provided as indicated in the electrical section of this specification (if selected). Lights shall provide a minimum of 10 foot-candles of illumination per OSHA 1926.56(a) standards for mechanical equipment rooms.
  - 5. Vestibule shall be provided with **[208/240V 1-3Phase, 5KW or 480V 3Phase, 5KW]** heater with integral thermostat set to maintain a minimum of 50 deg F. (if selected).
  - 6. Provide ventilation for removing heat of motor starters or other devices located within the vestibule.
- G. Pipe-Chase:
- 1. Air handling unit(s) shall be provided with an external pipe-chase consisting of casing equivalent to the unit casing, having a minimum thermal conductivity R of 12 hr-ft<sup>2</sup>-°F/BTU.
    - a. Pipe-chase shall be **[24"]****[36"]****[48"]** to provide sufficient space for coil connections to be installed without interference.
    - b. [Loose-shipped pipe-chase enclosures shall be provided with lifting lugs for field installation (if any loose shipped).]
    - c. Pipe-chase shall be provided with **[18"]****[24"]****[30"]** doors. Doors shall be the same construction as the main unit doors. Door quantities shall match contract drawings.



- d. Pipe chase floor construction shall be the same as that of the unit.
- 2. Air handling unit(s) shall be provided with a recessed pipe chase consisting of casing equivalent to the unit casing, having a minimum thermal conductivity R of 12 hr-ft<sup>2</sup>-°F/BTU. Pipe chase shall be flush with the unit exterior.
  - a. Pipe-chase shall be [24"][36"][48"] to provide sufficient space for coil connections to be installed without interference.
  - b. [Optional: Internal pipe chase shall be furnished with an additional [24"][36"][48"] external pipe chase extension.]
  - c. Pipe-chase shall be provided with [18"][24"][30"] doors. Doors shall be the same construction as the main unit doors. Door quantities shall match contract drawings.
  - d. Pipe chase floor construction shall be the same as that of the unit.

H. Floors:

- 1. Floor shall be 10 ga. hot rolled steel [**stitch welded, caulked and sealed**] [**full seam welded**] to the base.  
 [Floor shall be 18 ga [10 ga., 12 ga., 14 ga., 16 ga.] G90 galvanized steel stitch welded, caulked and sealed to the base.]  
 [Floor shall be [12 ga., 16 ga.], Type [304, 316L] stainless steel [**stitch welded, caulked and sealed**] [**full seam welded**] to the base.]  
 [Floor shall be [0.125-in, 0.100-in] aluminum diamond plate [**stitch welded, caulked and sealed**] [**full seam welded**] to the base.]  
 [Floor shall be [0.125-in, 14 ga.] hot rolled steel diamond plate [**stitch welded, caulked and sealed**] [**full seam welded**] to the base.]  
 [Floor shall be 0.125-in, Type 304 stainless steel diamond plate [**stitch welded, caulked and sealed**] [**full seam welded**] to the base.]  
 Floor shall be insulated with [2-inch, 3-inch, 4-inch] polyurethane spray foam insulation.
- 2. Floor shall be thermally isolated from welded base frame members (perimeter and internal supports). Construction without thermally isolated floor and walls shall not be acceptable.
  - a. Floor shall have upturned lip with fully welded seams, and be capable of holding 2-inch of water. Penetrations through the floor shall not exist. Construction allowing screws or bolts to penetrate floor shall not be allowed. All floor openings shall have a fully welded 2" upturned lip.
  - b. Each section shall be equipped with drain connection to facilitate washdown and maintenance. Drain connection shall be extended through the base and have a removable cap installed.
  - c. All internal equipment shall be provided with a minimum 2-inch high base to raise equipment and components off the unit floor for housekeeping.
- 3. Floor Paint:
  - a. [Factory applied high build (3 to 5 mils) alkyd enamel. Coating shall pass ASTM B-117 500 hour salt spray test. Color shall be manufacturer's standard champagne or as specified by Architect.]  
 [Factory applied single coat industrial 2-part epoxy shall be 3 – 4 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]

[Factory applied double coat industrial 2-part epoxy shall be 6 – 8 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]

4. Subfloors:
  - a. [Subfloor shall be 0.05" Aluminum screwed to the base channel.]
  - b. [Subfloor shall be **[16 ga., 20 ga., 22 ga.]** G90 Galvanized Steel screwed to the base channel.]
  - c. [Subfloor shall be 20 ga. Type 304 Stainless Steel screwed to the base channel.]
5. Floor Drains:
  - a. Factory shall provide 1-1/4" floor drain in segments where noted on the unit drawing.
  - b. Floor drain piping shall be **[Schedule 40 black steel, 304 stainless steel]** extended from the floor drain and terminated with a 1-1/4" MPT threaded connection to the exterior through the unit base.
6. Floor Openings:
  - a. Factory shall provide c-channel support around perimeter of all floor openings.
  - b. Factory shall provide **[galvanized steel, 304 stainless steel]** flattened expanded metal safety screen attached with screws over all floor openings.
  - c. Factory shall provide **[galvanized steel, 304 stainless steel, aluminum]** walk on grate attached with screws over all floor openings.

I. Baserails:

1. [Type ASTM A36 welded structural steel c-channel, **[6-inch, 8-inch, 10-inch, 12-inch]** height, with cross supports spaced at regular intervals and removable lifting lugs. Factory shall provide curb angle welded to the base for outdoor curb mounted units.]  
[Type 6061 T6 welded structural aluminum, **[6-inch, 8-inch, 10-inch, 12-inch]** height, with cross supports spaced at regular intervals and removable lifting lugs.]
2. [Factory applied high build (3 to 5 mils) alkyd enamel. Coating shall pass ASTM B-117 500 hour salt spray test. Color shall be manufacturer's standard champagne or as specified by Architect.]  
[Factory applied single coat industrial 2-part epoxy shall be 3 – 4 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]  
[Factory applied double coat industrial 2-part epoxy shall be 6 – 8 mils and pass ASTM B-117 3,500 hours salt spray test. Color shall be manufacturer's standard champagne.]

2.1 FAN AND DRIVE SECTION

- A. Fan and drive assemblies shall be statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Shafts shall be designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
  1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating.
  2. Close tolerances shall be maintained where the shaft makes contact with the bearing.
  3. Designed to operate at no more than 70 percent **[80 percent (for commercial grade fans)]** of first critical speed at top of fan's speed range.
- C. Centrifugal fan housings shall be of heavy gauge, continuously welded construction. Housings with lock seams or partially welded construction are not acceptable. Housings shall be suitably

braced to prevent vibration or pulsation. Housings shall have spun, aerodynamically designed inlet cones or inlet venturies for smooth airflow into the wheels.

1. Housings shall be reinforced with rigid bracing to increase structural integrity. The support angles shall be intermittently welded and caulked between welds to prevent bleed-through corrosion.
  2. The entire fan assembly, excluding the shaft, shall be thoroughly degreased and deburred before application of a rust-preventative primer. After the fan is completely assembled, a finish coat of paint shall be applied to the entire assembly. The fan shaft shall be coated with a petroleum-based rust protectant.
  3. Housing shall be attached to the fan bulkhead wall with metal-edged flexible duct connector.
  4. Flexible connector shall be factory fabricated with a 3 inch wide (76-mm) fabric strip attached to two strips of 3 inch wide (76-mm), 24 gauge, galvanized-steel sheet [0.032-inch- (0.8-mm-) thick aluminum sheets (if fan bulkhead wall is aluminum or stainless steel)].
    - a. Flexible connector fabric shall be woven nylon/polyester blend with a vinyl coating. Fabrics, coatings, and adhesives shall comply with NFPA 701, and NFPA 90A & 90B.
      - 1) Fabric Minimum Weight: 22 oz./sq. yd. (746 g/sq. m).
      - 2) Fabric Tensile Strength: 240 lb (1067 N) in the warp and 220 lb (978 N) in the fill.
      - 3) Fabric Service Temperature: Minus 40 to plus 180 deg F (Minus 40 to plus 82 deg C).
      - 4) Fabric Pressure Resistance: Minus 10 in-w.g. to plus 15 in-w.g. (Minus 2.5 kPa to plus 3.7 kPa).
- D. Plenum fan housings shall be steel frame and panel; fabricated without fan scroll and volute housing. All single width single inlet (SWSI) plenum fans shall have airfoil blades. Flat plate blades shall not be acceptable. SWSI fans shall be provided with [inlet screens][fan screens and wheel guards].
- E. Airfoil, centrifugal fan wheels shall be smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws. All airfoil fans shall bear the AMCA Seal. Airfoil fan performance shall be based on tests made in accordance with AMCA standard 210 and comply with the requirements of AMCA standard 300 for inlet sound and outlet sound. In addition, all airfoil wheels shall comply with AMCA standard 2408-69. Fans shall be run tested at the specified operating speed prior to shipment. Each fan shall be dynamically balanced as a complete assembly in accordance with ISO-1940, to achieve Balance Quality Grade of at least G6.3 for the rotating assembly. Maximum vibration shall be within the limits of ANSI/AMCA 204 Fan Application Category BV-3. Balance readings shall be taken electronically in the axial, vertical, and horizontal directions. Records of each fan balance shall be made available upon request.
- F. Fan Shaft Bearings:
1. Bearings shall be [heavy duty, grease lubricated, spherical roller or adapter mounted anti-friction ball, self-aligning, pillow block type(for Twin City fans)] [self-aligning single

- row deep groove ball type in pillow block cast iron housings(**for Comefri fans except as follows**) [a double row roller bearing in a pillow block split cast iron housings(**for Comefri fans DRIVE SIDE bearing of 25 and 28 T3 and from 32 to 55 T2**)]
2. All bearings shall have a guaranteed minimum L50 life time of 200,000 hours (as per AFBMA standards). Bearing ratings are to be based on the fan's maximum operating speed and horsepower.
  3. All fan bearings shall be provided with grease fittings [extended to accessible location internal (**external**) to the unit].
- G. Belt drives shall be factory mounted, with adjustable alignment and belt tensioning, and shall have a 1.5 service factor.
1. Sheave shall be machined from a close grain cast iron and statically balanced by the manufacturer.
  2. Fan drives shall be fixed pitch.
  3. Motor drives shall be fixed pitch [adjustable pitch available for use with 7.5 hp motors and smaller on fans running at less than 2000 rpm. Adjustable drive size shall be selected at the middle of the pitch adjustment range at fan design conditions.]
  4. Drive belts shall be a V type. All drive belts shall be precision molded raw edge construction. Belts shall be oil resistant, heat resistant, non-sparking, and non-static; in matched sets for multiple-belt drives.
  5. [Belt guards shall comply with requirements specified by OSHA 1910.212 for machinery and machine guarding.]
- H. Each fan shall be provided with an individual industrial grade low leak back-draft damper. Frame shall be minimum 9" deep x 2" (229 x 51) flanged 12 (2.8) gage galvanized steel channel. The blades shall be maximum 7" (178) wide, minimum .080 (2) thick, 6063T5 extruded aluminum airfoil shaped with integral structural reinforcing tube running full length of each blade. Damper blades shall be equipped with silicone rubber seals mechanically locked into extruded blade slots. Adhesive type seals are not acceptable. Adhesive type seals are not acceptable. Dampers shall be equipped with vinyl jamb seals for low leakage application. Wind stop type seals are not acceptable. Axles shall be minimum 3/4" (19) diameter with machined edge to provide positive locking connection to blades. Full round axles are not acceptable. Bearings shall be ball style pressed into frame. Linkage shall be minimum 3/16" thick 3/4" (5 x 19) bar located on face of blade in airstream. Submittal must include leakage, pressure drop, and maximum pressure data based on AMCA Publication 500 testing.
- I. Fans shall be factory mounted with 2 inch (50 mm) deflection spring isolators with seismic restraints.
1. Seismic Fabrication Requirements: Fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components shall be fabricated with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
  2. SWSI plenum fans shall include thrust restraints to resist horizontal motion due to thrust during start-up, and to mitigate fan assembly vibration in the horizontal plane during operation.

- J. Each fan shall be provided with an Airflow Measuring System (AFMS) consisting of a piezometer ring mounted in the throat and a static pressure tap mounted on the face of the inlet cone. [A differential pressure transducer [and an analog display] shall be provided. Transducer shall have a field configurable 0-5 VDC or 0-10 VDC output, as well as a 4-20 mA output. Transducer shall have a standard accuracy of  $\pm 1\%$  FS.] AFMS shall not obstruct the airflow in any way and shall have no effect on fan airflow performance, static pressure, or sound power levels. Default motor characteristics are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment." If different characteristics are required, insert paragraphs to suit Project.

## 2.2 DIRECT-DRIVE FANS SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
    - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating.
    - b. Close tolerances shall be maintained where the shaft makes contact with the bearing.
    - c. Designed to operate at no more than 70 percent [80 percent (for commercial grade fans)] of first critical speed at top of fan's speed range.
  2. Flexible Connector: Factory fabricated with a 3 inch wide (76-mm) fabric strip attached to two strips of 3 inch wide (76-mm), 24 gauge, galvanized-steel sheet [0.032-inch- (0.8-mm-) thick aluminum sheets (if fan bulkhead wall is aluminum or stainless steel)].
    - a. Flexible Connector Fabric: Woven nylon/polyester blend with a vinyl coating. Fabrics, coatings, and adhesives shall comply with NFPA 701, and NFPA 90A & 90B.
      - 1) Fabric Minimum Weight: 22 oz./sq. yd. (746 g/sq. m).
      - 2) Fabric Tensile Strength: 240 lb (1067 N) in the warp and 220 lb (978 N) in the fill.
      - 3) Fabric Service Temperature: Minus 40 to plus 180 deg F (Minus 40 to plus 82 deg C).
      - 4) Fabric Pressure Resistance: Minus 10 in-w.g. to plus 15 in-w.g. (Minus 2.5 kPa to plus 3.7 kPa).
- B. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing. All single width single inlet (SWSI) plenum fans shall have airfoil blades. Flat plate blades shall not be acceptable. SWSI fans shall be provided with [inlet screens][fan screens and wheel guards].
1. Arrangement 4 direct drive plenum fans shall include wheels constructed entirely of aluminum to reduce weight and vibration. Airfoil blades shall be extruded aluminum, and continuously welded around all edges.
  2. Direct drive plenum fan wheels are attached to the motor shaft using taper lock bushings. The wheel and fan inlet are matched and have precise running tolerances for maximum performance and operating efficiency.

- C. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws. All airfoil fans shall bear the AMCA Seal. Airfoil fan performance shall be based on tests made in accordance with AMCA standard 210 and comply with the requirements of AMCA standard 300 for inlet sound and outlet sound. In addition, all airfoil wheels shall comply with AMCA standard 2408-69. Fans shall be run tested at the specified operating speed prior to shipment. Each fan shall be dynamically balanced as a complete assembly in accordance with ISO-1940, to achieve Balance Quality Grade G6.3 for the rotating assembly. Maximum vibration shall be within the limits of ANSI/AMCA 204 Fan Application Category BV-3. Balance readings shall be taken electronically in the axial, vertical, and horizontal directions. Records of each fan balance shall be made available upon request.
- D. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with 2 inch (50 mm) deflection spring isolators with seismic restraints.
  - 1. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
  - 2. SWSI plenum fans shall include thrust restraints to resist horizontal motion due to thrust during start-up, and to mitigate fan assembly vibration in the horizontal plane during operation.

### 2.3 FAN ARRAYS

- A. Fan Arrays: Fan arrays shall consist of multiple direct-drive, arrangement 4, modular plenum fans selected to provide the scheduled airflow at the scheduled total static pressure. Fans shall be statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation. Fans shall have a non-overloading design with self-limiting horsepower characteristics and shall reach a peak in the normal selection area. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA's Standard 2408-69.
- B. Fans shall be tested in accordance with AMCA 210 and AMCA 300 test standards for air moving devices and shall be guaranteed by the manufacturer to deliver rated published performance levels. [\[Fans shall be licensed to bear the AMCA certified ratings seal for fan inlet sound, fan outlet sound, and air performance. \(for MPQN and Lau Model SF fans only\)\]](#)
- C. Fan Housings: Steel frame and panel; fabricated without fan scroll. Shall incorporate a non-overloading type backward inclined airfoil blade wheel. Flat plate blades shall not be acceptable. Fans shall be provided with heavy-gauge reinforced steel inlet plate and structural steel frame. [\[Fans shall be provided with inlet screens\]. \[Fans shall be provided with a minimum of 2"](#)

acoustical insulation. Insulation shall be protected with an erosion resistant vapor barrier preventing insulation shedding for IAQ (indoor air quality). Galvanized, perforated steel shall be located on the airstream side of the vapor barrier providing additional protection without affecting air and sound performance. **(for MPQN fans only)**

- D. Airfoil, Centrifugal Fan Wheels: Wheels constructed entirely of aluminum to reduce weight and vibration. Airfoil blades shall be extruded aluminum, and continuously welded around all edges. Wheels to be attached to the motor shaft using taper lock bushings or set screws. The wheel and fan inlet are matched and have precise running tolerances for maximum performance and operating efficiency. In addition, fans shall be run tested at the specified operating speed prior to shipment. Each fan shall be dynamically balanced as a complete assembly to achieve Balance Quality Grade G6.3 for the rotating assembly. Maximum vibration shall be within the limits ANSI/AMCA 204 Fan Application Category BV-3 **[BV-4 (for MPQ fans only)]**. Balance readings shall be taken electronically in the axial, vertical, and horizontal directions. Records of each fan balance shall be made available upon request.
- E. Internal Vibration Isolation and Seismic Control:
1. Fans shall be factory mounted with Neoprene pads. **[Fans shall be factory mounted on inertia bases with 2 inch (50 mm) deflection spring isolators with seismic restraints. (option for Lau Stack Fan)]**
  2. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
- F. Fan Options
1. Back-Draft Dampers: Each fan shall have an individual industrial grade low leak back-draft damper. Frame shall be minimum 9" deep x 2" (229 x 51) flanged 12 (2.8) gage galvanized steel channel. The blades shall be maximum 7" (178) wide, minimum .080 (2) thick, 6063T5 extruded aluminum airfoil shaped with integral structural reinforcing tube running full length of each blade. Damper blades shall be equipped with silicone rubber seals mechanically locked into extruded blade slots. Adhesive type seals are not acceptable. Adhesive type seals are not acceptable. Dampers shall be equipped with vinyl jamb seals for low leakage application. Wind stop type seals are not acceptable. Axles shall be minimum 3/4" (19) diameter with machined edge to provide positive locking connection to blades. Full round axles are not acceptable. Bearings shall be ball style pressed into frame. Linkage shall be minimum 3/16" thick 3/4" (5 x 19) bar located on face of blade in airstream. Submittal must include leakage, pressure drop, and maximum pressure data based on AMCA Publication 500 testing.
  2. Airflow Measuring: Each fan shall include an Airflow Measuring System (AFMS) consisting of a piezometer ring mounted in the throat and a static pressure tap mounted on the face of the inlet cone. **[A differential pressure transducer [and an analog display] shall be provided. Transducer shall have a field configurable 0-5 VDC or 0-10 VDC output, as well as a 4-20 mA output. Transducer shall have a standard accuracy of ±1% FS.]** AFMS shall not obstruct the airflow in any way and shall have no effect on fan airflow performance, static pressure, or sound power levels.

## 2.4 MOTORS

- A. All fan motors shall comply with NEMA and IEEE for temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Enclosure Type shall be [totally enclosed, fan cooled (TEFC)] [open drip proof (ODP)].
  2. All fan motors shall be NEMA Premium™ efficient motors as defined in NEMA MG 1.
  3. Motors shall be rated for continuous duty at full load at 40°C ambient temperature rise.
  4. Motor sizes shall be as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.15.
  5. Motors shall be [900rpm 60Hz][1200rpm 60HZ][1500rpm 50Hz][1800rpm 60Hz][3600rpm 60Hz]
  6. Motors shall be "inverter ready", complying with NEMA STD MG1 PART 31.4.4.2
  7. Motors shall have an insulation Class F.
  8. [Motors shall include a shaft grounding ring.]

## 2.5 COILS

- A. General Requirements for Coil Section:

1. Provide coils manufactured by AHU manufacturer, except where noted in contract documents.
2. Coils shall meet or exceed performance scheduled on drawings.
  1. When applicable, provide coils with performance certified in accordance with AHRI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at design flow.
2. Provide heating and cooling coils with a maximum face velocity as scheduled. Face velocity calculations shall be based on the finned area of the coil.
3. Provide cooling coil drain pan that is sufficient to contain coil condensate. Drain pan shall be 16 ga. 304 Stainless steel [16 ga. G-90 Steel][316L Stainless Steel] construction and extend a minimum of 6 [12] [18] inches downstream of leaving face of the Coil to allow for condensate pan access and maintenance and meet requirements for ASHRAE 62-2007. IAQ drain pan must slope in 3 directions and have single 304 Stainless steel 1.5 [2] inch connection for trapping at jobsite.
4. Provide a minimum of 24 inches clearance between preheat and cooling coil banks and provide access door as shown on drawings.
5. Locate access doors near coils connections to provide minimum clearance of 2 inches for field installed external piping insulation. Space shall allow a minimum of 90 degrees of door swing.
6. Provide coil segment casing that meets or exceeds casing thermal performance of the unit. Provide coil pull panel that are easily removable with no special tools. Coils shall be removable from the side of the AHU. [For units with multiple stacked coils, provide a G-90



**steel [304 stainless steel] [316L Stainless Steel] stacking rack to allow individual coils to be removed from side of AHU without disturbing any other coils].**

7. Provide Heating coils built in their own full perimeter frame G-90 steel **[304 stainless steel]**. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. When required, intermediate vertical coils support will be same material as casing. Bulkhead support shall be G-90 steel **[304 stainless steel] [316L Stainless Steel]** and shall not block finned area.
8. Provide Cooling coils built in their own full perimeter frame G-90 steel **[304 stainless steel]**. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. When required, intermediate vertical coils support will be same material as casing. Bulkhead support shall be G-90 steel **[304 stainless steel] [316L Stainless Steel]** and shall not block finned area.
9. Provide an intermediate drain pan G-90 steel **[304 stainless steel] [316L Stainless Steel]** on stacked cooling coils or any cooling coil taller than 48 inches finned height. Intermediate drain pan shall slope in a minimum of two planes and provide copper downspouts to lower drain pan.
10. Water and glycol coils shall have a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow draining and venting when installed. Extend vent, drain, and coil connections through AHU casing, when possible.
11. Water and glycol coils shall be operable at 250 psig working pressure and up to 300° F. Factory test water and glycol coils with 325 psig compressed air under water.
12. Direct expansion (DX) coils shall conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a maximum refrigerant pressure of 250 psig. Factory test DX coils with 325 psig compressed air under water. DX coils will be dehydrated and sealed prior to installation.
13. Provide DX coils with brass distributor and solder-type connections. Suction and discharge connections shall be on the same end regardless of coil depth. [Provide DX coils with a hot gas bypass port on one **[Both]** distributor].
14. Provide submittals with Cross plot table and chart with selected DX coil and Condensing unit provided.
15. Steam distributing coils shall be operable at 50 psig pressure and a corresponding saturated steam temperature of 298° F. Factory test steam coils with 325 psig compressed air under water. Dehydrate and seal coils prior to shipping.
16. Provide steam-distributing coils with a tube outer diameter (OD) of 1" and an inner distribution tube of 5/8" O.D and wall thickness of 0.035" [0.049"]. Circuit coils for gravity drain of condensate without trapping. Steam shall discharge in the direction of condensate flow to ensure even heat transfer across each tube.
17. Provide water, glycol and DX coils with a tube OD of 1/2 **[5/8]** inch. Mechanically expand tubes to form fin bond and provide burnished, work-hardened interior surface. 1/2 inch tube

wall thickness available in .016 [.020] [.032]. 5/8 inch tube wall thickness available in .020 [.025] [.035] [.049]

18. Return bends shall be hairpin construction on ½” .016” twt [5/8” .020’ twt]. . All other tube wall thicknesses will be brazed return bends.
19. Provide water and glycol coil headers made of seamless copper [Red Brass] tubing. Pipe connections shall be steel threaded MPT [Grooves for mechanical coupling] [Red Brass threaded MPT]. Header connections (tubes and piping connections) shall be silver-brazed or TIG welded. [On units with Pipe chases/vestibule or 90 deg connections, offset coil connection a minimum of 6” to allow room for field connections. With 6” offset coils provide ½” vent and drains on coil headers]
20. Provide coils with die-formed, continuous Aluminum [Copper - .006” only] fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Sine wave, Fin thickness shall be 0.006 [.008] [.010] inches. [ For low air pressure drop, and easier cleaning, provide a Flat fin (not sine wave) of fin thickness of [.010] inches]
21. Provide factory provided coil coating prior to installation in AHU.

Electrofin, [with UV-Resistant polyurethane top coat]  
Electrofin/Phenolic Coating  
Electrofin/Heresite Coating, [with UV-Resistant polyurethane top coat]

## 2.6 AIR FILTRATION

### A. General Requirements for Air Filtration Section:

1. Filters shall be manufactured by Koch, Camfil/Farr, or Flanders.
2. Provide a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
3. Provide filter segments with filters and frames as scheduled.
4. Provide filter holding frames arranged for flat or angular orientation, with access doors as indicated on drawings. Filters shall be removable from one side or lifted out from access plenum.
5. Filter media shall be in compliance with UL900.

### B. 2” Throwaway Panel Filters:

1. Thickness: 2 inches (50 mm).
2. MERV (ASHRAE 52.2): 4
3. Media: Interlaced fiberglass fibers coated with a non-migrating adhesive.
4. Media Frame: Sturdy, one-piece frame.
5. Koch model C&I Disposable or equivalent

### C. 2” Cleanable Panel Filters:

1. Thickness: 2 inches (50 mm).
2. MERV (ASHRAE 52.2): 1
3. Media: aluminum cloth secured by expanded aluminum mesh

4. Media Frame: Sturdy, all aluminum frame.
  5. Reusable, washable with hose or soapy water
  6. Koch model MA or equivalent
- D. Extended-Surface, 2" Disposable Panel Filters:
1. Factory-fabricated, dry, extended-surface, pleated type.
  2. Thickness: 2 inches (50 mm).
  3. Recommended Final Resistance: 1 inches wg (Pa).
  4. MERV (ASHRAE 52.2): 8
  5. Media: Synthetic blended fibers formed into deep-V-shaped self-supporting pleats requiring no metal reinforcement.
  6. Media-Grid Frame: Moisture-resistant beverage board frame.
  7. Koch model Multi-Pleat Elite SC or equivalent.
- E. Extended-Surface, 4" Disposable Panel Filters:
1. Factory-fabricated, dry, extended-surface, pleated type.
  2. Thickness: 4 inches (100 mm).
  3. Recommended Final Resistance: 1 inches wg (Pa).
  4. MERV (ASHRAE 52.2): 8
  5. Media: Synthetic blended fibers formed into deep-V-shaped pleats held by self-supporting wire grid
  6. Media-Grid Frame: Double wall, moisture-resistant beverage board frame
  7. Koch model Multi-Pleat XL8-SC or equivalent
- F. Extended-Surface, 12" Rigid, High Efficiency Filters:
1. Factory-fabricated, dry, extended-surface, self-supporting type
  2. Thickness: 12 inches (305 mm)
  3. Recommended Final Resistance: 1.5 inches wg (Pa)
  4. MERV (ASHRAE 52.2): [11] **[13]** **[14]**.
  5. Media: Wet-laid, gradient density, micro-fiberglass with corrugated aluminum separators, with hemmed safety edge, to maintain pleat uniformity and spacing
  6. Filter-Media Frame: Galvanized steel with 13/16" header
  7. Koch model Multi-Cell FM (single header) **[Multi-Cell SBM (double header)]** or equivalent
- G. Extended-Surface, 4" Minipleat Filters:
1. Factory-fabricated, dry, extended-surface, self-supporting type
  2. Thickness: 4 inches (100 mm)
  3. Recommended Final Resistance: 1.5 inches wg (Pa)
  4. MERV (ASHRAE 52.2): [11] **[13]** **[14]**
  5. Media: Wet-laid, gradient density, micro-fiberglass with hot melt adhesive beads to maintain pleat uniformity and spacing
  6. Filter-Media Frame: Moisture resistant beverage board die cuts, double wall, with retainer supports bonded to the media pack for rigidity
  7. Koch model MicroMAX or equivalent

H. Extended-Surface, 22" Bag Filters:

1. Factory-fabricated, dry, extended-surface, vertical pocket type
2. Thickness: 22 inches (559 mm)
3. Recommended Final Resistance: 1.5 inches wg (Pa)
4. MERV (ASHRAE 52.2): [12] [14] [15]
5. Media: 100% synthetic fibers
6. Filter-Media Frame: Galvanized steel with 13/16" header
7. Koch model Multi-Sak Series S or equivalent

I. HEPA Filters:

1. Factory-fabricated unit.
2. Testing: Each filter shall be individually tested and certified to provide a minimum overall efficiency of (99.97%, 99.99%) on 0.3 micrometer particles. Each filter shall be tested per MIL-STD 282 in accordance with IEST-RP-CC001.3. Each filter shall be labeled with test results.
3. Thickness: 12 inches (305 mm)
4. Recommended Final Resistance: 2 inches wg (Pa).
5. MERV (ASHRAE 52.2): [17, 99.97% eff] [18, 99.99% eff]
6. Media: Water resistant, ultra fine fiber glass formed into high density paper and pleated with corrugated aluminum separators
7. Frame Material: 18 Ga Galvanized steel
8. Media to Frame Side Bond: Polyurethane Elastomer
9. Face Gasket: Neoprene rubber or gel seal
10. Koch Model BioMAX HC or equivalent

J. Filter Gage:

1. [~~3-1/2-inch- (90-mm-)~~] [~~2-inch- (50-mm-)~~] diameter, diaphragm-actuated dial in metal case.
2. Vent valves.
3. Black figures on white background.
4. Front recalibration adjustment.
5. [2] [3] percent of full-scale accuracy.
6. Range: [~~0- to 0.5-inch wg (0 to 125 Pa)~~] [~~0- to 1.0-inch wg (0 to 250 Pa)~~] [~~0- to 2.0-inch wg (0 to 500 Pa)~~] [~~0- to 3.0-inch wg (0 to 750 Pa)~~] [~~0- to 4.0-inch wg (0 to 1000 Pa)~~].
7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm) [~~aluminum~~] [~~plastic~~] tubing, and 2- or 3-way vent valves.

## 2.7 DAMPERS

- A. Control Dampers: Dampers shall be [~~opposed~~] [~~parallel~~]-blade, leakage Class 1A design with a leakage rate that shall not exceed 3 cfm/sq. ft. (15 L/s· m<sup>2</sup>) at 1 in. w.g. (249.09 Pa) pressure differential when tested according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating." Dampers shall be provided with [~~galvanized-steel~~] [~~extruded-aluminum~~] airfoil-shaped, single-piece blades with flexible metal compressible type jamb seals, extruded

Ruskiprene blade edge seals, and [stainless-steel sleeve] [molded synthetic] bearings mounted in a single [galvanized-steel] [extruded-aluminum] frame. Axles shall be hexagonal positively locked into the damper blade. Dampers shall be provided with a jackshaft.

- B. Smoke Dampers: Dampers shall be opposed blade, leakage class 1, [galvanized-steel] [extruded aluminum] with a leakage rate that shall not exceed 4 cfm/sq. ft. (20 L/s· m<sup>2</sup>) at 1 in. w.g. (1000 Pa) pressure differential. Smoke Dampers shall be provided with [an Electric 120 V, 60 Hz, two-position, fail close] [an Electric 24V, 60 Hz, two-position, fail close] [a Pneumatic, 25 psi minimum control pressure, two-position, fail close] damper operator. All smoke dampers shall comply with UL 555S, NFPA 90A, NFPA 92A, NFPA 92B, and NFPA 101.
- C. Airflow Monitoring Dampers: Dampers shall be parallel-blade, leakage Class 1A design with a leakage rate that shall not exceed 3 cfm/sq. ft. (15 L/s· m<sup>2</sup>) at 1 in. w.g. (249.09 Pa) pressure differential when tested according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating." Dampers shall have galvanized-steel airfoil-shaped, single-piece blades with flexible metal compressible type jamb seals, extruded Ruskiprene blade edge seals, and stainless-steel sleeve bearings mounted in a single galvanized-steel frame. Dampers shall be provided with a jackshaft. Airflow monitoring stations shall be tested to AMCA Standard 610 and 611 and shall be qualified to bear the AMCA Ratings Seal for Airflow Measurement Station Air Performance.
  - 1. Damper shall include airfoil shaped, heavy gage, anodized aluminum monitoring blades which are fixed within the damper frame and contain air pressure sensing ports.
  - 2. Damper shall include a 3000 series aluminum alloy honeycomb air straightener contained in a galvanized steel sleeve attached to the monitoring blade frame.
  - 3. Airflow Monitoring Options:
    - a. 100%: Damper shall consist of a single section of monitoring blades and air straightener covering 100% of the damper face area.
    - b. 25% Min / Max: Damper shall consist of two sections split in a 25%/75% min/max arrangement. Only the 25% damper section shall include monitoring blades and air straightener.
    - c. 25% / 75% Split: Damper shall consist of two sections split in a 25%/75% min/max arrangement. Both the 25% and the 75% damper sections shall include independent monitoring blades and air straightener.

## 2.8 HUMIDIFIERS

### A. Humidifier Steam Manifold/Dispersion Panel

- 1. Provide and factory mount NORTEC Short Absorption Manifold (Humidifier Steam Dispersion Panel) - SAM-e Humidifier[s] as indicated on drawing[s] and as indicated on schedule[s]. Short Absorption Manifold is designed to distribute pressurized steam from a facility steam boiler, to directly inject the steam into Air handling unit for humidification.

- a. Absorption distance characteristic shall prevent water accumulation on any induct surfaces beyond 12 in [**18 in**] downstream of the steam dispersion panel.
  - b. Steam dispersion panel consisting of a (one) horizontal 304 stainless steel round header supplying steam to a bank of closely spaced 12” [**9”**] [**6”**] [**3”**] vertical tubes, as necessary to meet absorption distance requirements, and to reduce condensation losses.
  - c. Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.
  - d. Vertical stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not acceptable.
  - e. Distribution tubes shall include threaded standoffs for trouble free attachment to factory- supplied support bracket.
  - f. All tubes are 304 stainless steel construction. 409 stainless steel header and distribution tubes are not acceptable.
  - g. Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Systems without nozzle inserts, or other than stainless steel, are not acceptable.
  - h. Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
  - i. The SAM-e header functions as an internal steam separator, therefore an external Steam separator is not required.
  - j. Provide adjustable galvanized [**304 stainless steel**] mounting frame.
  - k. Tubes and headers shall accommodate factory installation or field retrofit of optional insulation for increased energy efficiency.
  - l. [**Provide Tube and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. (Patent Pending). Uninsulated headers, or simple foam insulation not accepted.**]
2. Ship Loose Items
    - a. Provide steam control valve with electrical actuator normally closed, spring return (24V), steam control valve with equal percent flow characteristics and positive shut off against steam. Control valve shall be compliant with ANSI B 16.15 class 250 pressures and temperature rating B 16.104 class IV control shut off leakage and ANSI/ISA-575.11 flow characteristics standards. Steam control valve to be brass [Stainless Steel] body with Stainless Steel seat, stem and plug.
    - b. [Stainless Steel] steam traps and [Stainless Steel] wye strainer
    - c. Air Proving switch
    - d. [**External SS steam separator with internal baffles to ensure dry condensate free steam supply to the control valve**]

B. Humidifier Steam Exchange Steam Generator With SAM-e Distribution Panel

1. Provide Nortec SETC Steam Exchange humidifier operating will boiler steam pressures between 5 psi to 15 psi, with output capacities up to 1050 lbs/hr (477 kg/hr), suitable for immediate, or future, use of all water types including, De-Ionized (DI), Reverse Osmosis (RO), potable and softened water, without modifications. INDOOR [**OUTDOOR**] packaged unit steam exchange generating system produces consistent atmospheric steam using boiler steam provided by a central plant. Generator ships loose with AHU.

2. Steam to Steam Generator is complete with:
  - a) Enclosed cabinet, powder painted steel construction and air gap between cabinet and insulated humidifier tank ensures safe surface temperature.
    - i. Evaporation tank and all internal tank components to be constructed of 304 stainless steel.
    - ii. All tank surfaces shall be insulated with minimum 1" (25 mm) thick insulation and enclosed within unit cabinetry to ensure safe surface temperature, high overall efficiency, and fast unit response time. Units with exposed insulation shall not be acceptable.
    - iii. Maintenance shall not require the removal of the steam distribution lines.
    - iv. Standard internal drain water cooler to ensure drain water tempering to 140° F (60° C). If external drain water cooler required, provide factory cross-braced unit stand and factory supplied stainless steel water seal.
    - v. Blow-down p-trap, factory installed, enclosed in cabinet, prevents steam leakage to drain. Field installation not acceptable.
    - vi. Provide easily accessible, primary voltage terminal block, internal to cabinetry, for single point field connection of electrical supply.
    - vii. Single point connection for pressure steam inlet must be provided. Internal piping from steam valve to heat exchanger[s] must be factory installed and tested. Field piping from the inlet to the exchanger[s] is not allowed.
    - viii. Humidifier to prevent "back-siphoning" using an internal air gap for supply water, to meet local plumbing codes.
    - ix. Drain line to include a vacuum breaker to prevent siphon drainage of the tank.
  - b) Stainless steel heat exchanger[s] shall have flat surfaces to retard scale build-up. Tubular heat exchangers are not acceptable.
    - x. Removable heat exchanger[s] with modular, horizontal design for easy handling during maintenance.
    - xi. Large surface area promoting equal distribution across surface area and good heat transfer. Pre-formed welded frame construction to minimize weld area and leakage potential.
    - xii. Heat exchanger[s] are constructed from 316 stainless steel. Copper exchanger[s], Teflon coating, and nickel plating not acceptable.
    - xiii. Access through front panel for maintenance of heat exchanger(s).
    - xiv. Stainless steel tank lid with gasket, easily removed for maintenance.
    - xv. Float and thermostatic (F & T) trap[s], must be included internal to the unit.
    - xvi. Inlet steam pressure must not exceed 15 psig.
  - c) Automatic water level control within a separate float chamber, isolated from the boiling action, to prevent false water level indication.
    - i. Fill rate must modulate to match capacity demand to ensure consistent output. Fill cycles based on low water only is not acceptable.
    - ii. System shall fill through the bottom of the tank to reduce steam-quenching effect and noise level. Filling at top of the tank is not acceptable.
    - iii. Unit water level is to be continuously monitored with a dual magnetic electronic float system, located outside of the boiling water to ensure accurate water level control and

- reduced maintenance. Cool fill water is to be supplied into the sensing chamber to keep the device cool. Systems using conductivity probes or floats located within hot reservoir water are not acceptable.
- iv. Float chamber must be located outside of the tank to keep the floats away from the boiling action. Units with floats in the tank as well as conductivity probes are susceptible to inaccurate water level sensing and failure, will not be considered.
  - v. Humidifier shall have a dual fill valve to feed water to the tank and float chamber, to reduce scaling and mineral build up on the magnetic floats.
  - vi. Float chamber to include LED indication of five possible water level indications.
  - vii. Ongoing self-diagnostics including periodic float operation and fill/drain rate verification.
  - viii. Positive drainage/blow-down using a drain pump, drawing water from the bottom of the tank, maximizing mineral evacuation (when applicable). Skimmer not acceptable.
  - ix. Blow down interval shall be based on actual steam production, and must be adjustable to compensate for all water conditions, to ensure maximum energy and maintenance efficiency.
  - x. Pre-cleaning flushing feature shall be provided to reduce maintenance time.
  - xi. Must include end of season blow-down feature to evacuate contained water and minerals after 72 hours with no demand for humidification.
- d) Factory mounted, full size, backlit, Liquid Crystal Display provides full operational status. Display to include a keypad for user interface and adjustment of operational parameters including:
- i. Unit output (%).
  - ii. Water level in the tank.
  - iii. Modulating control demand status.
  - iv. On/off control and safety (High limit, air proving) circuit status.
  - v. Actual room and/or duct RH, and humidity set point, when using transducer input[s].
  - vi. Controller configuration (Proportional band and integral) when using transducer input[s].
  - vii. Troubleshooting guide with scroll down menu.
  - viii. Fault indication including date and time history.
  - ix. Maintenance intervals.
  - x. Fill and drain status.
  - xi. Drain/flush intervals and duration.
  - xii. Date and time.
  - xiii. Capacity limitation.
  - xiv. 72 hours drain enable/disable.
  - xv. Control type configuration on/off or full modulation when demand signal(s), or transducer input[s] are provided.
  - xvi. Up to 10 humidifiers, supplying one AHU or area, can be controlled in series from one modulating humidity control system.
  - xvii. Capability of interface to building management system using BACnet or LonTalk protocols.

Note: All operational parameters factory set to reduce field set-up time.

3. Provide and factory mount NORTEC Short Absorption Manifold (Humidifier Steam Dispersion Panel) - SAM-e Humidifier[s] as indicated on drawing[s] and as indicated on schedule[s]. Short Absorption Manifold is designed to distribute atmospheric steam from a steam



exchange generator, to directly inject the steam into Air handling unit for humidification.

- a) Absorption distance characteristic shall prevent water accumulation on any induct surfaces beyond 12 in **[18 in]** downstream of the steam dispersion panel.
- b) Steam dispersion panel consisting of a (one) horizontal 304 stainless steel round header supplying steam to a bank of closely spaced 12” **[9”]** **[6”]** **[3”]** vertical tubes, as necessary to meet absorption distance requirements, and to reduce condensation losses.
- c) Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.
- d) Vertical stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not acceptable.
- e) Distribution tubes shall include threaded standoffs for trouble free attachment to factory-supplied support bracket.
- f) All tubes are 304 stainless steel construction. 409 stainless steel header and distribution tubes are not acceptable.
- g) Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Systems without nozzle inserts, or other than stainless steel, are not acceptable.
- h) Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
- i) The SAM-e header functions as an internal steam separator, therefore an external Steam separator is not required.
- j) Provide adjustable galvanized **[304 stainless steel]** mounting frame.
- k) Tubes and headers shall accommodate factory installation or field retrofit of optional insulation for increased energy efficiency.
- l) **[Provide Tube and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. (Patent Pending). Uninsulated headers, or simple foam insulation not accepted.]**

4. Optional Accessories

- a) Keep Warm Option
- b) Remote Fault
- c) Freeze Protection

5. Ship Loose Items

- a) Air Proving Switch
- b) INDOOR **[OUTDOOR]** Steam Exchange Generator

C. Humidifier Electrode Steam Generator With SAM-e Distribution Panel

1. Provide Nortec NH-EL electrode humidifier generating mineral-free, sterile steam from a potable water supply. INDOOR Packaged unit, wall mounted, electric steam generating system produces consistent atmospheric steam using an electrode steam cylinder[s]. Generator ships loose with AHU.
2. Electrode Steam Generator is complete with:

- a) Touchscreen controller with standard building automation and Online connectivity:
  - i. Intuitive touchscreen control with color graphic user interface.
  - ii. Standard building automation communication protocols BACnet IP, BACnet MSTP and Modbus. Additional hardware required for building automation communication not acceptable.
  - iii. Standard Nortec Online connectivity for remote monitoring and factory diagnostic.
  - iv. Embedded web interface for easy configuration and remote monitoring from any computer with a web browser over a local area network (LAN) connection.
  - v. USB interface for new software/feature upload and download of operational information.
  - vi. Single or dual channel analog signal acceptance, supporting both demand and transducer control. Ability to control setpoint from humidifier control when using transducer controls.
- b) Standard remote monitoring with Nortec Online
  - i. Integrated hardware and software allows for remote end-user and factory diagnostic of humidifier(s) via the internet.
  - ii. Humidifier parameter data and performance trending data can be exported remotely using the internet.
  - iii. Humidifier will be accessed via the internet by registering humidifier to [www.norteconline.com](http://www.norteconline.com). Controls contractor to provide internet access to humidifier through Ethernet cable with RJ-45 connection.
- c) Packaged system with Nortec electrode cylinder technology:
  - i. Nortec cylinder optimized for humidifier capacity and supply voltage. Cylinder must have welded seam to ensure watertight and have high water sensor to prevent overfilling.
  - ii. Durable powder coated steel cabinet with zero side clearance requirement for minimal footprint.
  - iii. Insulating air gap between plumbing and electrical compartment for increased electronic reliability.
  - iv. Standard internal drain water tempering to ensure maximum 140° F [60° C] drain water. External drain water cooler not acceptable.
  - v. Integral fill cup with minimum 1-inch [25 mm] air gap to prevent back siphoning.
  - vi. Full cylinder indication and pre-notification of automatic shutdown at end of cylinder life.
  - vii. Automatic pulse feature to clean any obstruction from the drain solenoid valve if required.
  - viii. Automatic off-season shut-down [after 3 days of "no call"] will completely drain the cylinder[s] and automatically restart on call for humidity. Adjustable on/off and time sequence. Provides extended cylinder life, while ensuring stagnant water does not remain in the system.
  - ix. Plumbing door interlock safety switch to allow power interruption when installing or servicing the humidifier.
- d) Nortec Auto-Adaptive Control water management:
  - i. Advanced water management utilizing the patented Proportional plus Integral Auto-Adaptive Control system for optimal energy efficiency, water usage and cylinder life.
  - ii. 98% thermal efficiency from startup until end of cylinder life.
  - iii. Drains automatically optimized to water conditions to maximize cylinder and reduce water usage.

- iv. Modulating output between 20% and 100% of rated capacity.
3. Provide and factory mount NORTEC Short Absorption Manifold (Humidifier Steam Dispersion Panel) - SAM-e Humidifier[s] as indicated on drawing[s] and as indicated on schedule[s]. Short Absorption Manifold is designed to distribute atmospheric steam from an electrode generator, to directly inject the steam into Air handling unit for humidification.
    - a. Absorption distance characteristic shall prevent water accumulation on any induct surfaces beyond 12 in [**18 in**] downstream of the steam dispersion panel.
    - b. Steam dispersion panel consisting of a (one) horizontal 304 stainless steel round header supplying steam to a bank of closely spaced 12" [**9"**] [**6"**] [**3"**] vertical tubes, as necessary to meet absorption distance requirements, and to reduce condensation losses.
    - c. Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.
    - d. Vertical stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not acceptable.
    - e. Distribution tubes shall include threaded standoffs for trouble free attachment to factory- supplied support bracket.
    - f. All tubes are 304 stainless steel construction. 409 stainless steel header and distribution tubes are not acceptable.
    - g. Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Systems without nozzle inserts, or other than stainless steel, are not acceptable.
    - h. Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
    - i. The SAM-e header functions as an internal steam separator, therefore an external Steam separator is not required.
    - j. Provide adjustable galvanized [**304 stainless steel**] mounting frame.
    - k. Tubes and headers shall accommodate factory installation or field retrofit of optional insulation for increased energy efficiency.
    - l. [**Provide Tube and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. (Patent Pending). Uninsulated headers, or simple foam insulation not accepted.**]
  4. Optional Accessories
    - a. Keep Warm Option
    - b. Remote Fault
  5. Ship Loose Items
    - a. Air Proving Switch
    - b. INDOOR Electrode Steam Generator
- D. Humidifier Resistive Element Steam Generator With SAM-e Distribution Panel
1. Provide Nortec NHRS resistive steam generating system is suitable for use with potable, De-Ionized (DI), and Reverse Osmosis (RO) water. INDOOR packaged unit, wall mounted, electric steam generating system produces consistent atmospheric steam using resistive heating elements. Generator ships loose with AHU.

2. Resistive Element Generator is complete with:
  - a. Incoloy based resistive heating elements are used to produce steam.
  - b. Modulating output between 0% and 100% of rated maximum capacity.
  - c. Control accuracy of up to  $\pm 1\%$  RH using optional SSR control.
  - d. Keypad programming to configure monitor and control humidifier with information messages on alphanumeric LCD display.
  - e. Internal drain water tempering to ensure maximum 140° F [60° C] drain water.
  - f. Dual magnetic electronic float system, located outside of the boiling water to ensure accurate water level control and reduced maintenance. Systems using conductivity probes or floats located within hot reservoir water are not acceptable.
  - g. Self-diagnostics during start-up of system to prevent unsafe operation on the unit(s).
    - i. Fill valve check.
    - ii. Float level check.
    - iii. Drain pump check.
  - h. Dual signal status light indicates unit operation.
  - i. Cabinet has powder coated paint finish with removable doors to allow the user full front access.
  - j. Plumbing door interlock safety switch to allow power interruption when installing or servicing the humidifier.
  - k. Integral fill cup with minimum 1-inch [25 mm] air gap to prevent back siphoning.
  - l. Automatic off-season shut-down [after 3 days of "no call"] will completely drain the cylinder[s] and automatically restart on call for humidity. Adjustable on/off and time sequence. Provides extended cylinder life, while ensuring stagnant water does not remain in the system.
  - m. Accepts a signal from BMS system using Modbus protocols or modulating humidistat.
  - n. Integral design allowing easy installation and access for servicing.
  - o. Internal cooling and heating fans to maintain an optimal cabinet operating temperature.
  
3. Provide and factory mount NORTEC Short Absorption Manifold (Humidifier Steam Dispersion Panel) - SAM-e Humidifier[s] as indicated on drawing[s] and as indicated on schedule[s]. Short Absorption Manifold is designed to distribute atmospheric steam from a resistive element generator, to directly inject the steam into Air handling unit for humidification.
  - a. Absorption distance characteristic shall prevent water accumulation on any induct surfaces beyond 12 in [**18 in**] downstream of the steam dispersion panel.
  - b. Steam dispersion panel consisting of a (one) horizontal 304 stainless steel round header supplying steam to a bank of closely spaced 12" [**9"**] [**6"**] [**3"**] vertical tubes, as necessary to meet absorption distance requirements, and to reduce condensation losses.
  - c. Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.
  - d. Vertical stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not acceptable.
  - e. Distribution tubes shall include threaded standoffs for trouble free attachment to factory-supplied support bracket.
  - f. All tubes are 304 stainless steel construction. 409 stainless steel header and distribution tubes are not acceptable.
  - g. Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Systems without nozzle inserts, or other than stainless steel, are not acceptable.

- h. Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
- i. The SAM-e header functions as an internal steam separator, therefore an external Steam separator is not required.
- j. Provide adjustable galvanized **[304 stainless steel]** mounting frame.
- k. Tubes and headers shall accommodate factory installation or field retrofit of optional insulation for increased energy efficiency.
- l. **[Provide Tube and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. (Patent Pending). Uninsulated headers, or simple foam insulation not accepted.]**

4. Optional Accessories

- c. Keep Warm Option
- d. Remote Fault
- e. Scale Control
- c. SSR Control

5. Ship Loose Items

- a. Air Proving Switch
- b. INDOOR Resistive Element Steam Generator

E. Humidifier Gas Fired Steam Generator With SAM-e Distribution Panel

- 1. Provide Nortec GSTC gas fired steam generating system is suitable for use of all water types including, De-Ionized (DI), Reverse Osmosis (RO), potable and softened water, without modifications INDOOR **[OUTDOOR]** packaged unit, generates clean, sterile, and efficient atmospheric pressure steam through combustion of natural gas or propane. Generator ships loose with AHU.
- 2. Gas Fired Steam Generator is complete with:
  - a) INDOOR **[OUTDOOR]** enclosure cabinet, powder painted steel construction and air gap between cabinet and insulated humidifier tank ensures safe surface temperature.
  - b) All tank surfaces shall be insulated with minimum 1" (25 mm) thick insulation and enclosed within unit cabinetry to ensure safe surface temperature, high overall efficiency, and fast unit response time. Units with exposed insulation shall not be acceptable.
  - c) Standard internal drain water cooler to ensure drain water tempering to 140° F (60° C). If external drain water cooler required, provide factory cross-braced unit stand and factory supplied stainless steel p-trap.
  - d) Blow-down p-trap, factory installed, enclosed in cabinet, prevents steam leakage to drain. Field installation not acceptable.
  - e) Humidifier to prevent "back-siphoning" using an internal air gap for supply water, to meet local plumbing codes.
  - f) Drain line to include a vacuum breaker to prevent siphon drainage of the tank.

- g) All venting components are included for assembly.
- h) Stainless Steel combustion chamber(s)/heat exchanger(s) shall have flat surfaces to retard scale build-up. Tubular heat exchangers are not acceptable.
- i) Stainless Steel combustion chamber(s)/heat exchanger(s) shall be heat treated to protect against possible stress corrosion cracking. Combustion chamber(s)/heat exchanger(s) that are not heat treated stainless steel are not acceptable.
- j) Each burner, capable of true modulation will provide steam production of 25 to 105 lbs/hr (11 to 48 kg/hr). Time proportioning modulation is not acceptable.
- k) Combustion efficiency of 83.7% based on the higher heating value and 94.5% based on the lower heating value.
- l) Gas system with gas valve(s), explosion proof, premix combustion air blower(s), micro-processor controlled ignition, flame sensing and fault indicator light(s), 100% premix infrared burner(s), hot surface igniters(s) and heat transfer efficiency maintained overall operating ranges.
- m) A secondary combustion air safety, in addition to blower speed monitoring, utilizing a mechanical pressure differential switch, used with each blower to ensure combustion air is entering the pre-mix blower properly.
- n) Removable cover at front of unit facilitates easy cleaning (when applicable) with complete access to tank and heat exchanger surfaces.
- o) Automatic water level control within a separate float chamber, isolated from the boiling action, to prevent false water level indication.
- p) Dual magnetic electronic float system, located outside of the boiling water to ensure accurate water level control and reduced maintenance. Cool fill water is to be supplied into the sensing chamber to keep the device cool. Systems using conductivity probes or floats located within hot reservoir water are not acceptable.
- q) Humidifier shall have a dual fill valve to feed water to the tank and float chamber, to reduce scaling and mineral build up on the magnetic floats.
- r) Float chamber to include LED indication of five possible water level indications.
- s) Pre-cleaning flushing feature shall be provided to reduce maintenance time.
- t) End of season blow-down feature to evacuate contained water and minerals after 72 hours with no demand for humidification.
- u) Standard Modbus protocol communication capability with BACnet, LonWorks, and Johnson N2 adaptability.
- v) Keep warm function allows the water temperature in the cylinder to be maintained at a high temperature for quick response of the unit to a call for humidity.
- w) Total Controller microprocessor with alphanumeric backlit display.
- x) **[Outdoor generators Internal cooling and heating fans to maintain an optimal cabi-**

**net operating temperature and Freeze protection where a failsafe normally open valve ensures water is drained from the tank in the event of power loss.]**

3. Provide and factory mount NORTEC Short Absorption Manifold (Humidifier Steam Dispersion Panel) - SAM-e Humidifier[s] as indicated on drawing[s] and as indicated on schedule[s]. Short Absorption Manifold is designed to distribute atmospheric steam from a gas fired steam generator, to directly inject the steam into Air handling unit for humidification.
  - a) Absorption distance characteristic shall prevent water accumulation on any induct surfaces beyond 12 in **[18 in]** downstream of the steam dispersion panel.
  - b) Steam dispersion panel consisting of a (one) horizontal 304 stainless steel round header supplying steam to a bank of closely spaced 12” **[9”] [6”] [3”]** vertical tubes, as necessary to meet absorption distance requirements, and to reduce condensation losses.
  - c) Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.
  - d) Vertical stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not acceptable.
  - e) Distribution tubes shall include threaded standoffs for trouble free attachment to factory-supplied support bracket.
  - f) All tubes are 304 stainless steel construction. 409 stainless steel header and distribution tubes are not acceptable.
  - g) Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Systems without nozzle inserts, or other than stainless steel, are not acceptable.
  - h) Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
  - i) The SAM-e header functions as an internal steam separator, therefore an external Steam separator is not required.
  - j) Provide adjustable galvanized **[304 stainless steel]** mounting frame.
  - k) Tubes and headers shall accommodate factory installation or field retrofit of optional insulation for increased energy efficiency.
  - l) [Provide Tube and header insulation constructed from 304 stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. (Patent Pending). Uninsulated headers, or simple foam insulation not accepted.]**
  
4. Optional Accessories
  - a) Keep Warm Option
  - b) Remote Fault
  - c) Freeze Protection
  - d) Direct Vent Kit
  
5. Ship Loose Items
  - a) Air Proving Switch
  - b) INDOOR **[OUTDOOR]** Gas Fired Generator

2.9 Sound Attenuators

- A. Sound attenuator (silencer) segments shall be provided as shown on drawings. Silencers shall be rectangular, 24" [36", 60"] long sound attenuators as indicated on drawings and equipment schedule.
- B. Outer casings of rectangular silencers shall be made of 22 gauge type #G-90 lock-former-quality galvanized steel [304 stainless steel].
- C. Interior partitions for rectangular silencers shall be not less than 26 gauge type #G-90 galvanized lock-former-quality perforated steel [304 stainless steel].
- D. Filler material shall be inorganic glass fiber of a proper density to obtain the specified acoustic performance and be packed under not less than 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin- and moisture-proof. [Filler material shall be totally encapsulated and sealed with polymeric film of an appropriate thickness. The encapsulated fill material shall be separated from the interior perforated baffles by means of a noncombustible, erosion resistant, factory-installed, acoustic stand-off. It shall not be acceptable to omit the acoustic stand-off and try to compensate for its absence by means of corrugated baffles. (Hospital grade)]
- E. Combustion ratings for the silencer acoustic fill shall be not greater than the following when tested to ASTM E 84, NFPA Standard 255, or UL No. 723:
  - 1. Flamespread Classification . . . . . 20
  - 2. Smoke Development Rating . . . . . 20

2.10 Air Blenders

- A. Multiple-blade, air-mixer assembly shall mix air to prevent stratification.
- B. Air blenders shall be of the rotary turbulating design consisting of radially extending blades. Units shall be completely fixed devices, with no moving parts.
- C. Static air mixers material shall be .080" or .125" thick aluminum [.095" 304 Stainless Steel]. Static air mixers shall be welded.
- D. When multiple air blenders are used, they shall impart a counter rotational mixing of the airstreams relative to each other. Simple mixing devices that do not produce expanding discharge with counter rotational mixing will not be acceptable.
- E. The air blenders shall be installed such that the blender shall be capable of providing a minimum mixing effectiveness of 75% and  $\pm 6$  °F standard deviation when mixing 50% OA with 50% RAS at 50 °F inlet temperature differential, and minimum mixing effectiveness of 80% and  $\pm 5$  °F standard deviation when mixing 30% OA with 70% RAS at 50 °F inlet temperature differential.



## 2.11 Indirect Gas-Fired Heater

### A. General

1. Provide an indirect fired heating system having 80% minimum thermal efficiency and incorporating Gas-fired Duct Furnaces manufactured by Heatco Inc. The Duct Furnace models HDB-HH shall be listed by Intertek Testing Services (ITS / ETL) for operation on Natural or Propane gas to the current edition of ANSI Z83.8 Standard for Gas-Fired Duct Furnaces. Duct furnaces are for installation on the positive pressure side of the circulating air blower, only.

### B. Stainless Steel Heat Exchanger

1. Gas-fired duct furnaces provided shall have a tubular heat exchanger constructed of Type 409 Stainless Steel .044 Min. Wall thickness produced to ASTM A268. Heat exchanger design shall be suitable to withstand 3.0" w.c. total external static pressure without burner flame disturbance
2. Duct Furnaces shall be Listed for application downstream of refrigeration and cooling systems and shall provide means for removal of condensate that occurs in the tubes during cooling operation. Heat exchanger tubes shall have integral formed dimpled restrictors to provide for an unobstructed drainage path and tubes shall be formed to provide a positive pitch to promote condensate drainage.
3. Drainage shall be configured so that burners and burner surfaces are not exposed to condensate.

### C. Individual Duct Furnaces

1. Individual Duct Furnaces shall incorporate a Direct Spark Ignition control module that is design certified by a recognized national testing agency. The control shall provide:
  - a. 100% safety shut-off
  - b. A 15 second minimum pre-purge period prior to trial for ignition
  - c. High energy direct spark ignition of main burners
  - d. Electronic flame supervision incorporating a 0.8 second flame failure response time
  - e. Up to 2 additional ignition retries preceded by an interpurge period
  - f. A minimum 30 second post-purge
  - g. Automatic reset after one hour to initiate additional ignition trials if lockout occurs during heat call
  - h. An LED indicator light to provide a flash code to identify the operating condition of the control
2. The Duct furnace may be equipped for operation on a 115, 208 or 230 VAC, 1  $\Phi$ , 60 Hz power supply
3. All electrical components shall be listed or recognized by a Nationally Recognized Test Laboratory (ETL, UL, CSA, etc.).

### D. Rack Assembly

1. All duct furnaces shall fit in a single 14 gauge galvanized metal frame
2. 18 gauge galvanized sheet metal shall be used to optimize air flow across the furnaces
3. The system design shall allow for removal of individual furnaces without disassembly
4. All wiring shall utilize quick connects for serviceability
5. All wiring from the individual duct furnaces to the sequencer shall be completed. A connection panel for customer power, heat enable and analog input shall be provided
6. All individual furnace gas piping shall be pre-piped to a suitably sized main gas header
7. Each furnace shall have a flexible connector and manual isolation valve for easy service

8. All condensate lines shall be piped to a suitably sized CPVC header using high temperature silicon rubber tubing

E. Operating Controls

1. **Lead Duct Furnace Electronic Modulation-** Operates from 20 to 100% of input based on an external analog input of 0 -10 VDC (supplied by others). Thermostat or heat enable contact (supplied by others) initiates and opens to end heating cycles. Furnace controls provide two-speed induced draft fan operation and electronic modulating controller to control modulating furnace section.
2. **Slave Furnaces On/Off or Two-Stage operation.**
3. **Vernier Staging Controller-** Integral to the complete assembly will be an electronic controller to provide Vernier modulation and staging of all duct furnaces within the assembly. As a minimum it will include the following features:
  - a. Capability of handling the lead modulating heater and up to (4, 8 or 16) subsequent stages of heat.
  - b. Power Supply is to be low voltage 24VAC
  - c. The controller has to be capable of inputting either an analog 0 to 10vDC signal or analog 4 to 20 ma DC and output a controlled 0 to 10vDC, for modulation
  - d. The control board will have adjustable ratio modulation output control function
  - e. Relays to control subsequent stages will be integral to the control board
  - f. The control will have a fully adjustable time delay between relay stages
  - g. The control board will have diagnostic lights and a function test button

F. Vestibule and Flue Riser

1. The system will include an Indoor [**Weatherproof**] vestibule section manufactured from 20 gauge pre-painted steel. The section shall enclose all exposed furnace components and include full length hinged doors with latches. Properly sized fresh air inlets with expanded metal guards shall be integral to the doors. An engineered double wall flue riser to vent flue gases shall be integral to the vestibule and shown on unit drawing. All electrical components shall be mounted within the vestibule section
2. Gas supply pressure to the gas valve inlet shall be 6.0" to 13.5" w.c. for Natural Gas [**11.0" to 13.5" w.c. for Propane Gas**].
3. Units are orificed for operation up to 2000 ft. above sea level unless specified for high altitude operation.
4. Duct furnaces shall be test fired prior to shipment to verify proper ignition, operation and shut down and satisfactory operation of all components.
5. Each system shall be provided with printed installation and maintenance instructions, burner operating and maintenance instructions, piping and wiring diagrams and Installation Start-up data sheet
6. Shipped loose, shall be **air flow switch** to prove that sufficient air flow is present and must be customer installed upstream of the heating system, as well as a **manual reset high temperature limit control** to shut down the furnace in an over temperature condition must be installed downstream of the heating system.

2.12 Testing

- A. [Perform factory test on a fully assembled unit with sections joined per manufacturer's installation instructions. Use of additional material (tape, sealant, caulk) shall be minimized to

only that required to simulate permanent jobsite conditions not otherwise duplicable in the factory.]

- B. [Factory performance to be witnessed by owner's representative. Owner's representative shall select one unit, at time of release, to be tested. Manufacturer shall notify contractor and/or owner 14 days prior to test for witnessing. (Travel expenses are not part of this contract). A written report shall be provided showing the test results and the test methods used.]
- C. [Factory Panel Deflection Test: The unit manufacturer shall provide a factory deflection test on one unit. Casing panel deflection shall not exceed  $L/240$  at  $\pm 10''$  w.g. (or as required by AHRI 1350.) 'L' is defined as the panel span length and 'L/X' is the deflection at panel midpoint. Measurements shall be taken along the vertical seam of the largest panel on the side.]
- D. [Factory Leak Testing: The unit manufacturer shall provide a factory leak test on one unit across the cabinet exterior walls. Casing leakage shall not exceed 0.5% of design CFM at  $\pm 10''$  w.g. (or as required by AHRI 1350.)]
- E. [Factory Sound Pressure Testing: The unit manufacturer shall test one unit for sound power of AHU discharge and/or return openings using sound pressure measurements. All sound pressure level measurements shall be made with a Type 1, Precision Sound Level Meter that complies with both ANSI S1.4 & ANSI S1.4A. Sound meter's octave band filters shall conform to ANSI I.11 and be calibrated with handheld acoustical calibrator immediately before each measurement session. Sound pressure readings shall be reviewed and converted to sound power level by a professional engineer (acoustical engineer) using established ANSI S12.34 and ISO 3744 methods. Testing per AHRI 260 or AMCA 300 will be considered acceptable alternative methods. All other test methods must be approved by Engineer prior to bid.]
- F. [Factory Sound Power Testing: The unit manufacturer shall test one unit for sound power of AHU discharge and/or return openings using sound intensity measurements. All sound intensity level measurements shall be made with a Type 1-D analyzer meeting the requirements of ANSI S1.11 for octave and 1/3 octave band filters. Analyzer shall be periodically calibrated with reference sound source as specified in Section 5.8 of ANSI S12.12. Sound Intensity measurements shall be performed by professional engineer (acoustical engineer) using methods based on AHRI Standard 230. Testing per AHRI 260 or AMCA 300 will be considered acceptable alternative methods. All other test methods must be approved by Engineer prior to bid.]
- G. [Should a unit fail a test, the unit shall be treated with a permanent remedy at manufacturer's expense until test is successfully passed.]

## 2.13 Lights and Outlets

- A. Lights
  1. Vapor Resistant Pendant: Factory shall provide vapor resistant pendant, marine type light fixture with clear globe, metal guard, and **[100W incandescent, 23W compact fluorescent]** bulb in segments and quantity as noted on drawings.
  2. Fluorescent Twin Tube: Factory shall provide 48" fluorescent light fixture with corrosion resistant housing, acrylic diffuser and twin 32W, T8 lamps and rated for installation in damp environment.

3. Factory shall wire all light fixtures to a common 120v switch located on the supply fan segment.
4. Factory shall wire each light fixture to a separate 120v switch located near the access door of the segment with the light fixture.

B. Outlets

1. Factory shall provide a 15A GFI duplex outlet mounted in a weatherproof enclosure in segments and quantity as indicated on the drawings.

2.14 Hoods and Louvers

A. Louvers

1. Provide 16 ga., galvanized steel, stationary type, drainable blade louver with downspouts in the jamb and mullions and 1/4" sq. galvanized mesh birdscreen. Blades shall be housed inside a 16 ga. galvanized steel frame flush mounted to the unit exterior. Louver to be pre-painted with baked enamel finish in manufacturer's standard Champagne.

B. Weather Hood

1. Provide weather hood of same material type and thickness as unit exterior skin with 1/4" sq. galvanized mesh birdscreen.

2.15 Integral Face and Bypass Coil Specification (L.J. Wing)

A. General

1. Furnish an integral face and bypass coil with performance as shown in the schedule. The unit inlet and discharge flanges shall be pre-punched and designed for easy adaptation to external duct work or optional accessories. The unit shall include all components and accessories as set forth herein.
2. Coil shall have vertical [**horizontal**] tubes.
3. All coils will be built with orientation and control locations as indicated on drawings.
4. The coil shall be manufactured by the L.J. Wing Company, Model: VIFB [**IFB**].
5. Certified in accordance with the AHRI Forced-Circulation Air-Cooling and Air-Heating Coils Certification Program which is based on AHRI Standard 410 within the Range of Standard Rating Conditions listed in Table 1 of the Standard. Certified units may be found in the AHRI Directory. Each coil shall carry ETL label for compliance with UL.
6. Standard 1995 and bear the seal indicating manufacturer's compliance. All electrical components shall be UL/CSA approved devices.

B. Heating Coil Construction and Material

1. Coil shall consist of a built-in series of finned heating elements.
2. By-passes with mechanically interlocked dampers shall be designed into the casing of each unit.
3. Coil shall be capable of maintaining a constant discharge air temperature within  $\pm 1-5$  degrees F regardless of variations in entering air temperature.
4. Finned heating elements shall be fabricated of seamless 5/8 inch O.D. return bend type copper tubes with 0.035 inch wall thickness.
5. Each tube shall be individually secured to the supply and return headers by a brazed joint. Each tube shall be individually removable for ease in maintenance and repair.
6. Fins shall be rectangular embossed aluminum with a thickness of 0.010 inch.

7. Headers shall be constructed of steel tubing or pipe with a minimum wall thickness of 0.216 inches. Vertical - Bottom header shall be free floating and tubes shall have a 90 degree bend to insure individual freedom of each tube for thermal expansion and contraction. **[Horizontal - Each tube shall be free to expand and contract individually. Channel-shaped tube retainers shall maintain distances between tubes and shall be free floating to allow for tube expansion.]**

C. Damper and Casing Construction

1. Dampers shall be arranged so as to completely enclose and isolate the heating coil passes when no temperature rise is required.
2. Dampers shall be constructed of heavy gauge G90 galvanized steel roll-formed to an aerodynamic shape designed for minimum airflow resistance.
3. Damper position shall be controlled by electric actuator 24V (2-10 V). Pivot brackets shall be welded to individual damper blades and connected to precision punched 1/4" thick steel bar with brass pins. Misadjustment of individual dampers will not be possible.
4. Casing shall be constructed of heavy gauge G90 galvanized steel.
5. Manufacturer shall provide heavy gauge G90 anti-stratification baffles on leaving air side of coil to reduce suggested downstream clearance from 36" to 24".

D. Operation

1. Volume of air passing through the coil shall not vary more than +/-5% regardless of the position of the internal dampers.
2. The temperature at any point in a parallel plane to the face of the coil three feet downstream from the leaving air side will not vary more than +1-5 degrees F from the average discharge air stream temperature.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install equipment per industry standards, applicable codes, and manufacturer's instructions.
- B. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.
- C. Install AHUs on a concrete pad, roof curb, or structural steel base, as shown on drawings.
- D. Install AHUs with manufacturer's recommended clearances for access, coil pull, and fan removal.
- E. Provide one complete set of filters for testing, balancing, and commissioning. Provide second complete set of filters at time of transfer to owner.
- F. Install AHU plumb and level. Connect piping and ductwork according to manufacturer's instructions.
- G. Install seismic restraints and anchors per applicable local building codes. Refer to specification Section 230548 (15240 / 15070) for product and installation requirements.

- H. Install pipe chases per manufacturer's instructions.
- I. Insulate plumbing associated with drain pan drains and connections.
- J. Install insulation on all staggered coil piping connections, both internal and external to the unit.

### 3.02 FIELD QUALITY CONTROL

- A. Store per AHU manufacturer's written recommendations. Store AHUs indoors in a warm, clean, dry place where units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will be stored for more than 6 months, follow manufacturer's instruction for long-term storage.
- B. Rig and lift units according manufacturer's instructions.

### 3.03 AHU INSPECTION

- A. Hire manufacturer's factory-trained and factory-employed service technician to perform an inspection of unit and installation prior to startup. Technician shall inspect and verify the following as a minimum:
  - 1. Damage of any kind
  - 2. Level installation of unit
  - 3. Proper reassembly and sealing of unit segments at shipping splits.
  - 4. Tight seal around perimeter of unit at the roof curb
  - 5. Installation of shipped-loose parts, including filters, air hoods, bird screens and mist eliminators.
  - 6. Completion and tightness of electrical, ductwork and piping
  - 7. Tight seals around wiring, conduit and piping penetrations through AHU casing.
  - 8. Supply of electricity from the building's permanent source
  - 9. Integrity of condensate trap for positive or negative pressure operation
  - 10. Condensate traps charged with water
  - 11. Removal of shipping bolts and shipping restraints
  - 12. Sealing of pipe chase floor(s) at penetration locations.
  - 13. Tightness and full motion range of damper linkages (operate manually)
  - 14. Complete installation of control system including end devices and wiring
  - 15. Cleanliness of AHU interior and connecting ductwork
  - 16. Proper service and access clearances
  - 17. Proper installation of filters
  - 18. Filter gauge set to zero
- B. **Resolve any non-compliant items prior to unit start-up.**

### 3.04 INSPECTION AND ADJUSTMENT: AHU FAN ASSEMBLY

- A. Hire the manufacturer's factory-trained and factory-employed service technician perform an inspection of the AHU fan assembly subsequent to general AHU inspection and prior to startup. Technician shall inspect and verify the following as a minimum:
  - 1. Fan isolation base and thrust restraint alignment
  - 2. Tight set screws on pulleys, bearings and fan
  - 3. Tight fan bearing bolts
  - 4. Tight fan and motor sheaves

5. Tight motor base and mounting bolts
6. Blower wheel tight and aligned to fan shaft
7. Sheave alignment and belt tension
8. Fan discharge alignment with discharge opening
9. Fan bearing lubrication
10. Free rotation of moving components (rotate manually)

### 3.05 STARTUP SERVICE and OWNER TRAINING

- A. Manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Technician shall perform the following steps as a minimum:
  1. Energize the unit disconnect switch
  2. Verify correct voltage, phases and cycles
  3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
  4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
  5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.
- B. Provide a minimum of 4 hours of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician. Training shall include AHU controls, motor starter, VFD, and AHU.
- C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.
- D. If AHU is provided with a factory-mounted variable frequency drive (VFD), hire the VFD manufacturer's factory-trained and factory-employed service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.
- E. Submit a startup report summarizing any problems found and remedies performed.

### 3.06 FIELD PERFORMANCE VERIFICATION

- A. Leakage: Pressurize casing to maximum operating static pressure (up to +/-8" w.g.) and measure leakage. If leakage exceeds 1% of design airflow, seal leakage points with a permanent solution. Repeat test. If the AHU still does not pass, contact the manufacturer to seal unit.
- B. Submit a field test report with testing data recorded. Include description of corrective actions taken.

### 3.07 CLEANING

- A. Clean unit interior prior to operating. Remove tools, debris, dust and dirt.
- B. Clean exterior prior to transfer to owner.

3.08 DOCUMENTATION

- A. Provide Installation Instruction Manual, & Startup checklist in the supply fan section of each unit.
- B. Provide six copies of Spare Parts Manual for owner's project system manual.

END OF SECTION