

**SECTION 23 73 00**  
**INDOOR CENTRAL-STATION AIR-HANDLING UNITS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

- A. Air handling units including integral components specified herein.
- B. Definitions: Air Handling Unit (AHU): A factory fabricated and tested assembly of modular sections consisting of fan, coils, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled on the drawings.

**1.2 RELATED WORK**

- B. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- C. Sound and vibration requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- D. Piping and duct insulation: Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
- E. Piping and valves: Section 23 21 13 / 23 22 13, HYDRONIC PIPING / STEAM AND CONDENSATE HEATING PIPING.
- F. Heating and cooling coils and pressure requirements: Section 23 82 16, AIR COILS.
- G. Return and exhaust fans: Section 23 34 00, HVAC FANS.
- H. Requirements for flexible duct connectors, sound attenuators and sound absorbing duct lining, and air leakage: Section 23 31 00, HVAC DUCTS and CASINGS.
- I. Air filters and filters' efficiency: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- J. Testing, adjusting and balancing of air and water flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
- K. Types of motors: Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
- L. Types of motor starters: Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.

**1.3 QUALITY ASSURANCE**

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
- B. Air Handling Units Certification: Certify air-handling units in accordance with ARI 430.

C. Heating, Cooling, and Air Handling Capacity and Performance Standards:  
ARI 430, ARI 410, ASHRAE 51, and AMCA 210.

D. Performance Criteria:

1. The fan schedule indicates design CFM - Design Cubic Feet per Minute - followed by L/s - Liters per Second in brackets. The Fan motor BHP (KW) at the operating point on the fan curves shall be increased by 10% (safety factor) to cover the drive losses and field conditions. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
2. Select the fan operating point as follows:
  - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point.
  - b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency.
3. Operating Limits: AMCA 99.

E. Units shall be constructed by a manufacturer who has been manufacturing air handling units for at least five (5) years.

**1.4. SUBMITTALS:**

A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, furnish a complete submission for all air handling units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.

B. Manufacturer's Literature and Data:

1. Submittals for AHUs shall include fans, drives, motors, coils, humidifiers, mixing box with outside/return air dampers, filter housings, blender sections, and all other related accessories. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc).
2. Submittal drawings of section or component only will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves or certified computer selection data; data sheets; fabrication and insulation details. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements. This data shall be submitted in hard copies and in electronic version

compatible to AutoCAD version used by the VA at the time of submission. Include a minimum of the following inside the final submittal package.

- (a) Overall unit dimensions and individual components and section dimensions.
- (b) Sound analysis consisting of inlet, outlet and radiated sound power levels per unit performed by an AMCA 300 accredited lab.
- (c) Shipping and operating weight of unit and/or sections.
- (d) Materials of construction.
- (e) Cross section details of typical wall, floor and roof construction.
- (f) Component equipment data as detailed in component specification section.
- (g) Unit performance data including sound data.
- (h) Details of coil support in a coil bank.
- (i) Piping connection sizes and approximate locations.
- (j) Door and window sizes and elevations.
- (k) Drain pan details.
- (l) Operating and Maintenance Data

- 3. Submit sound power levels in each octave band for fan and at entrance and discharge of AHUs at scheduled conditions.
- 4. Provide fan curves showing cubic feet per minute, static pressure, efficiency, and horsepower for design point of operation and at maximum design cubic feet per minute.
- 5. Submit total fan static pressure, external static pressure, for AHU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule on drawings.
- C. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.
- D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.

- E. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below for Knock-Down Construction (with complete re-assembly on site).

1. Unit shall be shipped in pieces small enough to fit through the available opening(s), yet large enough to minimize work required in the field by installing contractor. All air handler pieces will ship on palettes with all pieces and palettes clearly labeled and which will refer to a clear and concise Assembly Drawing supplied by the air handler manufacturer. An Installation/Procedures Manual shall be supplied by the air handler manufacturer and will include tools and materials required for installation. Factory personnel shall be provided to supervise the assembly from start to finish. Manufacturer shall guarantee the performance of the field assembled units just as if they were built in the factory. Approval by factory personnel shall confirm that installing contractor followed all assembly procedures and that unit will perform as specified. All field-assembled units will not bear the factory ETL label. All motors are to be wired in the field and terminated by the installing contractor at the Motor Start Panel (MSP). Lights, light switches, and GFI will be supplied by the air handler manufacturer with all 120V wiring done in the field by the installing contractor. Each fan Air Flow Monitoring Station to be field connected to the MSP Panel (via transparent tubing) by the installing contractor. Plastic transparent tubing shall be supplied by air handler manufacturer.
2. Manufacturer shall pay for all travel expenses for a factory representative to supervise and advise the Mechanical Contractor on proper assembly procedures and methods of panel assembly. Factory representative will be responsible for final inspection of unit to maintain same quality standards as a factory assembled unit to maintain manufacturer warranty.
3. The factory representative shall provide field test per SMACNA standards to verify casing leakage after units are installed at jobsite. Casing tests shall verify that unit casing leakage is less than 1% of design air flow at 1.5 time design static pressure. Total casing leakage shall be calculated as sum of positive pressure section leakage and negative pressure sections leakage. Total casing leakage shall be less than 1% of unit design airflow.
4. The factory representative shall also conduct flood testing while on site after field fabrication. Manufacturer's liability insurance shall cover any potential water damaged caused from a failed flood

test while on site during this testing. All unit bases shall be flooded to a level of 1.5" after manufacturing to assure there is no leakage through the floor and the perimeter water barrier. The results of the flood test shall be certified by the manufacturer's representative.

5. Field assembled filter frame assemblies shall be constructed of galvanized steel and be specifically designed and sized for field assembly. Filter frames shall have matching mounting holes such that frames may be riveted together. Frame comes with pre-installed gasket so as to provide a surface onto which the filter will self seal. Filter frames come with stiffeners which are installed between each column of filter frames. Stiffeners are installed in the field. All filter holding frames must be caulked in between them to minimize bypass air through the frames.
6. Proper structural support (every 5 frames wide, an additional structural 2" tube to reinforce is recommended) for attachment of frame assembly to existing AHU casing / building structure as well as a proper air seal - materials and installation - at and around the assembled filter rack shall be provided by contractor as needed.

F. Delivery, Storage and Handling: All equipment shall be delivered to the job site suitably packaged and protected for overland trucking using heavy-duty protective shrink-wrap plastic. Where multiple units are required, a schedule of priority will be furnished which shall determine the manufacturing and delivery sequence. In general, units shall be delivered in one piece unless indicated otherwise. Where building constraints, unit size or trucking limitations require that units ship in more than one piece, the manufacturer shall indicate all split points on the shop drawings. All items shipped loose such as filters, steam humidifier assemblies, caulking, etc. shall be itemized on the packing slip and be suitably secured in the unit or on a separate pallet.

G. General Design Considerations: Coils shall be arranged so that space between coils is a minimum of 24", unless specifically shown otherwise on drawings. Fan compartment shall be arranged such that the space between the fan inlet(s) and the housing is a minimum of 75% of fan diameter, unless noted or shown otherwise on the schedule or drawings. Coil assembly shall have provisions to facilitate total or partial removal from coil bank. Housing shall be designed and sealed to minimize air and water vapor leakage. Housing shall be designed and tested to meet maximum leakage of SMACNA class 4 when tested in accordance with the procedure outlined in the SMACNA HVAC Air Duct Leakage Manual.

H. Factory Testing: The unit will be field assembled. Refer to "Knock-Down Construction" requirements within this specification for required pressure testing for air leakage, and floor construction flood testing, that will be required to be performed on site after unit assembly is complete. A factory representative shall be available on site for final inspection of all panel connections for conformity to manufacturer's standards prior to this field testing.

## 1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI)/(ARI):  
410-01.....Standard for Forced-Circulation Air-Heating and Air-Cooling Coils  
430-09.....Central Station Air Handling Units
- C. Air Movement and Control Association International, Inc. (AMCA):  
210-07.....Laboratory Methods of Testing Fans for Rating
- D. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):  
170-2008.....Ventilation of Health Care Facilities
- E. American Society for Testing and Materials (ASTM):  
ASTM B117-07a.....Standard Practice for Operating Salt Spray (Fog) Apparatus  
ASTM D1654-08.....Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments  
ASTM D1735-08.....Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus  
ASTM D3359-08.....Standard Test Methods for Measuring Adhesion by Tape Test
- F. Military Specifications (Mil. Spec.):  
MIL-P-21035B-2003.....Paint, High Zinc Dust Content, Galvanizing Repair (Metric)
- G. National Fire Protection Association (NFPA):  
NFPA 90A.....Standard for Installation of Air Conditioning and Ventilating Systems, 2009
- H. Energy Policy Act of 2005 (P.L.109-58)

## PART 2 - PRODUCTS

### 2.1 CUSTOM AIR HANDLING UNITS

- A. Equivalent Manufacturers:
- a. BASE BID: Ventrol with FanWall supply fans
- b. Add Alternate 1: Haakon with AcoustiFLO supply fans
- B. General:
1. AHUs shall be entirely of double wall galvanized steel construction without any perforations except as specified in section 2.1.C.2.

Casing is specified in paragraph 2.1.C. Foil face lining is not an acceptable substitute for double wall construction. Galvanizing shall be hot dipped conforming to ASTM A525 and shall provide a minimum of 0.275 kg of zinc per square meter (0.90 oz. of zinc per square foot) (G90). Aluminum constructed units may be provided subject to VA approval and documentation that structural rigidity is equal or greater than the galvanized steel specified.

2. Cabinet (Ventrol Option): Formed and reinforced wall panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Outside Casing shall be solid 16-ga, Bright spangled G-90 galvanized steel, double die-formed 4" thick panel secured with 1/4" hex head, zinc plated fasteners at 12" on-centers. The inside liner shall be 20-ga, G-90 galvanized steel and incorporate a 5 degree bend on all exposed surfaces to eliminate any waving. Liner shall be secured with sheet metal screws to outside casing at 12" on-centers.

The unit construction needs to be of thermal break hybrid polyisocyanurate foam, meeting NFPA 90 A and B. The thermal break must have a minimum R value of 3.3 and the panels to have a minimum R value of 17.9. The fiberglass insulation has an effective thermal conductivity (C) of 0.24 (BTU in. / hr sq.ft.°F) and a noise reduction coefficient (NRC) of 0.70 per inch thick (based on a type 'A' mounting). Coefficient meets or exceeds a 3.0 P.C.F. density material rating. The fiberglass and foam insulated panels meets erosion requirement of UL 181 facing the air stream and fire hazard classification of 25/50 tested per ASTM E84 for flame and smoke spread, to meet NFPA 90 A and B.

3. Cabinet (Haakon Option): Formed and reinforced wall panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Outside Casing shall be solid 16-ga, Bright spangled G-90 galvanized steel, double die-formed 4" thick panel secured with 1/4" hex head, zinc plated fasteners at 12" on-centers. The inside liner shall be 20-ga, G-90 galvanized steel and incorporate a 5 degree bend on all exposed surfaces to eliminate any waving. Liner shall be secured with sheet metal screws to outside casing at 12" on-centers.

The unit construction needs to be no-thru metal construction, meeting NFPA 90 A and B. The panel construction must have a minimum R value of 1.3 in the walls, ceiling and unit base, to ensure no thru metal

unit design throughout the entire unit. The fiberglass insulation has an effective thermal conductivity (C) of 0.24 (BTU in. / hr sq.ft.°F) and a noise reduction coefficient (NRC) of 0.70 per inch thick (based on a type 'A' mounting). Coefficient meets or exceeds a 3.0 P.C.F. density material rating. The fiberglass and foam insulated panels meets erosion requirement of UL 181 facing the air stream and fire hazard classification of 25/50 tested per ASTM E84 for flame and smoke spread, to meet NFPA 90 A and B

4. The contractor and the AHU manufacturer shall be responsible for insuring that the unit will not exceed the allocated space shown on the drawings, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost to the government.
5. AHUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown on the drawings. The correct fit of all components and casing sections shall be verified in the factory for all units prior to shipment. All units shall be fully assembled, tested and then disassembled and palletized to accommodate shipment and job site rigging. On units not shipped fully assembled, the manufacturer shall tag each pallet clearly to facilitate assembly at the job site. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.
6. The AHU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a local representative at the job site to supervise the assembly and to assure the units are assembled to meet manufacturer's recommendations and requirements noted on the drawings. Provide documentation that this representative has provided this service on similar jobs to the Contracting Officer. If a local representative cannot be provided, the manufacturer shall provide a factory representative.
7. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal air tight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.



8. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed 1/200 of the span based on a differential static pressure of 1991 PA (8 inch WG) or higher.

9. Acoustical Performance: The housing shall have acoustical performance described below.

Test methods and facilities used to establish sound transmission loss values shall conform explicitly with the ASTM designation E90-85 and E413-73.

Sound Transmission Loss DB ASTM E-90 & E413-73:

	1	2	3	4	5	6	7	8	
2"-4" Walls	20	20	28	41	51	56	55	57	STC=40

Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83.

Sound Absorption ASTM C423-84A & E795-83:

	1	2	3	4	5	6	7	8	
2"-4" Walls	.40	.65	1.38	1.28	1.09	1.05	1.02	1.02	STC=40

C. Base:

1. Provide a heavy duty steel base for supporting all major AHU components. Bases shall be constructed of wide-flange steel I-beams, channels, or minimum 5 inch high 10 Gauge steel base rails. Welded or bolted cross members shall be provided as required for lateral stability. Contractor shall provide supplemental steel supports as required to obtain proper operation heights for cooling coil condensate drain trap and steam coil condensate return trap as shown on drawings.
2. AHUs shall be completely self supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended as shown on drawings.
3. The AHU bases not constructed of galvanized steel shall be cleaned, primed with a rust inhibiting primer, and finished with rust inhibiting exterior enamel.

4. Units shall be constructed from structural steel C-channel around the perimeter of the unit with intermediate channel and angle iron supports. Units less than or equal to 20' in length shall have a minimum 4" channel, and units greater than 20' in length shall have a minimum 6" channel.
5. Use a 12 gauge floor shall be installed on the base. The floor shall be slip resistant and corrosion resistant. The floor shall be flat, reinforced from below, with all seams continuously welded. Floors that "oil can" are not acceptable. Drive screw attachment and caulking are not acceptable.
6. The base shall be provided with lifting lugs, a minimum of four [4] per unit section. The base shall be insulated with 4" fiberglass insulation and sheeted with a galvanized steel liner. The insulation shall be encapsulated with a minimum 22 ga galvanized steel under-liner with joints sealed to provide a continuous vapor barrier. Floors that "oil can" are not acceptable.
7. The manufacturer shall provide a 1.5" perimeter collar around the entire unit and around each floor opening to ensure the unit is internally watertight. The entire base shall act as an auxiliary drain pan and hold up to 1.5" of water.
8. The manufacturer shall provide auxiliary floor drains in fan sections downstream of cooling coils and in mixing sections. All drain connections on floor mounted air handling units shall terminate at the side of the unit.
9. Floors and walls operating under positive pressure (Fan Discharge Side), a maximum allowable deflection shall not exceed more than 1/200th of any span in any direction at 1.5 times design pressure or 10" WG, whichever is more positive. Floors and walls operating under negative pressure (Fan Inlet Side), a maximum allowable deflection shall not exceed more than 1/200th of any span in any direction at 1.5 times design pressure or 10" WG, whichever is more negative.

C. Casing (including wall, floor and roof):

1. General: AHU casing shall be constructed as solid double wall, galvanized steel insulated panels without any perforations, integral of or attached to a structural frame. The thickness of insulation, mode of application and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU located in the non-conditioned spaces.
2. Casing Construction (Ventrol Option):

Table 2.1.C.2

Outer Panel	0.8 mm (20 Gage) Minimum
Inner Panel	0.8 mm (22 Gage) Minimum
Insulation	Foam
Thickness	50 mm (2 inch) Minimum
Density	48 kg/m <sup>3</sup> (3.0 lb/ft <sup>3</sup> ) Minimum
Total R Value	2.3 m <sup>2</sup> .K/W (13.0 ft <sup>2</sup> .°F.hr/Btu) Minimum

3. Casing Construction (Haakon Option):

Table 2.1.C.3

Outer Panel	1.3 mm (18 Gage) Minimum
Inner Panel	1.0 mm (20 Gage) Minimum
Insulation	Fiberglass
Thickness	50 mm (2 inch) Minimum
Density	24 kg/m <sup>3</sup> (1.5 lb/ft <sup>3</sup> ) Minimum
Total R Value	1.4 m <sup>2</sup> .K/W (8.0 ft <sup>2</sup> .°F.hr/Btu) Minimum

4. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.

5. The wet sections of the air handler shall be lined with 20 gauge 316 stainless steel liner. This includes the cooling coil and humidifier sections.

6. Casing panels shall be secured to the support structure with stainless steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are not acceptable.

7. Access Doors: Provide in each access section and where shown on drawings. Doors shall be a minimum of 50 mm (2 inch) thick with same double wall construction as the unit casing. Doors shall be a minimum of 600 mm (24 inches) wide, unless shown of different size on drawings, and shall be the full casing height up to a maximum of 1850 mm (6 feet). Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan section, mixing box, humidifier, and coil section shall include a minimum 150 mm x 150 mm (6 inch x 6 inch) double thickness, with air space between the glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.

- a. Hinges: Manufacturers standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 45 kg (100 lb) weight hung on latch side of door.
- b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 0.785 radian (45 degrees) further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 1991 Pa (8 inch WG).
- c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.
- d. Access doors are constructed with a double wall construction and an extruded aluminum frame. The doorframe features a built-in no-through-metal high density resin barrier and a perimeter gasket. Door frames with no thermal break are not acceptable. The door gasket is seamed together at each corner to prevent leakage through the door. Door is attached to the unit with 3 axes adjustable stainless steel hinges. Doors shall open against higher pressure side. Where this is not feasible due to site constraints, an interlocking mechanism furnished on the fan section access door with a de-energizing switch complying with CAL-OSHA, ETL and the mechanical protection requirements of UL 1995 will be provided.
- e. Access doors shall be manufactured from 16 gauge galvanized steel. The doors shall be double wall construction with 20 gauge solid metal liner on the inside. Corners of the doors shall be continuously welded for rigidity. Doors shall be the same thickness as the unit casing to maximize thermal and acoustical resistance. A 12" round (or equivalent) hermetically sealed double pane thermally insulated glass window shall be provided in each door. Hinges shall be heavy duty stainless steel, resistant to damage.
- f. Two [2] high pressure latches operable from either side of the door shall be provided. The door opening shall be fully gasketed with continuous ½" closed cell hollow round black gasketing and a metal encapsulated reinforcing backing that mechanically fastens to the door frame. Door frames shall be made from 16 gauge galvanized steel with the outside of the door flush with the unit. The minimum door opening size shall be 18" x 70" [where height

permits] or as shown on the drawings. Fan compartments must have a door of minimum width to remove the motor and fan scroll.

g. Inspection access panels and doors shall be sized and located to allow periodic maintenance and inspections. Provide access panels and doors in the following locations as shown on drawings

h. Dual-paned tempered glass with vacuum seal windows with thermally broken frames shall be supplied as shown on unit drawings. Singled paned windows are not acceptable.

i. All outward swinging doors must be equipped with a door chain to limit door swing.

7. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.

E. Floor:

1. Unit floor shall be level without offset space or gap and designed to support a minimum of 488 kg/square meter (100 lbs per square foot) distributed load without permanent deformation or crushing of internal insulation. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation. Unit floors in casing sections, which may contain water or condensate, shall be watertight with drain pan.
2. Where indicated, furnish and install floor drains, flush with the floor, with nonferrous grate cover and stub through floor for external connection.
3. Units shall be constructed from structural steel C-channel around the perimeter of the unit with intermediate channel and angle iron supports. Units less than or equal to 20' in length shall have a minimum 4" channel, and units greater than 20' in length shall have a minimum 6" channel.
4. A 12 gauge floor shall be installed on the base. The floor shall be slip resistant and corrosion resistant. The floor shall be flat, reinforced from below, with all seams continuously welded. Floors

- that "oil can" are not acceptable. Drive screw attachment and caulking are not acceptable.
5. The base shall be provided with lifting lugs, a minimum of four [4] per unit section. The base shall be insulated with 2" or 4" fiberglass insulation and sheeted with a galvanized steel liner. The insulation shall be encapsulated with a minimum 22 ga galvanized steel under-liner with joints sealed to provide a continuous vapor barrier. Floors that "oil can" are not acceptable.
  6. The manufacturer shall provide a 1.5" perimeter collar around the entire unit and around each floor opening to ensure the unit is internally watertight. The entire base shall act as an auxiliary drain pan and hold up to 1.5" of water.
  7. The manufacturer shall provide auxiliary floor drains in fan sections downstream of cooling coils and in mixing sections. All drain connections on floor mounted air handling units shall terminate at the side of the unit.
  8. Floors and walls operating under positive pressure (Fan Discharge Side), a maximum allowable deflection shall not exceed more than 1/200th of any span in any direction at 1.5 times design pressure or 10" WG, whichever is more positive. Floors and walls operating under negative pressure (Fan Inlet Side), a maximum allowable deflection shall not exceed more than 1/200th of any span in any direction at 1.5 times design pressure or 10" WG, whichever is more negative.
- F. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 43 mm (1.7 inches) and shall handle all condensate without overflowing. Drain pan shall be double-wall, double sloping type, and fabricated from stainless (304) with at least 50 mm (2 inch) thick insulation sandwiched between the inner and outer surfaces. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.
1. An intermediate, stainless-steel (304) condensate drip pan with copper downspouts shall be provided on stacked cooling coils. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.

2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
3. Installation, including frame, shall be designed and sealed to prevent blow-by.

G. Supply Fan Sections:

1. FANWALL TECHNOLOGY®(Ventrol Option)

- a. The multiple fan array systems shall include multiple, direct driven, arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, minimum Class II or class III as required. Class I fans are not acceptable.
- b. Fans shall be certified by AMCA for performance. All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed.
- c. The fan array shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan's peak static pressure producing capability at the specified fan/motor speed.
- d. Each fan/motor cube or cell shall include a 12 gauge, G 90U Galvanized steel intake wall, 14 gauge spun steel fan inlet funnel, and an 10 gauge G90 Galvanized steel motor support plate rail and structure.
- e. All fan array components (excluding wheel and base) shall be coated with air dried industrial grade alkyd enamel that meets the requirements set forth in corrosion resistance standard ASTM B-117 providing 500 hour salt spray resistance.
- f. Motors
  - i. All motors shall be standard foot mounted type, TEFC or TEAO motors selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere.
  - ii. Motors shall meet the requirements of NEMA MG-1 Part 30 and 31, section 4.4.2.
  - iii. Motors shall be as manufactured by Baldor, Siemens, or Toshiba for use in multiple fan arrays that operate at varying synchronous speeds as driven by an approved VFD with all features required for use in multiple fan arrays.
  - iv. Motors shall be available in 1/2 HP increments so that the nameplate electrical service is at the minimum possible. Any additional electrical service required by an alternative fan array shall be by the contractor.

v. Motor HP shall not exceed the scheduled HP as indicated in the AHU equipment schedule(s).

vi. Motor BHP shall not exceed the scheduled BHP as indicated in the AHU equipment schedule(s).

vii. Steel cased motors and/or ODP motors are not acceptable.

viii. All motors shall include permanently sealed bearings and shaft grounding to protect the motor bearings from electrical discharge machining due to stray shaft currents.

ix. Motors sizes that are larger than 10 HP (7.47 KW) shall be provided with electrically isolated ceramic bearings.

**g. Array Assembly**

i. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, exceeding category BV-5, to meet or exceed an equivalent Grade G.55, producing a maximum rotational imbalance of .022" per second peak, filter in (.55mm per second peak, filter in).

ii. All fan and motor assemblies with 27" dia. and less shall be balanced to meet or exceed the G .55 residual unbalance. Fan and motor assemblies submitted for approval incorporating larger than 10 HP motors shall be balanced in three orthogonal planes to demonstrate compliance with the G.55 requirement with a maximum rotational imbalance of .022" per second peak filter in ( .55 mm per second peak, filter in).

iii. Fan arrays that meet the balancing specification do not require spring isolation.

iv. Copies of the certified balancing reports shall be provided with the unit O&M manuals at the time of shipment. Submittals that do not include a statement of compliance with this requirement will be returned to the contractor without review.

**h. Acoustical Performance**

i. The multiple fan array AHU unit shall provide the specified acoustical performance as scheduled for the unit supply discharge opening(s), RA opening(s), and the Outside air and Exhaust air opening(s).

ii. A coplanar silencer shall be required so that discharge radial fan noise shall pass through multiple acoustically attenuated wall panels within the fan array.

iii. Submitted sound and performance data for preapproval showing only single fan performance for multiple fan arrays will be returned without review.



iv. Any proposed remedy for deviations in submitted sound power levels shall be approved by a registered acoustical consultant as selected by the owner or architect. Costs for review of proposed changes shall be borne by the contractor.

j. Array Construction

i. The fan array shall consist of multiple fan and motor "cubes" or "cells", spaced in the air way tunnel cross section to provide a uniform air flow and velocity profile across the entire air way tunnel cross section and components contained therein.

ii. In order to assure uniform velocity profile in the AHU cross section, the fan cube dimensions must be variable, such that each fan rests in an identically sized cube or cell, and in a spacing that must be such that the submitted array dimensions fill a minimum of 90% of the cross sectional area of the AHU air way tunnel.

iii. There shall be no blank off plates or "spacers" between adjacent fan columns or rows to position the fans across the air way tunnel.

iv. Each fan & motor assembly shall be removable through a 30" wide, free area, access door located on the discharge side of the fan wall array without removing the fan wheel from the motor.

v. All fan/motor access doors shall open against pressure.

k. Array Performance

i. Scheduled fan performance and static efficiencies shall be based upon actual installed conditions that include the system effects associated with the actual fan mounting arrangement, enclosures around each individual fan, and the effects of any back flow prevention devices, or other appurtenances necessary for proper fan system performance in the event of disabling of one or more fans in the array. All fans in the multiple fan arrays shall be AMCA certified for performance, and that certified performance shall be corrected for system effects introduced by the mounting arrangement, enclosures, back draft dampers, and other fan appurtenances not considered when AMCA certified performance for free inlet and discharge is determined. Submitted AHU performance that does not indicate allowance for system effects for the back flow prevention device(s) and the system effect for the fan and motor enclosure in which each fan is mounted, will be returned to the contractor disapproved and will need to be resubmitted with all of the requested information included for approval.

- ii. The array shall produce a uniform air flow profile and velocity profile within the airway tunnel of the air handling unit to equal the specified cooling coil and/or filter bank face velocity by +/- 10% when measured at a point 36" from the intake side of the fan array intake plenum wall, and at a distance of 72" from the discharge side of the fan array intake plenum wall.
  - iii. Any increase in fan system power requirements or sound power levels that exceed those as specified will be corrected at no additional cost to the owner. Corrections for both fan power and sound power levels shall be determined and submitted to the engineer for approval prior to release for production of the submitted equipment.
  - iv. Submittals for units providing less than the scheduled quantity of fans and/or spacing of the fans for multiple fan arrays shall submit CFD modeling of the air flow profile for pre-bid approval that indicates uniform velocity and flow across all internal components without increasing the length of the AHU unit or changing the aspect ratio of the unit casing as designed.
- k. Backdraft dampers
- i. Each individual cube or cell in the multiple fan arrays shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan or multiple fans become disabled.
  - ii. All fans in the multiple fan arrays shall be provided with a back flow prevention means that produces near no static pressure drop and/or system effect when that fan is enabled.
  - iii. The system effects for the back flow prevention device(s) shall be included in the criteria for TSP determination for fan selection purposes, and shall be indicated as a separate line item SP loss in the submittals.
  - iv. Back Draft Damper performance data that is per AMCA ducted inlet and discharge arrangements will not be accepted. Damper data must be for the specific purpose of preventing back flow in any disabled fan cube and that is close coupled to the entering face of the inlet cone of each fan. Motorized dampers for this purpose are not acceptable.
- l. Control Panel
- i. Each fan motor shall be individually wired to a motor control panel containing motor overloads and VFD(s). VFD configuration shall be,

- ii. Each control panel shall have a single point electrical power connections. Therefore, units with supply and return fan wall would have two power connections.
- iii. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards and local code requirements.
- iv. Provide internal ground fault protection such that a ground fault in any of the motor circuits does not cause a system shutdown.
- v. The AHU unit shall be completely factory-wired, requiring only field wiring of main power wiring to the line side of the main power disconnect switch, and a separate 120/60/1 power supply with disconnect switch for receptacles and light fixtures when indicated and required.
- vi. Redundancy in the variable frequency drives shall be included, along with all necessary controls and devices to assure that in a fault condition for any drive, whether internal or external to the drive, the fan array shall maintain flow and pressure at the required fan operating speed at the time of the fault with no interruption in flow to the system affected.

## 2. ACOUSTICFLO FANS (Haakon Option)

- a. Plenum fan assembly include (qty shown on schedules) direct drive single width, single inlet plenum fans with radial outlet silencers acting as an attenuator and static regain device. Fans shall be AcoustiFlo or approved equal.
- b. Fan performance shall be based on tests run in an AMCA certified laboratory and administered in accordance with AMCA Standard 210. Fans shall bear AMCA seal for air and sound.
- c. Each fan shall be sized to perform as indicated on the equipment schedule. The wheel diameter shall not be less than that shown on the equipment schedule. The fan shall be constructed to AMCA Standards for the Class Rating as indicated on the Equipment Schedule.
- d. Fan static efficiencies shall not be less 68% for the supply fans, and shall modulate to 10% of design capacity without entering a surge region with the system static pressure control point set at 0.75" w.g. If a fan were to fail the remaining fans shall provide a standby capacity of 94% at the design static pressure.
- e. Mount fan and motor on an internal rigid steel frame. The fan shall be isolated from the cabinet by steel springs. The spring

isolators shall be mounted to structural steel members and shall be mounted on a waffle pad for vibration isolation.

f. The fan shaft shall be sized not to exceed 75% of the first critical speed for maximum RPM of Class specified. The critical speed will refer to the top of the speed range of the fans' AMCA class. The lateral static deflection shall not exceed 0.003" per foot of the length of the shaft. Fans shall be balanced to ISO standard G6.3.

g. A copy of the above balance test data for this project showing calculations for deflection and critical speed of the shaft and wheel assembly shall be submitted to the engineer and a copy forwarded to the Owner.

h. Furnish premium-efficiency open drip proof, NEMA frame, NEMA premium ball bearing type motors. Horsepower as shown on the schedule are minimum allowable. The fan motors shall be factory wired to an external junction box with flexible conduit of adequate length so that it will not have any affect on the vibration isolation. Motor efficiencies shall not be below NEMA Premium efficiencies.

i. The connected motor horsepower for the fan array shall not exceed that of the scheduled unit.

j. The scheduled KW of the fan array shall be exceeded.

3. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. For plenum fan applications, the fan wheel shall meet or exceed guidelines in AMCA 801-92 for dynamic balancing requirements. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).

H. Fan Motor, Drive and Mounting Assembly:

1. Provide internally vibration isolated fan, motor and drive, mounted on a common integral bolted or welded structural steel base with

- adjustable motor slide rail with locking device. Provide vibration isolators and flexible duct connections at fan discharge to completely isolate fan assembly. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, for additional requirements.
2. Fan Motor and Drive: Motors shall be premium energy efficient type, as mandated by the Energy Policy Act of 2005, with efficiencies as shown in the Specifications Section 23 05 12 (General Motor Requirements For HVAC and Steam Equipment), on drawings and suitable for use in variable frequency drive applications on AHUs where this type of drive is indicated. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, for additional motor and drive specifications. Refer to Specification Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
3. Fan drive and belts shall be factory mounted with final alignment and belt adjustment to be made by the Contractor after installation. Drive and belts shall be as specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Provide additional drive(s) if required during balancing, to achieve desired airflow.
- J. Mixing Boxes: Mixing box shall consist of casing and outdoor air and return air dampers in opposed blade arrangement with damper linkage for automatic operation. Coordinate damper operator with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Dampers shall be of ultra-low leak design with metal compressible bronze jamb seals and extruded vinyl edge seals on all blades. Blades shall rotate on stainless steel sleeve bearings or bronze bushings. Leakage rate shall not exceed 1.6 cubic meters/min/square meter (5 CFM per square foot) at 250 Pa (1 inch WG) and 2.8 cubic meters/min/square meter (9 CFM per square foot) at 995 Pa (4 inch WG). Electronic operators shall be furnished and mounted in an accessible and easily serviceable location by the air handling unit manufacturer at the factory. Damper operators shall be of same manufacturer as controls furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- K. Blenders: Construction of the blender section shall be of welded aluminum 2 mm (0.081 inch) thick framing and turbulators. The mixer shall have no moving parts and shall contain a primary set of directional changing vanes, a secondary set of turbulator vanes, and a cone design for mixing of air streams. Certify blender performance to achieve no more than a 5°F variation across the cross section of the AHU measured 12 inches downstream of the blender over a face velocity range of 1-4 m/s (200-800 FPM).

L. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.

1. Filters including one complete set for temporary use at site shall be provided independent of the AHU. The AHU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The AHU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown on drawings) required for AHU testing.
2. Factory-fabricated filter section shall be of the same construction and finish as the AHU casing including filter racks and hinged double wall access doors. Filter housings shall be constructed in accordance with side service or holding frame housing requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.
3. Air-Handling Units serving surgical suites, shall have after filters located on the downstream side of the supply air fans and cooling coils. Provide a diffuser section between the fan and the after-filters to ensure uniform air distribution. The final filters shall be HEPA filters located prior to the air outlets
4. Prefilters: The filter shall consist of a pleated media, media support grid, and enclosing frame. The filters shall be labeled by Underwriters Laboratories as Class 2. The media shall be non-woven cotton fabric and shall have a minimum efficiency (ASHRAE test standard 52-76) of 30% with minimum arrestance of 90%. The media support shall be a welded wire grid with an effective open area of not less than 90%. The grid shall be bonded to the filter media to eliminate media oscillation and pull away. The enclosing frame shall be constructed of rigid, heavy duty, high wet strength beverage board. The frame shall be bonded to the filter pack. Standard sizes shall be 12" x 24" x 2" and 24" x 24" x 2". All filter holding frames must be caulked in between them to minimize bypass air through the frames. Filters shall be American Air Filter Perfect Pleat, or equal by Cam-Farr, Eco-Air or Airguard.
5. Final Filter - Rigid Type: The filter shall be a high performance, deep pleated, totally rigid type and shall consist of a glass fiber media, media support frame, contour stabilizers, and enclosing frame. The filter shall be labeled by Underwriters Laboratories as Class 2. The filter media shall be a high density microfine glass fiber laminated to a non-woven synthetic backing to form a lofted filter blanket. The media shall have a minimum efficiency (ASHRAE test standard 52-76) of 90% with a minimum arrestance of 90%. The media support shall be a welded wire grid with an effective open area of

not less than 96%. The grid shall be bonded to the filter media to eliminate media oscillation and pull-away. The grid shall support the media both vertically and horizontally. Contour stabilizers shall be permanently installed on both the air entering and exiting sides of the filter media pack to insure the pleat configuration is maintained throughout the life of the filter. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled to provide a rigid and durable enclosure for the filter pack. The frame shall be bonded to the filter pack. Standard filter sizes shall be 12" x 24" x 12" and 24" x 24" x 12". All filter holding frames must be caulked in between them to minimize bypass air through the frames. Filters shall be American Air Filter Rigifil, or equal by Cam-Farr, Eco-Air or Airguard. Provide Dwyer Instruments Inc Series 2000 Magnahelic gauges across each filter bank.

- M. Cooling Coils: Coils shall be mounted on hot dipped galvanized steel supports to assure proper anchoring of coil and future maintenance. Coils shall be face or side removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to insure no condensate carry over. Provide factory installed extended supply, return, drain, and vent piping connections. Refer to Drawings and Section 23 82 16, AIR COILS for additional coil requirements.

Primary Tube Surface: Round seamless 5/8" O.D. copper tubes with 0.020" wall thickness mechanically expanded into fin collars of the secondary surface. Tubes shall be mechanically expanded to provide a permanent metal-to-metal bond for efficient heat transfer. Manufacturer may only use staggered tubes in direction of airflow and only return bends - reduced tube wall hairpin bends are not acceptable. 10 rows maximum.

Secondary Fin Surface: Die-formed, corrugated plate-type 0.008" Aluminum fins with full drawing fin collars to provide accurate fin spacing control and maximum tube contact. 12 fins per inch maximum.

Headers: Seamless copper with die-formed holes to provide a parallel surface to the coil tube for strong brazing joints. Coil is supplied with 1/8" brass female pipe thread (FPT) vents and drains. All circuiting is designed to gravity-drain.

Connections: Red Brass Schedule 40 male pipe thread (MPT) to prevent dielectric reaction between dissimilar metals.

Casing: Minimum 16 ga., 304 stainless steel, with 1-1/2" die-formed flanges to permit easy stacking and mounting. Intermediate tube supports are supplied on coils over 44" fin length with additional supports every 42" multiple thereafter. Coils shall be fully enclosed within the casing and shall be on mounted 304 stainless steel angle racks manufactured to allow coils to slide out individually.

Removable coil access panels: Shall be provided for removal of coils through the casing wall. Coils shall be individually removable towards the access side. Coils must be individually racked, removable through the side access panels. Refer to drawings for coil configuration.

Drain pans for all cooling coils: Drain pans shall be continuously welded 304 stainless steel. The coil section must have intermediate drain pans and shall be interconnected with 1" copper drain lines. Each coil support shall include a minimum 16ga 304 stainless steel all welded condensate drain pan extending no more than 12" downstream of coil face unless specified. Each drain pan shall have sufficient depth to hold condensate water but not less than 2". Drain pan shall be sloped in 2 directions (pitched in direction of airflow and pitched sideways to drain connection) for self-drainage at minimum 1/4" per foot slope. If multiple coils are stacked, intermediate drain pans shall be individually piped down to the drain pan located below, and bottom drain pan shall be piped to the exterior of the unit through the base rail. Drain pan connections shall be located at the lowest point of the drain pan. Drain pipe shall be copper with sufficient size, but not less than 1.5".

Testing and Performance: All coil assemblies are leak tested under water at 500 PSIG. Standard construction is suitable for 250 PSIG operating pressure up to 300° F. PERFORMANCE is CERTIFIED under ARI Standard 410. All coil performance ratings are generated with manufacturer's ARI certified selection software.

- N. Integral Face and Bypass Steam Coils: Provide integral vertical face and bypass dampers. Electric damper operators shall be furnished and mounted by the AHU manufacturer at the factory. Damper operators shall be of same manufacturer as controls furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- O. Humidifier: When included in design, coordinate the humidification requirements with section 23 84 13 Humidifiers. Provide humidification section with stainless steel drain pan of adequate length to allow complete absorption of water vapor. Provide stainless steel dispersion



panel or distributors as indicated, with stainless steel supports and hardware.

**General:** All humidifier sections shall have a stainless steel drain pan as minimum 12" longer than scheduled absorption distance. Manufacturer to mount humidifier dispersion tube panel only. (See the unit drawing for location). All exterior piping shall be done in the field by Mechanical Contractor. Humidity controls and safeties such as air proving and high limit to be provided by Controls Contractor. See the air handling unit schedule for humidifier capacities.

**Manifold header:** The manifold header shall be constructed of type 304 stainless steel and installed at the bottom of the duct or air handler for a horizontal airflow installation. The header shall be mounted on supplied support brackets, sloped to ensure efficient condensate removal through the steam inlet connection without the use of a separate condensate connection/leg.

**Dispersion tubes:** The dispersion tubes shall be constructed of type 304 stainless steel. They shall be welded to the header, closely spaced and spanning the width of the duct. The dispersion tubes spacing shall be optimized for every application to provide the best steam coverage, and the required absorption distance. Each tube shall contain a single row of integrally formed holes facing the airflow for shorter absorption distances. The dispersion tubes shall be supplied with a top support bracket adjustable in height for easy field installation. Manifolds supplied with all around frames will not be accepted because of their higher pressure drop.

**Tube holes:** Each hole shall be formed to extend the tube material internally in a cylindrical shape to get the driest steam from the center of the tube and prevent any condensation entrainment through the holes. Added plastic/resin or stainless steel nozzles are not acceptable. The spacing between holes shall be optimized, spanning the height of the tube and sized to ensure constant pressure inside every tube for even steam distribution.

**Pressurized Manifold Steam Accessories:**

The appropriate steam valve, actuator, steam trap and strainer shall be shipped loose for field installation by Mechanical Contractor.

The steam valve body should be made of bronze and the valve trim should be made of stainless steel for extended life.

The valve actuator should be electrical (24 Vdc) or pneumatic. For electric valve actuators, the control signal should be 0-10 Vdc or 4-20 mA.

The steam trap should be of the Float and Thermostatic (F&T) type with a cast iron body. When using treated water (DI or RO), the trap should be of the stainless steel Inverted Bucket type.

The Y strainer should be made of cast iron, except when using treated water (DI or RO) where stainless steel Y strainer should be supplied.

P. Sound Attenuators: Refer to Drawings, Specification Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, and Section 23 31 00, HVAC DUCTS AND CASINGS, for additional unit mounted sound attenuator requirements. AHU sound attenuators shall be factory installed as an integral part of AHU.

Q. Discharge Section: Provide aerodynamically designed framed discharge openings or spun bellmouth fittings to minimize pressure loss.

R. Variable Frequency Drives:

1. General: Provide enclosed variable frequency drives suitable for operation at the current, voltage, and horsepower indicated on the schedule. Conform to requirements of NEMA ICS 3.1.

2. VFD Ratings:

- a. VFD must operate, without fault or failure, when voltage varies plus 10% or minus 15% from rating, and frequency varies plus or minus 5% from rating.
- b. Displacement Power Factor: 0.98 over entire range of operating speed and load.
- c. Operating Ambient Temperature: -10 degrees C to 40 degrees C (14 degrees F to 104 degrees F)
- d. Humidity: 0% to 95% non-condensing.
- e. Altitude: to 3,300 feet, higher altitudes achieved by derating.
- f. Minimum Efficiency: 96% at half speed; 98% at full speed.
- g. Starting Torque: 100% starting torque shall be available from 0.5 Hz. to 60 Hz.
- h. Overload capability: 110% of rated FLA (Full Load Amps) for 60 seconds; 180% of rated FLA, instantaneously.
- i. The VFD must meet the requirements for Radio Frequency Interference (RFI) above 7 MHz as specified by FCC regulations, part 15, subpart J, Class A devices.
- j. Total Harmonic Distortion (THD) compliance: Given the information provided by the customer's electric power single line diagram and distribution transformer data, the VFD manufacturer shall carry out an analysis of the system. The analysis reviews the potential for the proposed equipment,

and any existing equipment, to meet IEEE 519 (tables 10.2 and 10.3) recommendations at the Point of Common Coupling (PCC). The result of the analysis shall determine if additional power quality improvement measures should be included in the proposal to meet the THD recommendations of IEEE 519. The PCC shall be at the primary side of the main distribution transformer.

- k. VFDs must have a minimum short circuit rating of 65K amps RMS (100K amps RMS with a DC bus reactor) without additional input fusing.

### 3. VFD Design:

- a. VFD shall employ microprocessor based inverter logic, isolated from all power circuits.
- b. VFD shall include surface mount technology with protective coating.
- c. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
  - i. Input Section: VFD input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection.
  - ii. Intermediate Section:
    - 1. DC bus as a supply to the VFD output Section shall maintain a fixed voltage with filtering and short circuit protection.
    - 2. DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.
    - 3. 30 HP to 150 HP @ 208 VAC, 30 HP to 150 HP @ 240 VAC, and 40 HP to 500 HP 480 VAC, VFDs shall include a DC bus reactor to minimize reflected harmonics.
  - iii. Output Section
    - 1. Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
    - 2. The VFD shall employ PWM sine coded output technology to power the motor.
- d. VFD shall have a disconnect and removable control I/O terminal block to simplify control wiring procedures.

- e. VFD shall include two independent analog inputs. One shall be 0-10 VDC. The other shall be programmable for either 0-10 VDC or 4-20 mA. Either input shall respond to a programmable bias and gain.
- f. VFD shall include two 0-10 VDC or 4-20 mA analog output for monitoring, or "speed tracking" the VFD. The analog output signal will be proportional to output frequency, output current, output power, PI (Proportional & Integral control) feedback or DC bus voltage.
- g. VFD shall provide terminals for remote input contact closure, to allow starting in the automatic mode.
- h. VFD shall include at least one external fault input, which shall be programmable for a normally open or normally closed contact. These terminals can be used for connection of firestats, freezestats, high pressure limits or similar safety devices.
- i. VFD shall include two form "A" contacts and one form "C" contact, capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 5A at 120 VAC and shall provide up to 18 functions, including, but not limited to: Speed agree detection, Low and high frequency detection, Missing frequency reference detection, Overtorque/Undertorque detection, Drive Running, and Drive Faulted
- j. VFD shall include a power loss ride through of 2 seconds.
- k. VFD shall have DC injection braking capability, to prevent fan "wind milling" at start or stop, adjustable, current limited.
- l. VFD shall include diagnostic fault indication in selected language, last 10 faults storage and heatsink cooling fan operating hours.
- m. VFD shall include loss of input signal protection, with a selectable response strategy including speed default to a percent of the most recent speed.
- n. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL. If the electronic thermal motor overload is not approved by UL, a separate UL approved thermal overload relay shall be provided in the VFD enclosure.

- o. VFD shall include the following program functions:
  - i. Critical frequency rejection capability: 3 selectable, adjustable deadbands.
  - ii. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
  - iii. Stall prevention capability.
  - iv. Bi-directional "Speed search" capability, in order to start a rotating load.
  - v. Heatsink over temperature speed fold back capability
  - vi. Preset speeds
- p. VFD shall include factory settings for all parameters, and the capability for those settings to be reset.

Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL.

1. Lights: Marine lights with a protective metal cage and glass seals, complete with duplex receptacles, shall be installed on the wall across from the access doors by unit manufacturer. A switch with an indicator light shall be installed on the unit by unit manufacturer. Vapor-proof lights using cast aluminum base style with glass globe and cast aluminum guard shall be installed in access sections for fan, mixing box, humidifier and any section over 300 mm (12 inch) wide. A switch shall control the lights in each compartment with pilot light mounted outside the respective compartment access door. Wiring between switches and lights shall be factory installed. All wiring shall run in neatly installed electrical conduits and terminate in a junction box for field connection to the building system. Provide single point 115 volt - one phase connection at junction box.
2. Install compatible 100 watt bulb in each light fixture.
3. Provide a convenience duplex weatherproof receptacle next to the light switch.
4. Disconnect switch and power wiring: Provide factory or field mounted disconnect switch. Coordinate with Division 26, ELECTRICAL.
5. Electrical power shall be 120V/1/60.
6. Filter Gauges: The unit manufacturer shall provide magnehelic gauges across all filter sections. One gauge shall be provided for each filter bank. All gauges shall be recessed into the cabinet casing. In addition, digital differential pressure sensors to integrate into building automation will be provided by the Controls Contractor, refer to section SEQUENCE OF OPERATIONS.

7. Section Drains: The manufacturer shall provide 1" capped floor drain connections on the side of the unit for complete drainability of the base pan for all sections. This will be necessary for cleaning purposes. Drains will be necessary in the following sections: Return air plenum, Return fan section, Mixing plenum, Pre-filter section, Heating coil section, Cooling coil section, Supply fan section, Final filter section

**P. Electrical:**

1. The manufacturer shall factory wire, test, and have all air handling units approved by UL.
2. The manufacturer shall label and number code all wiring and electrical devices in accordance with the unit electrical diagram. The manufacturer shall mount the devices in a control panel inside the unit's service enclosure or on the outside and ensure the control panel meets the UL requirements.
3. The manufacturer shall provide a system of motor control including all necessary terminal blocks, motor contactors, motor overload protection, grounding lugs, auxiliary contactors and terminals for the connection of external control devices or relays. The manufacturer shall individually fuse all fan and branch circuits.
4. The manufacturer shall provide wiring from the motors to the motor control in accordance with UL and contained by EMT conduit with liquid tight connections. The manufacturer shall seal the casing penetrations in a manner that eliminates air leaks.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

- A. Install air handling unit in conformance with ARI 435.
- B. Assemble air handling unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Military Spec. DOD-P-21035. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air handling units clean prior to operation.
- C. Leakage and test requirements for air handling units shall be the same as specified for ductwork in Specification Section 23 31 00, HVAC DUCTS AND CASINGS except leakage shall not exceed Leakage Class ( $C_L$ ) 12 listed in SMACNA HVAC Air Duct Leakage Test Manual when tested at 1.5 times the design static pressure. Repair casing air leaks that can be heard or felt during normal operation and to meet test requirements.

- D. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- E. Seal and/or fill all openings between the casing and AHU components and utility connections to prevent air leakage or bypass.

**3.2 KNOCK-DOWN CONSTRUCTION (for assembly on site):**

- A. Unit shall be shipped in pieces small enough to fit through the available opening(s), yet large enough to minimize work required in the field by installing contractor. All air handler pieces will ship on pallets with all pieces and pallets clearly labeled and which will refer to a clear and concise Assembly Drawing supplied by the air handler manufacturer. An Installation/Procedures Manual shall be supplied by the air handler manufacturer and will include tools and materials required for installation. Factory personnel shall be provided to supervise the assembly from start to finish. Manufacturer shall guarantee the performance of the field assembled units just as if they were built in the factory. Approval by factory personnel shall confirm that installing contractor followed all assembly procedures and that unit will perform as specified. All field-assembled units will not bear the factory ETL label. All motors are to be wired in the field and terminated by the installing contractor at the Motor Start Panel (MSP). Lights, light switches, and GFI will be supplied by the air handler manufacturer with all 120V wiring done in the field by the installing contractor. Each fan Air Flow Monitoring Station to be field connected to the MSP Panel (via transparent tubing) by the installing contractor. Plastic transparent tubing shall be supplied by air handler manufacturer.
- B. Manufacturer shall pay for all travel expenses for a factory representative to supervise and advise the Mechanical Contractor on proper assembly procedures and methods of panel assembly. Factory representative will be responsible for final inspection of unit to maintain same quality standards as a factory assembled unit to maintain manufacturer warranty.
- C. The factory representative shall provide field test per SMACNA standards to verify casing leakage after units are installed at jobsite. Casing tests shall verify that unit casing leakage is less than 1% of design air flow at 1.5 time design static pressure. Total casing leakage shall be calculated as sum of positive pressure section leakage and negative pressure sections leakage. Total casing leakage shall be less than 1% of unit design airflow.

- D. The factory representative shall also conduct flood testing while on site after field fabrication. Manufacturer's liability insurance shall cover any potential water damaged caused from a failed flood test while on site during this testing. All unit bases shall be flooded to a level of 1.5" after manufacturing to assure there is no leakage through the floor and the perimeter water barrier. The results of the flood test shall be certified by the manufacturer's representative.
- E. Field assembled filter frame assemblies shall be constructed of galvanized steel and be specifically designed and sized for field assembly. Filter frames shall have matching mounting holes such that frames may be riveted together. Frame comes with pre-installed gasket so as to provide a surface onto which the filter will self seal. Filter frames come with stiffeners which are installed between each column of filter frames. Stiffeners are installed in the field. All filter holding frames must be caulked in between them to minimize bypass air through the frames.
- F. Proper structural support (every 5 frames wide, an additional structural 2" tube to reinforce is recommended) for attachment of frame assembly to existing AHU casing / building structure as well as complete safig and proper air seal - materials and installation - at and around the assembled filter rack shall be provided by contractor as needed.

### 3.2 STARTUP SERVICES

- A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated and fan has been test run under observation.
- B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.
- C. An authorized factory representative should start up, test and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc.

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