

SECTION 15721 – FACTORY BUILT-UP AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 WORK INCLUDED

- A. Furnish and install all factory built-up air handling units. This shall include all piping, ducts and supports specified in this Division and as shown on the drawings
- B. All units shall be new and manufactured for the specific purpose of providing conditioned air (heating and cooling) to the systems indicated.
- C. All system components shall be installed in accordance with local codes including seismic isolation.
- D. Secure all permits and local/state approval for the components as specified and included under this Section.

1.3 RELATED SECTIONS

- A. Examine all drawings and criteria sheets and all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.
- B. Refer to Section 15241 – Mechanical Vibration Controls and Seismic Restraints.
- C. Refer to Section 15050 – Basic Mechanical Materials and Methods and Section 01230 – Alternates, for air handling unit alternates.

1.4 REFERENCES

- A. Applicable provisions of the following Codes and Trade Standard Publications shall apply to the work of this Section, and are hereby incorporated into, and made part of the Contract Documents.

B. Material standards shall be as specified or detailed hereinafter and as follows:

1. ABMA STD 9 – Load Ratings and Fatigue Life for Ball Bearings.
2. ABMA STD 11 – Load Ratings and Fatigue Life for Roller Bearings.
3. AMCA 99 – Standards Handbook.
4. AMCA 210 – Laboratory Methods of Testing Fans for Rating.
5. AMCA 300 – Reverberant Room Method for Sound Testing of Fans.
6. AMCA 301 – Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
7. AMCA 500 – Test Methods for Louvers, Dampers and Shutters.
8. ARI 410 – Standard for Forced-Circulation Air-Cooling and Air-Heating Coils.
9. ARI 430 – Standard for Central-Station Air-Handling Units.
10. ARI 610 – Central System Humidifiers.
11. ARI Guideline D – Application and Installation of Central Station Air-Handling Units.
12. NEMA MG 1 – Motors and Generators (1).
13. NFPA 70 – National Electrical Code.
14. SMACNA (DCS) – HVAC Duct Construction Standards – Metal and Flexible.
15. UL 900 – Standard for Air Filter Units.
16. UL 1096 – Electric Central Air Heating Equipment.

1.5 SYSTEM DESCRIPTION

- A. Furnish and install complete factory built-up air handling units of the size and capacity scheduled on the drawings.
- B. The units shall be of one manufacturer and shall include all components hereinafter specified including fans, coils, filters, humidifiers, UVC emitters, controls and complete double wall insulated cabinets.

1.6 SUBMITTALS

- A. See Section 15050 and General Condition for additional submittal requirements.
- B. Shop Drawings: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements and duct connections.
- C. The unit manufacturer shall submit without delay after receipt of notice of award, shop drawings for approval which shall indicate, but not be limited to, the following information in detail:
 1. Structural loading plan.
 2. Detailed drawings and data of all proposed components.

3. To scale dimensional drawings (plans and sections) of the entire air handling unit showing all component locations, equipment arrangements, piping connections and sizes, duct connections and sizes, and all safing required.
 4. Casing and hoisting details including floor structures, internal structures, panel fabrication, insulation material, equipment supports and thermal, acoustic and air pressure performance of proposed panels. Location of drains and method of piping penetration and sealing of penetrations through the casings.
 5. Sound data for sound attenuators at rated flow and sound data for casing walls, floor and roof.
 6. The sound power levels on all fans, fan and motor efficiency, horsepower, RPM and fan size.
 7. Fan curves shall be submitted. Fan curves shall be prepared and submitted indicating performance of the fans. When units have two fans indicate curves with (2) similar fans operating in parallel and individual fans operating. Where fans are indicated to be controlled by variable speed drives, submit performance curves based on fans rpm from 200% to 50% of fan speed in 100-rpm increments. Where fans are in parallel, submit composite (rpm based) curves indicating parallel operation.
 8. Subway type, steel grating at airflow openings in the unit floor to protect personnel, elevated 6" above the opening.
 9. ARI certified calculations for coil selections.
 10. List of proposed component manufacturers and models, such as fans, casing, coils, humidifiers, filters, dampers, controls, door hinges, disconnect switches, etc.
 11. Structural calculation indication and compliance with performance data.
 12. Pressure drop calculation indicating losses of all components, plenums, contractions, expansions at rated flow of unit. Pressure drop calculations are to be submitted in tabular form and shall indicate the total of all unit-associated losses plus the scheduled external static pressure. Calculations are to be based upon wet cooling coils and filters at recommended dirty change out pressure drop.
- D. Manufacturer's Instructions: Indicate assembly, support details, connection requirements and include start-up instructions.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data and parts listing.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- G. Point by point. Specification compliance specification.
- H. No fabrication shall occur until shop drawings are reviewed and accepted by the Engineer.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, as pre-qualified and in accordance with technical specifications herein.

- B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc. as suitable for the purpose specified and indicated.
- C. The units shall be ETL or equivalently labeled.

1.8 DELIVERY, STORAGE AND HANDLING

A. Cleanliness

1. The intent of this Section is to ensure the Owner that the air handling units are manufactured, shipped, stored, field reconnected and started-up while maintaining a high degree of cleanliness. Unit interior and exterior shall be fully cleaned prior to start-up by the Contractor. Units shall be shrink wrapped with a minimum of 10 mil plastic to protect the sections during shipping and while in storage. Once the units are received by the contractor, it shall be the contractor's responsibility to take whatever steps are necessary to deliver the units in like new condition upon start-up and turn-over to the Owner, whichever occurs the latest.

B. Manufacturing

1. Casings shall be manufactured only after all panel components (structural members, facing sheets, etc.) have been thoroughly cleaned of any mill grease, oxidation, etc.
2. The interior and exterior of the casing system shall be thoroughly protected from contamination from the manufacturing process through start-up procedures and Owner's acceptance.
3. Internal components (fans, coils, air filter frames, etc.), shall be free of all grease and dirt.
4. In general, any products such as caulks, gaskets, etc., employed within the unit shall be non-petroleum based products with no outgasing characteristics.

C. Shipping

1. Shipping protection shall be provided such that both the interior and the exterior of each unit is protected from road dirt exposure during shipment. This protection shall remain on the unit until unit start-up is performed.
2. Any units damaged in shipment shall be returned to the factory for all corrective work. A representative of the manufacturer shall accept or reject the shipment.

D. On-Site Storage

1. If equipment is to be stored before use, the unit manufacturer shall have provided adequate protection at the factory to ensure that Cleanliness Standards for both the unit interior and unit exterior are met. This protection shall remain on the unit until such time as unit start-up is performed. Accommodations shall be made by the contractor to rotate fan assemblies on a periodic basis as recommended by the fan manufacturer. Fan assemblies shall be rotated without compromising Cleanliness Standards.

2. The unit interiors will not be compromised by their use for tool storage or any other type of storage during the construction of the project. This requirement is mandatory.
3. Provide commonly keyed locks on all unit access doors to eliminate misuse of unit.

E. Rigging

1. The Contractor shall be responsible for rigging under the direct supervision of the unit manufacturer.

F. Field Reconnection

1. Any and all shipping splits requiring field reconnection shall be made by the Contractor under the direct supervision of the air handling unit manufacturer.
2. The unit manufacturer shall supply all necessary gasketing, sealant, installation instructions and supervision.
3. Unit Touch-Up Painting: The contractor shall provide labor and the unit manufacturer shall provide touch-up paint as required to ensure that the appearance of each unit complies with these specifications.

G. Leveling

1. The Contractor shall level all unit sections in accordance with the unit manufacturer's instructions. The contractor shall furnish and install all necessary permanent shim material to assure the levelness of the individual sections and the entire assembled unit.

1.9 WARRANTY

1. The unit manufacturer shall be responsible for and warranty the proper operation and performance of the units, all unit components, leak tightness and non-condensation of the unit casing, structural integrity of the unit including all provisions required for rigging, trucking and installation of units in the areas indicated on the drawings. Units shall be guaranteed for 1 year from date of acceptance of project by owner.

PART 2 - PRODUCTS

2.1 DOUBLE WALL BUILT-UP SUPPLY AIR HANDLING UNIT

A. General

1. Acceptable manufacturers subject to compliance with the specification:
 - a. Standard units
 - 1) WEBCO
 - 2) Environmental Air Systems (EAS)

- 3) Buffalo Air Handling
- 4) Ventrol
- 5) Haakon

b. Foam Wall Construction

- 1) Environmental Air Systems (EAS)
- 2) Buffalo Air Handling

- 2. Provide factory fabricated air handling units with components as indicated and scheduled on the drawings, to provide the services designated. Close coordination shall be exercised between the contractors and the unit manufacturer, to ensure that the unit is provided complete with all operating dampers, operators, isolation dampers, detectors, etc. Units shall be suitable for indoor or outdoor installation as required by location. Contractor designed field erected or assembled air handling units shall not be acceptable or considered as equal. The unit manufacturer shall design provisions for any special requirements such as structural columns being installed through the unit. Bidding manufacturers shall advise Engineer early in the bidding time frame of any problems in meeting the scheduled requirements or unit overall dimensions shown on the drawings. The Contractor shall submit complete detailed assembly and component shop drawings prior to fabrication, assembly and installation of any part, portion or component of the unit.
- 3. The word "unit" shall mean each unit and all work associated for each unit, for the total quantity of units scheduled on the drawings.
- 4. The air handling unit components shall be fit together and seal properly.
- 5. The unit start-up and testing shall be performed by the unit manufacturer and shall be included under this Contract.
- 6. Unit shall be fabricated and assembled in modules in the unit manufacturer's plant or factory. Each of the units shall be assembled, sealed and tested at the factory prior to shipment.

B. Unit Construction

1. Unit housing performance

a. Minimum U value 0.07

- 1) Minimum insulation density 3 lbs. per square foot.

b. Provide thermal break construction between all interior and exterior surfaces.

- 1) Under normal internal operating conditions there shall be no condensation on the exterior of the unit at the following conditions:

Indoor Units	105°F DB	80°F WB
Outdoor Units	115°F DB	80°F WB

- c. Maximum deflection of walls shall be $L/250$ at ± 12 " w.c. (L = span in inches). Deflection is worst case at the center of panel.
- d. Maximum deflection of roof and floor shall be $L/360$ at design loading (L = span in inches).
 - 1) Minimum floor design load 150 lbs. per square foot.
 - 2) Minimum roof design load 75 lbs. per square foot plus snow load if exterior unit.
- e. Seismic requirements shall be as a minimum in accordance with IBC 2003, Use Group III, Seismic Design Category C with a component seismic coefficient of 2.0 and a performance criteria factor of 1.5 or shall comply with local seismic requirements at the site of unit installation, whichever is most stringent.
- f. Leakage class shall be 3.0 at ± 12 inches w.c. At that pressure, the maximum leakage shall be 15.0 CFM per 100 square foot of surface of the unit.
- g. Unit minimum panel sound transmission loss shall be:

Octave Band Hz	DB Reduction	Octave Bank Hz	DB Reduction
125	30	1000	46
250	42	2000	53
500	40	4000	52

- h. Materials
 - 1) Exterior
 - a) Painted galvanized steel or aluminum. (Note: Aluminum units shall not include exterior painting.)
 - 2) Interior
 - a) Solid aluminum or solid galvanized steel for outdoor air intake/mixing section, cooling coil sections and humidifier sections only.
 - b) Perforated aluminum with Tedlar lining sandwiched between the inner perforated liner and the insulation, fan section only.
 - c) Solid aluminum, solid galvanized steel or perforated aluminum with Tedlar lining between the inner perforated liner and the insulation for all other interior sections.

- i. Exterior paint:

Note: Aluminum units shall not require painting.

- 1) Two coats of primer
- 2) Two coats of enamel

- 3) Color shall be AHU manufacturer's standard off-white color, unless otherwise noted by the Architect.
- j. Air handling unit casing shall be built up from the unit base with panels. The unit manufacturer shall be the manufacturer of the panel system. Panels shall be load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets or stainless steel fasteners. Plated fasteners will not be accepted.
 - k. All panels shall be double wall. Interior finish to be smooth, mill finish; exterior finish to be a low-reflective textured mill finish. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation. Interior shall be suitable for pressure-wash cleaning.
 - l. Panel joints shall be sealed to ensure specified leakage rates. Panel construction method shall meet NFPA 90A requirements.
 - m. Acoustical absorptive panels shall have a perforated aluminum interior skin. Unit manufacturer shall have published data from an independent acoustical laboratory for lined and unlined acoustical panels.
 - n. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised.
 - o. All casing walls shall be of panel construction, including the fan discharge walls, mixing section walls and divider wall to the access corridor.
 - p. Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break. Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.
 - q. Acoustical absorptive panels shall be used, at a minimum, in all fan sections. Acoustical absorptive panels shall not be used in areas within 24" downstream of cooling coils, downstream of final filters, or in outside walls of outdoor units where humidity level in unit exceeds the outside humidity level.
 - r. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak-tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.
2. Minimum wall thickness shall be 4" (foam panel construction may be 2").

3. Minimum Gauge: THE FOLLOWING ARE MINIMUM GAUGES. HEAVIER GAUGES MAY BE REQUIRED TO MEET THE PERFORMANCE DEFLECTIONS SPECIFIED, SPECIFIED SOUND TRANSMISSION LOSS OR TO ALLOW FOR PROPER WELDING. FOAM PANEL CONSTRUCTION MAY UTILIZE GAUGES LESS THAN LISTED PROVIDED MANUFACTURER SUBMITS DOCUMENTATION OF COMPLIANCE WITH STRUCTURAL REQUIREMENTS.

a.	Roof	<u>Steel</u>	<u>Aluminum</u>
	1) Interior	16 gauge	0.09
	2) Exterior	16 gauge	0.09
b.	Walls		
	1) Interior	16 gauge	0.09
	2) Exterior	16 gauge	0.09
c.	Floor		
	1) Interior	1/8" primed & epoxy painted steel or 3/16" aluminum checker plate	3/16" checker plate
	2) Exterior	20 gauge	0.063
d.	Septum wall		
	1) Low side	16 gauge	0.09
	2) High side	16 gauge	0.09
e.	Safing		
	1) Cooling coil	16 gauge S/S	0.071
	2) All other	16 gauge	0.071
f.	Distribution perforated plate		
	1) Plate	16 gauge	0.09
	2) Air Blender	16 gauge	0.09

4. Floor/Base Frame

- a. The floor of each unit section shall be diamond safety plate. Floor shall be continuously welded to form a guaranteed waterproof surface. The waterproof floor shall not be used as part of a coil drain pan/collection system. Overall floor thickness shall be a minimum of 6" and shall incorporate a solid galvanized or aluminum underliner.
- b. All openings in the floor of the units shall be dammed a minimum of 3" high.

- c. The underside of the floor shall be insulated with 6" thick, 3 lb. density fiberglass, sealed in place by a metal underliner, except for cooling coil section. Cooling coil section and the entire underside of foam wall units shall be insulated with 2" foam insulation, sprayed on application.
5. All supply and exhaust discharge openings shall be long radius bellmouths, mounted flush with the interior skin of the unit casing. Bellmouths shall match duct sizes indicated on the drawings.
6. Access Doors and Panels
- a. Provide access doors of the same construction and thickness as the unit casing for all unit sections containing equipment requiring service, where dampers or damper operators are installed, or areas for cleaning of unit components such as coils, etc., is required. Access doors shall be equipped with continuous gaskets and shall fit in the door frame in a manner to guarantee 0% leakage at design pressure. Access door materials shall match casing material.
 - b. Each access door shall have a built-in static pressure probe port for ease of pressure readings across various internal components and to limit unnecessary or unauthorized access inside the unit.
 - c. Each access door shall be mounted with stainless steel hinges to prevent door racking and air leakage. At least (2) cast aluminum chrome plated handles operable from either side shall be provided. Other door accessories shall include handles and stainless steel hardware to ensure long-term, proper door operation.
 - d. Each door shall contain a thermal window of double pane safety glass at eye level when the viewer stands on the adjacent floor or grating outside the unit (coordinate with heights of housekeeping pads, vibration isolators, etc.), sized at a minimum of 12" by 12", properly sealed to operate safely against the suction or pressure. Windows shall be non fogging.
 - e. Removable access panels shall be provided in unit sections where components are larger than the door opening. Panels shall be of the same construction as doors.
7. Roof
- a. Unit roof performance shall be as specified above for unit housing, modified as follows:
 - 1) All exterior air handling unit roofs
 - a) Shall be pitched a minimum of 1/4" per foot for drainage.
 - b) Roof may be part of the unit or the manufacturer may elect to provide a secondary roofing system above the unit roof.
 - c) Outer most roof shall be a color to match the unit.
 - d) If the unit top is the roof, the final roof shall be 60 mil EPDM roofing. Roof to be tested to assure 0% leakage prior to installing EDPM material.
 - e) Roof shall be 100% watertight.

- f) Lifting lugs and rail for equipment removal shall be coordinated with unit top or roof.
 - g) All roofs shall be suitable for walking on and snow loads.
 - h) Roof shall be designed for earthquake loads and wind loading as well as other equipment imposed loads.
 - i) Provide written 10-year warranty for roofs.
8. Ladders and walkways and handrails
- a. Provide OSHA and ANSI approved handrails, walking surfaces, toe guards, safety cages, stairs and ladders.
 - 1) As indicated or noted on the drawings.
 - 2) As specified.
 - 3) As required for service of equipment.
 - b. They shall be galvanized or aluminum with non-skid surfaces.
 - c. Coordinate with all piping, ductwork, coil pull, equipment removal and other services.
9. Coils
- a. See section 15761
 - b. Provide a separate (2" minimum) drain from each pan under each coil down to the bottom pan near its drain. All drain pans shall have bottom outlets. All drain pans are to be designed to drain completely and leave no puddles or standing water.
 - c. Where drain pans are recessed into the floor of the units provide a non-corrosive, non-slip walk surface flush with the floor of the unit. Recessed drain pans to have minimum of 2" foam between lowest point of drain pan and underliner. Fiberglass insulated drain pans will not be accepted.
 - d. All coils shall be mounted to allow removal of any coil individually without disturbing any other coils. Allow sufficient space for individual isolation valves for inlet/outlet of each coil piping and all other equipment shall be mounted in a manner as such that they do not preclude coil removal.
 - 1) All coils shall be bolt off to allow removal of any coil individually without disturbing any other coils.
 - 2) Unit Manufacturer shall provide a detailed dimensioned piping drawing for all internal unit piping.
 - e. All cooling coil supports shall be stainless steel.
 - f. Drain pans shall be welded Type 304 stainless steel, minimum 18 gauge.
 - g. Each cooling coil drain pan including intermediate drain pans shall be **double wall insulated construction**.
 - h. The air velocity across the cooling coil shall not vary by more than 15% across the cooling coils.
 - i. All preheat coils shall be mounted a minimum of 30" above unit floor.

- j. Heating Coils - see Specification Section 15761.
10. Supply fans shall be:
- a. See specification section 15850 fans
 - b. Dual Centrifugal Plenum fans driven by a variable speed drive.
 - 1) Each capable of 50% of total flow with both fans running.
 - 2) Each with capable of 70% of total flow one fan running.
 - 3) With Inertia bases and vibration isolation see section 15241.
11. Dampers
- a. Acceptable manufacturers subject to compliance with specifications.
 - 1) Ruskin
 - 2) Tamco
 - 3) Greenheck
 - 4) Nailor
 - b. The unit manufacturer shall provide all dampers at units (outside air, return, exhaust, isolation, etc.). Damper operators shall be provided in the field by the ATC Contractor except as noted below.
 - c. Isolation dampers at fan outlets shall be industrial grade equal to Ruskin SD102, suitable for maximum system pressure, of 12.0" w.g. to 48" damper width, with maximum leakage of 8.0 cfm/sq.ft. at 48" x 48" damper size.
 - d. All other dampers shall be equal to Ruskin CD50 and shall be airfoil double thickness opposed blade type, with maximum leakage of 4 cfm/sq.ft. at 1" w.c. differential pressure for the size provided.
 - e. Unit discharge smoke damper shall be UL55J rated and shall be sized to as not to exceed their rated velocities or pressure ratings.
 - f. All hardware shall be stainless steel.
 - g. All dampers shall be low leakage airfoil type of aluminum construction.
12. Fan Isolation Doors
- a. Provide motorized roll-up aluminum doors where shown on the drawings, up and downstream of the fans to isolate each individual fan for service.
 - b. The roll up doors shall be constructed of double sided aluminum extrusions, each 1-3/8 inch wide by 3/8 inch thick with satin anodized finish. A weather-tight flexible extrusion seal shall be provided between each aluminum slat.
 - c. The roll up doors shall ride in side channels. Side channels, top rail and door bottom shall be provided with santoprene seals. Doors shall be capable of operating in temperatures of -40° F to 180° F and in 75 mph winds. Doors and frame shall be sized and mounted so that under normal fan operation, the entire assembly is out of the airstream.

- d. Roll up door shall be "Gortite" brand as manufactured by A&A Manufacturing Company, Inc. New Berlin, WI.
 - e. Provide electric operator, electrical wiring and automatic temperature interface.
13. Provide sound attenuators to isolate the supply and return fans.
- a. SEE SECTION 15830 SOUND ATTENUATORS.
14. Drains
- a. Provide drain pans for:
 - 1) Each cooling coil
 - 2) Humidifier section
 - 3) Outside air intake
 - b. Pipe each to exterior of unit for piping to floor drain by contractor.
 - c. Each cooling coil drain connection shall be properly sized for a drain line at a pitch of 1/8" per foot pitch and shall not be less than 2" pipe.
 - d. Provide with trap seal.
15. Additional Drains
- a. Provide each section with a 2' drain.
 - b. Pipe to outside unit with standard weight galvanized pipe.
 - c. Cap each section drain with a schedule 40 galvanized cap.
 - d. Each unit drain shall have a removable strainer cap.
16. Steam Humidifiers
- a. See Specification Section 15763.
17. Filters
- a. Provide prefilters and after filters complete with gauges, of types as shown and scheduled.
 - b. All filter frames shall be aluminum or stainless steel with vertical structural supports provided every 48".
 - c. See specification section 15861.
18. Filter Gauge
- a. See Specification Section 15861.

19. Air blender

- a. Provide where shown on plans to enhance the mixing of outside air with return air to a desired mixing effectiveness and provide even airflow across filters, coils and control sensors. Air mixer models shall be geometrically scaled to ensure proper performance across full range of sizes. Mixers that are not geometrically scaled are not acceptable.
- b. Acceptable manufactures subject to compliance with the specification
 - 1) Blender Products, Inc
 - 2) AHU Manufactures own product provided independent test data is provided.
 - 3) Kees
- c. Material: Static air mixers material shall be one of the following:
 - 1) Aluminum
 - 2) Galvanized Steel
 - 3) Aluminized Steel
 - 4) Stainless Steel
 - 5) If unit has a specified interior finish the construction shall match that specified for that unit.
- d. Performance Testing and Rating
 - 1) The mixing effectiveness rating for static air mixers shall be developed according to the following guidelines:
 - a) The mixing of the test unit shall be tested without any static mixer installed in order to determine the inherent mixing of the system. The inherent mixing effectiveness shall be less than 10% at the exit of the mixing chamber.
 - b) The temperature differential between hot and cold air streams (Th-Tc) should be at least 40 deg F. The flow rate of the cold air shall be equal to the flow rate of the hot air flow. (50% Cold air & 50% Warm air)
 - c) Temperature traverses shall be made at several distances downstream of the mixer. The mixing effectiveness must be developed for each model of mixer supplied unless it can be shown that the mixers are properly scaled.
 - d) $(E_{mixer} = 1 - (Range / (Th - Tc)))$ Where: Range = T_{max} - T_{min} at downstream traverse
 - e) The pressure drop rating for static air mixers shall be developed according to the following guidelines:

- f) The pressure drop shall be developed with the mixer mounted in a duct without dampers or other components present to disturb the flow. There should be at least one duct diameter upstream of the mixer and two duct diameters downstream of the mixer in the test setup.
 - g) The pressure drop shall be developed for a range of area ratios. Furthermore, the pressure drop must be determined for each different model of mixer being supplied, unless it can be shown that the mixer models are properly scaled.
- e. Provide detailed documentation of performance testing.
 - f. Installation shall be in accordance with the manufacturer's written installation instructions and SMACNA plenum construction guidelines.

20. Electrical Interface/Work

- a. Provide a complete factory wired electrical system for each unit, so as to allow single-source responsibility and to ensure proper selection and installation of all electrical components.
- b. The built-up AHU manufacturer shall provide a central termination point for power wiring to each motor (480 V/3 ph), lights (120 V/1 ph), unit heaters (480 V/3 pH) and receptacles (120 V/1 ph), etc. Electrical contractor shall provide wiring to each AHU from building distribution panel. All 120 volt and 480 volt wiring from the terminal blocks/junction box service entry points to the fans, unit heaters, lights, receptacles, etc. within the AHU enclosure shall be furnished and installed by the AHU manufacturer. All wiring connections at shipping splits shall be provided after assembly of units at the site by the AHU manufacturer.
- c. The unit manufacturer shall provide prewired and switched non-corroding vaportight fluorescent lights in each compartment that has an access door and in the service corridors as follows:
 - 1) Lights shall be equal to Appleton 4'-0" FRS Series, suitable for use in wet and damp locations.
 - 2) Lighting, internal wiring, switching mounted in bell boxes, and all other electrical wiring associated with the lighting shall be provided by the unit manufacturer, at the factory.
 - 3) Lights shall have 120 volt cold weather (-20°F) ballasts and shall comply with UL 1570 and shall carry the UL label.
- d. Provide duplex 20-amp electrical outlets with ground fault intervention suitable to be utilized for power tools.
 - 1) Unit manufacturer shall provide (2) 120 volt, single-phase 20-amp electric connections for the lights and receptacles (separate circuit for lights, receptacles), via junction boxes with circuit breakers for connection in the field by the Electrical Contractor (20 amperes power supply).

- e. The air handling unit manufacturer shall provide a non-fused safety disconnect switch with interlocking contactors to be wired back to VFD for each fan that shall be located within line-of-sight to the fan. Power wiring from the power source to the fan disconnect switch shall be provided by the Electrical Contractor under Division 16.
- f. Coordinate location and switching arrangement to ensure that layout shown on the drawings is followed strictly. Lighting system for each unit shall be wired through switches and extended to a terminal block at the side, one at each end of the unit, of each unit ready to accept 120V power. Provide (2) 3-way light switches for each AHU to activate all of the lights inside the unit sections that have access doors on that "side" of the unit from either switch. Provide similar switching arrangement for any piping spaces provided.
- g. Provide weatherproof 120 VAC electrical outlets prewired to a terminal block on the side of the unit.
- h. All unit splits shall be provided with a seal-tight flexible pigtail cable for connection to J box on next section.
- i. All sections shall be illuminated by lighting, including piping corridors when provided.
- j. Wiring and Conduit (By Unit Manufacturer)
 - 1) The unit wiring shall be No. 12 GA minimum stranded copper wire sheathed in a THHN covering, which will be distributed through the unit in rigid steel conduit or IMC.
 - a) **EMT shall not be allowed.**
 - b) The use of aluminum wire or flexible BX cable is prohibited.
 - 2) To allow for adjustment of fan motors, a 3'-0" section of waterproof Sealtite flex connect shall be provided at each motor. As fan motors are isolated from the unit casing by duct collars and vibration isolators, a separate ground wire for each motor shall be connected to a terminal strip in the disconnect switch.
 - 3) All outdoor electrical enclosures shall have a NEMA 3R rating, and indoor enclosures shall be rated NEMA 12. In addition to requirements outlined herein, all wiring shall comply with NEC requirements and Division 16000 of this specification.

21. Space Limitations

- a. The air handling units shall be designed within the dimensions and space limitations, as indicated on the drawings and as specified. The unit manufacturer shall take these dimensions and space limitations into consideration for the design required and shall submit dimensional data on the drawings. Advise the Engineer early in the bid process should any problems be detected with existing space limitations.

22. Unit Painting

- a. All steel units shall be factory painted as noted before. All necessary field touch-ups will be provided by the unit manufacturer. Aluminum units shall not require painting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that the mechanical rooms and roof are ready to receive work and opening dimensions are as indicated on the shop drawings and contract documents.
- B. Verify that proper power supply is available prior to starting of fans.
- C. Verify that housekeeping pads are level.

3.2 INSTALLATION

- A. Install in strict accordance with manufacturer's instructions.
- B. Install on a level base and level units.
- C. Install in accordance with NFPA 90A.
- D. Locate remote panels where indicated on drawings or as directed by the Architect.

3.3 STARTING EQUIPMENT AND SYSTEMS

- A. Provide initial start-up and shut-down, including routine servicing and check-out.
- B. Unit Manufacturer's Representative / Start-Up Services
 1. Each individual unit interior and exterior shall be inspected and reviewed by the unit manufacturer's representative, before start-up. The unit manufacturer shall supervise the installation of final filters, the removal of all component shipping blocks, removal of any and all interior and exterior cleanliness protection, and the removal of any duct covering protection. Units shall then be started-up by the unit manufacturer in conjunction with the contractor. Start-up shall include run testing the fan, and confirming the vibration parameters, etc., of the fan assembly, all per submitted test procedures. The unit manufacturer shall submit a written start-up report to the architect.

2. The unit manufacturer shall supervise the unit erection. This manufacturer's representative shall perform start-up, checkout and testing of each unit, witness field testing, and instruct the Owner's representatives of the use and maintenance of the individual components and entire unit. These services shall be part of the unit manufacturer's bid and shall be provided at no extra cost.

3.4 FACTORY TESTING

A. Each unit shall be tested by the unit manufacturer prior to shipping, as follows:

1. Factory Test: Air volume and total static test shall verify that the air volume is within the range of 100% to 110% of scheduled nominal CFM requirements when operating at design total static pressure. The test for airflow and static capability shall include airflow measuring devices installed in all ducts returning to or leaving the unit. These devices shall be installed in accordance with the measuring device manufacturer's recommendations. Pressures external to the unit shall be simulated using a combination of ducts and dampers. The tests shall prove design airflow and static capability of the complete assembled unit.
2. In addition test all VAV units at a 50% turn down.
3. Factory Test: Casing leakage tests shall be run to prove that unit casing leakage is leakage Class 3 at ± 12.0 " w.c. Test shall be in accordance with SMACNA. The unit shall be tested on the positive side of the fan septum wall to +12" w.c. and on the negative side to -12" w.c. in two tests (not at the same time). The leakage of both tests is to be summed (added) to derive the total unit leakage.
4. Factory Test: Both the casing leakage test and the airflow and static capability test, as defined above, shall meet the required acceptance criterion without the use of any temporary caulking at any permanent panel joints. Temporary test caulking shall be utilized at the unit shipping splits to simulate "as installed" conditions.
5. Factory test unit casing deflection by holding 12" positive pressure and 12" negative pressure for two hours and measuring deflection with dial micrometer gauges. All measurements to be made at center of span, center of panel.
6. Factory Test Sound
 - a. System sound power levels shall be measured in all none (9) octave bands (31.25 Hz through 8000 Hz) at system design operating conditions. Airborne sound power levels at all openings shall be read in the test ductwork 5'-0" from the openings. Transmitted sound power levels shall be read 5'-0" from the outside of the fan section.
 - b. Sound tests shall be conducted while the unit is running at design conditions. An octave band sound pressure level reading shall be taken at outside louver, exhaust louver, supply discharge opening, return air opening, economizer opening and adjacent to each fan section outside of the unit casing.
 - c. The following Sound Data criteria shall NOT BE EXCEEDED. The AHU manufacturer shall correct any deficiencies to meet the sound data at no additional cost to the Owner.

Air Handling Unit Supply Discharge							
Maximum Allowable Sound Power Level, dB re: 10 ⁻¹² watt							
Octave Band Hz	63	125	250	500	1000	2000	4000
Supply	102	93	83	76	72	70	69
Radiated	80	79	67	57	55	58	66

LWA (70) and 59 DBA @ 5 Feet

7. Factory Test Vibration: Each individual fan shall be tested for vibration in X-Y-Z directions at the manufacturer's facility before shipment to the unit manufacturer to assure that specified fan balancing criteria is adhered to.
8. Test Procedures
 - a. A complete test procedure detailing the methods, equipment, and techniques to be employed for each specific test shall be submitted to the Architect for approval. Equipment will not be considered approved until written approval of testing procedures is attained.
 - b. As hereinbefore specified, the preceding airflow/static, sound and vibration tests shall be required for AHUs specified shall be witnessed by designated representatives of the Engineer and Owner (total [2] people). The unit manufacturer shall notify the engineer at least (4) weeks prior to any scheduled testing and shall have a formal written report prepared at the conclusion of this testing to be submitted to the Engineer. The unit manufacturer shall pay for all air and ground transportation, lodging, and meals for the designated witnesses to attend the testing. If multiple trips are required, they shall all be paid for by the unit manufacturer.
 - c. Any deficiencies in unit performance must be corrected by the unit manufacturer in the manufacturing plant prior to shipping.

3.5 FIELD TESTING

- A. Field Pressure Test: Pressurized leak testing shall be performed in the field after assembly of the unit sections by the contractor at ±12". The unit manufacturer shall correct and/or pay for the repair of all deficiencies found during testing. The Contractor shall provide all field labor necessary to join the unit sections, including all electric and drain splits after they are delivered to the site and set in place. All field work shall be provided under the direct supervision of a qualified engineer employed by the unit manufacturer. Rigging for unit sections shall be provided by the contractor. This test shall be performed within 2 weeks of the unit assembly and placement.
- B. Drain Pans
 1. Test
 - a. Check drain trap for seal

- b. Plug pan
 - c. Flood drain pans with water to near top of drain pan
 - d. Pull plug with fan operating
2. Acceptable results:
- a. Shall drain completely in 3 minutes or less
 - b. Trap seal still functional
 - c. After three minutes NO puddles shall remain in the pan larger than 2 inches in diameter and no more than 3mm deep.
- C. Vibration Testing
- 1. All fans
 - 2. All VFD driven fans throughout the range of control.

END OF SECTION