

SECTION 23 73 13 – CUSTOM AIR-HANDLING UNITS.

CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes variable volume outdoor or indoor, custom air-handling units with capacities, characteristics and configurations indicated on Drawings.

1.3 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit indicated on Drawings include the following:

- 1. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated at the following conditions.
 - 1) Scheduled operating conditions including initial and final pressure drops as scheduled.
 - 2) 50% airflow of design operating conditions (used to evaluate potential surge conditions).
 - b. Certified fan-sound power ratings.
 - c. Fan construction and accessories.
 - d. Motor ratings, electrical characteristics, and motor accessories.
 - e. VFD characteristics.
- 2. Certified coil-performance ratings with system operating conditions indicated.
- 3. Certified sound power levels at each unit discharge and inlet opening and radiated levels.
- 4. Material gages and finishes.
- 5. Filters with performance characteristics (efficiency, pressure drop graph, size and quantity).
- 6. Dampers:

- a. Size.
 - b. Quantity.
 - c. Configuration – OBD or parallel.
 - d. Material.
 - e. Leakage.
 - f. Seal.
7. Unit dimensions and weight.
8. Cabinet thermal performance: material, metal thickness, finishes and insulation.
9. Airflow Monitors.
10. Vibration isolation - Indicate compliance with performance requirements and design criteria, for base and isolators including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
11. Calculated unit radiated sound pressure levels.
- B. Shop Drawings: For each type and configuration of indoor, custom air-handling unit.
 1. Wiring Diagrams: Power, signal, and control wiring.
 2. Dimensional shop drawings.
 - a. Show casing construction (base, floor and housing).
 - b. Access door and hardware.
 - c. Operating weight (point and distributed loads.
 - d. All components (i.e. fans, coils, dampers, etc.).
 - e. Unit demounts (if any).
 3. Wiring Diagrams: Power, signal, and control wiring.
 4. Fan/motor vibration isolation details.
 5. Required clearances.
- C. Coordination Drawings: Submit with Shop Drawings:
 1. Show mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
 2. Show support locations, type of support, and weight on each support.

3. Indicate and certify field connection details.

4. Indicate and certify field measurements.

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

1.4 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Startup service reports.
- C. Field quality-control reports.
- D. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data:
1. For air-handling units to include in emergency, operation, and maintenance manuals.
 2. Bearing lubrication instructions.
 3. Filter replacement instructions.
 4. Motor and drive replacement instructions.
 5. Wiring diagram.
- B. Factory certified pressure test report on cabinet casing.
1. Report factory certifying air handling unit CFM leakage rate.
 2. Report factory certifying air handling unit panel deflection.
- C. Warranty.

1.6 COORDINATION

- A. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two sets for each air-handling unit.

1.8 FACTORY VISITS FOR PRODUCT INSPECTION

- A. Manufacturer shall provide Owner and Architect with written notice at least 30 business days before units go into assembly.

1.9 DELIVERY, STORAGE, HANDLING

- A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
- B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.
- C. Store air-handling units in a clean dry place and protect them from weather and construction activities.
- D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
- E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.
- F. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
 1. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.

1.10 WARRANTY

- A. Parts Warranty by Manufacturer and Labor Warranty by Installing Contractor: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.
 1. Warranty Period: 1 year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Temtrol; A Nortek Air Solutions Company.

2. Miller-Picking.
3. Engineered Air.

2.2 GENERAL CONSTRUCTION DESCRIPTION

- A. Provide factory-fabricated, fully-custom air handling units with capacity as indicated on the schedule. "Semi-custom" level units or units not complying with this specification shall not be deemed acceptable. Units shall have overall dimensions as indicated and fit into the space available with adequate clearance for service as determined by the Engineer.
- B. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.

2.3 CAPACITIES AND CHARACTERISTICS

- A. See equipment schedules on Drawings.

2.4 SOURCE LIMITATIONS

- A. Source all outdoor and indoor custom air-handling units from same manufacturer.

2.5 UNIT ARRANGEMENT AND CONFIGURATION

- A. Arrangement: Project-specific arrangement and configuration of air-handling units indicated on Drawings. Do not deviate from requirements indicated without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Engineer's written acceptance.
- B. Mounting Requirements: Outdoor units mounted on roof curbs. Indoor units to be mounted on concrete housekeeping pads. Allow proper height for condensate p-traps as required per AHU. Reference manufacturer's minimum p-trap height requirements for verification of p-trap design and needed height.
- C. Multiple Sections: Each air-handling unit shall consist of multiple sections for field assembly to comply with requirements indicated on Drawings.
- D. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:
 1. Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.
 2. Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.

3. Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.

2.6 CABINET

A. Base Frame and Floor:

1. Unit base frames shall be self-supporting welded structural or channel steel. Formed metal base rails shall not be acceptable.
2. Base shall be insulated with a minimum 4-inch thick, 1.5 lb. density fiberglass or foam insulation. A minimum 20-gauge G-90 galvanized outer liner shall be tack welded to base and intermediate supports.
3. Floor shall be constructed of a 12 gauge G-90 galvanized inner tread-plate, walk-on surface. Secure floor to perimeter base and intermediate cross supports with tack welds.
4. Where floor is of dissimilar metal to the cross supports and/or perimeter base, weld a bracket of similar material as the floor to the floor and mechanically fasten to the perimeter base and intermediate cross supports. Mechanically fastening the floor directly to the perimeter base or intermediate cross supports is not acceptable.
5. Aluminum treadplate floor throughout unit.
6. Base frame shall be attached to the unit at the factory.
7. Seal seams between floor and wall with a continuous bead of high performance polyurethane sealant which meets ASTM-C920, Type S, Grade NS, Class 25 and is USDA approved, paintable and EPA approved for potable water contact.
8. Base rail shall C-shape structural member capable of supporting the full load of the unit. Base rail shall be bolted together at each unit demount. Provide cross-supports at regular intervals to prevent bowing of the unit floor during rigging and to prevent leaks through AHU floor.

B. Housing:

1. Double wall, construction such that all internal components can be easily accessed for service or removed without the removal or disassembly of any exterior wall or roof panels. Access and removal of interior unit components shall be achieved either through access doors or access panels.
2. Housing shall be of a mechanically fastened panel or welded frame construction. All cabinet construction shall be of thermal-break type, with no-thru-metal. Wall panels shall be constructed of a minimum 16-gauge outer galvanized steelpanels and minimum 20-gauge galvanized steel inner panels.
3. Minimum thickness: double wall, insulated with encapsulated foam with minimum thermal resistance of R-24.
4. With the exception of coils and their casings, all metal parts shall be cleaned and given a moisture resistant finish that is standard with the manufacturer.

5. Blank offs required at coils and other components shall be coordinated with wall panel and roof. Blank offs shall be permitted at wall and roof panel seams only. Blank offs shall be sealed airtight at the panel seams.

C. Access Doors:

1. Provide heavy duty hinged 3" double wall, perimeter gasketed access doors with thermal break doorframes and a minimum of two quick opening, corrosive resistant ¼ turn latches (Ventlok 260 or equal, metal construction). Three latches shall be provided on all doors 36" and greater in height. Formed steel doorframes with stick on style gasketing are NOT acceptable. Doors of lesser construction than the cabinet thickness shall not be acceptable.
2. Access doors provided in the following sections:
 - a. Fan sections. Provide a 10"x10" fully gasketed, dual thermal pane safety glass window.
 - b. Access sections.
 - c. Filter sections.
 - d. Between coils.
 - e. Supply and return plenums.
 - f. Sections where dampers are located.
3. Size doors to accommodate removal of the equipment through the door without modification to the housing.
4. Provide ETL, UL 1995, and CAL-OSHA approved tool operated safety latch on all fan section access doors.

D. Access Panels:

1. Where required, provide a fully removable access panel in housing. Panel construction and insulation shall be the same as the unit housing in which it is installed.
2. Access panels shall only be used where required, and shall NOT be used in place of access doors.

E. Exterior Finish:

1. Indoor units: Units shall be supplied with a moisture resistant finish that is standard with the manufacturer.

F. Unit Finishes:

1. Base finish:
 - a. Color: Manufacturer's standard.

- b. One coat of primer and one coat of phenolic coating for long term corrosion resistance top coat.
 - 1) Prime and top-coat panels on both sides.

2.7 FAN, DRIVE AND MOTOR SELECTION

- A. Fan-Section Construction: Fan section shall be complete with fan, motor and drive in section housing with fan ratings determined in accordance with test procedures of ANSI/AMCA Standard 210.
 - 1. Array Technology:
 - a. General
 - 1) The multiple fan array systems shall include multiple, direct driven, arrangement plenum fans constructed per AMCA requirements for duty specified class III as required. Belt-drive fans not acceptable. Mount fan with vibration isolation. Fans shall be rated in accordance with and certified by AMCA for performance.
 - 2) 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.
 - 3) Each fan shall be provided with an inlet backdraft damper with no additional pressure drop on the fan. Use of an inlet backdraft damper shall take into consideration any system effects and leakage associated with the damper.
 - 4) Fan systems shall be selected so that if any one fan or motor in the array fails, that the remaining fans can continue to supply at least 100% of the scheduled airflow at the scheduled TSP (including filter loading) with the blank-off panel or inlet backdraft damper in place. This capability must be demonstrated during the air balancing phase of construction.
 - 5) Each individual cube or cell in the multiple fan array shall be provided with an integral back flow prevention device that prohibits recirculation of air in the event a fan becomes disabled. 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.
 - 6) Each fan & motor assembly shall be removable through a 24" wide, free area, access door located on the discharge side of the fan wall array with removing the fan wheel from the motor. All fan/motor access doors shall open against pressure.
 - 2. Performance:
 - a. At a distance defined by where a 45 degree angle from the fans' inlet intersects the unit housing, the best developed air flow velocity profile shall be achieved.
 - b. Direct drive fans shall be structurally designed to withstand the maximum motor RPM at 60 hertz.

3. Motors: Refer Section 23 05 13 "Common Motor Requirements for HVAC Equipment".
 - a. Shall be selected by the manufacturer and suitable for array application.
 - b. Bearings: Permanently sealed, L-10, 250,000.
4. Balancing:
 - a. Each fan array and assembly shall be dynamically balanced to meet AMCA Standard 204.
5. Drives and wiring:
 - a. Refer Section 23 29 23 "Variable Frequency Motor Controllers" for Variable Frequency Drive requirements.
 - b. Each fan motor shall be individually wired to a control panel containing two Variable Frequency Drives.
 - c. Two Variable Frequency Drives serving each fan array shall be sized to handle the amp draw for 50% (50/50) of the total connected HP for all fan motors contained in the fan array that are served by those two Variable Frequency Drive. Each VFD shall be a redundant VFD package.
 - d. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards and local code requirements.
 - e. Each individual Variable Frequency Drive shall be provided with its own disconnecting means so that it can be electrically isolated while the other VFD is operational.
 - f. Motor circuit protectors shall be used for each individual motor in the fan array. Motor circuit protectors shall be housed and mounted in the VFD enclosure as required. Motor circuit protectors may be mounted in a remote enclosure that is separate from VFD enclosure if design requires. Variable frequency drive enclosure and remote motor circuit protector enclosure must be mounted at a minimal distance from fan array motors and each other.
 - g. Proof of motor "run" state shall be provided for each individual motor. Dry contacts shall be provided so that a fan "failure" state can be reported through the BAS. A light shall be provided to provide visual indication that a motor is in the "failed" state.
 - h. Shaft Grounding: Provide an AEGIS model "SGR" shaft grounding system for each AC motor to prevent electrical damage to motor bearings and to extend motor life by safely channeling harmful shaft currents to ground.]

B. Fan-Section Source Quality Control:

1. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

2. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

C. Motors

1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. All motors shall be selected by the manufacturer and suitable for array application.
3. Motor bearings shall be permanently sealed, I-10, 250,000.
4. Maximum motor weights, no individual fan motors to exceed 175 lbs.:
 - a. 1-2.5 HP: 65 lbs.
 - b. 3-7 HP: 105 lbs.
 - c. 7.5-9.5HP: 175 lbs.

D. Airflow monitoring system

1. Airflow Measuring Probes:
 - a. Provide air flow measuring devices on each supply fan, outside air duct/opening, and exhaust fan of each air handling unit.
 - b. Each airflow probe shall contain multiple, averaged velocity pressure taps located symmetrically around the throat of the fan inlet and a single static pressure tap located on the fan housing. The entire airflow monitoring probe must be located outside the inlet throat as to not obstruct airflow.
 - c. The probes shall be capable of producing steady, non-pulsating signal of the velocity pressure, independent of the upstream static pressure without adversely affecting the performance of the fan. The sensing probes shall be accurate +/-3% of actual fan airflow.
 - d. All necessary transducers, tubing, wiring and microprocessors shall be furnished and installed by manufacturer's representative for each AHU. Each AHU to include from the factory an internal conduit spanning from Exhaust Fan and Outside Air locations to Supply Fan section to allow for internal wiring of FAATS wiring.
 - e. Include microprocessor control for airflow totals and alarms, with Bacnet interface for relaying values and alarms to BMS. Monitoring system shall be Paragon FAATS or equivalent. Connection/integration of Bacnet interface to BMS by BMS contractor
2. Airflow Monitoring Display: Paragon FAATS or equivalent.
 - a. Provide on indicated fans a method of displaying digitally, in real time, the fans current airflow.
 - b. The display shall be capable of showing:

- 1) Total supply fan wall cfm.
- 2) Individual fan cfm for each fan.
- 3) Outside air CFM in real time.
- c. For interaction with a controller, the display shall output one (1) 0-10VDC signal for each fan being monitored.
- d. The output signal shall be accurate to +/-0.5% of Natural Span, including non-linearity, hysteresis and non-repeatability.
- e. The display must be water tight allowing for use in outdoor locations. If the display is not water tight it shall be enclosed in a weatherproof housing.]

2.8 COILS

A. General Requirements:

1. Provided with heat transfer coils of types and capacities as scheduled.
2. Completely enclose return bends and headers in unit housing.
3. Coils shall be rated and certified in accordance with ANSI/ARI Standard 410.
4. Provide stainless steel coil supports to permit the removal of individual coils through an access panel or door without affecting the structural integrity of the housing or disturbing the remaining coil.
 - a. Heating coils: 16 gauge G90 galvanized steel and 16 gauge 304 stainless steel when heating coil is mounted directly to cooling coil.
 - b. Cooling coils: 16 gauge 304 stainless steel.
5. Provide blank-off sheets to ensure air passes through coil.
 - a. Heating coils: 12 gauge G90 galvanized steel.
 - b. Cooling coils: 12 gauge 304 stainless steel.
6. Provide intermediate drain pans on all stacked cooling coils. The intermediate pan shall drain to the main drain pan through a copper downspout.
7. Coil connections:
 - a. Threaded connections located on same end, except where otherwise noted or shown.
 - b. Coil headers and distributors completely enclosed in unit casing. Extend coil connections to the exterior of the unit housing. Seal all penetrations to meet air leakage criteria.
 - c. Water coil vent and drain connections:

- 1) Provide for each section.
 - 2) Extend all condensate drain lines to the exterior of the unit housing.
 - 3) Locate on the same side of the unit as the supply and return piping.
 - 4) Interior manifolding of individual coil drain and vent lines, prior to extending to the unit exterior is not acceptable.
 8. Units with staggered, dual coils shall have both connections piped to one side of AHU.
 9. Working Pressure Rating:
 - a. Water coils: 250 PSIG.
 10. Temperature Rating: 300 deg F.
 11. Hydrostatic Testing: Test coil assembly complete with header, distributor, vent and drain lines.
 - a. Completely submerge coil assembly charged with air or nitrogen at the following pressures for a period of 1 hour:
 - 1) Hydronic coils: 300 PSIG.
 - b. Any coil assembly that produces air bubbles resulting from leaks in the assembly (no matter how minute) shall be considered defective and not used.
- B. Cooling Coils:
1. Construction shall be expanded surface type with non-ferrous fins (minimum 0.0075" thick) permanently bonded to seamless copper tubes (5/8" OD - .020" tube wall minimum), maximum fin spacing (10 FPI) and minimum number of rows as scheduled; stainless steel coil casings arranged to permit expansion and contraction of tubes.
 2. Return bends shall be a minimum of one tube thickness greater than the main tubes (.035" brazed replaceable copper).
 3. 16 gauge 304 stainless steel casing.
 4. Non-ferrous, copper headers.
 5. Provide intermediate supports on tubes having lengths in excess of 48 inches.
 6. Stainless-steel condensate drain pans.
 - a. Provide a drain pan under the following section(s):
 - 1) Cooling coil section.
 - b. Construct of double wall 304 or 304L stainless steel with 2", R-16 foam insulation between the walls. Pan shall be a minimum of 4" deep and shall be pitched for positive drainage (two direction sloping toward pan drain on each side of unit, IAQ

style pans). All seams shall be continuously welded. Pitch in direction of airflow to assure water migration.

c. Size:

1) Minimum width:

- a) Extend drain pan $\frac{1}{2}$ the height of the coil but no less than 12" downstream of cooling coil.
- b) Extend a minimum of 24" beyond the leaving side of the humidifier grid.

d. Drain pan slope: minimum of one percent and pitched toward unit drain connection.

e. Provide drain connections on one side of unit where floor drain(s) are located.

- 1) Construct drain lines of same material as pan.
- 2) Extend drain lines through perimeter base channel and continuously weld seams/penetrations to insure an air-tight seal.
- 3) Provide removable cap on each drain connection.

f. Clearances:

- 1) Provide adequate clearance between bottom of the coil mounting channels and top of the drain pan to allow for visual inspection and cleaning of the drain pan without coil removal.
 - a) Coil height, including the coil casing material, shall not extend into the drain pan height.
 - b) Coil supports shall be arranged to allow the coil to be removed to one side of the air handling unit by removal of pipe connections and one cabinet wall panel and sliding the coil horizontally (above the drain pan height) on the coil supports.

g. Elevation: Mount drain pans in unit at an elevation to allow proper drainage of condensate where all condensate piping can be installed without modification to the slab or housekeeping pad.

C. Heating Coils:

- 1. Construction shall be expanded surface type with non-ferrous fins (minimum 0.0075" thick) permanently bonded to seamless copper tubes (5/8" OD - .020 tube wall minimum), maximum fin spacing (10 fpi) and minimum number of rows as scheduled; stainless steel coil casings arranged to permit expansion and contraction of tubes.
- 2. Non-ferrous, copper headers.
- 3. Provide intermediate supports on tubes having lengths in excess of 48 inches.

2.9 DAMPERS

- A. General: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.
- B. Electric Damper Operators: Comply with requirements in Section 23 09 00 "Instrumentation and Control for HVAC"
- C. Damper Operators: Actuator provided by Controls Contractor.
- D. Return-Air, Relief-Air, and Outdoor-Air Dampers: Parallel, double-skin, airfoil-blade galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, with steel operating rods rotating in stainless-steel sleeve, sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with interconnected linkages so dampers operate simultaneously. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.

2.10 ECONOMIZER SECTION

- A. Economizer section includes:
 - 1. Dampers and linkage for return air, outside air, and exhaust/relief air.
 - 2. Drain pan.
- B. Dampers, control:
 - 1. Provide control dampers for return, outside and exhaust/relief air.
 - a. Control dampers: As specified in Section 23 33 00 "Air Duct Accessories", factory mounted.
 - b. Damper actuators: As specified in Section 23 09 00 "Instrumentation and Control for HVAC", field or factory mounted.
 - c. Size dampers at 1500 to 1800 FPM air velocity.
 - d. Outside and return air dampers: Parallel blades arranged to provide convergent airflow to minimize stratification.
 - e. Outside air dampers: Provide two control dampers in each unit. One shall be sized for scheduled minimum outside airflow, and the other shall be sized for the design supply CFM less the minimum outside air quantity. Minimum outside air flow damper shall be sized at a maximum velocity of 1000 fpm, and shall include a factory-mounted airflow monitoring station. All outside air intakes to have intake louvers on outside of unit, sized and designed to prevent entrainment of water.
 - f. Exhaust air openings to have internal control dampers with discharge hood sized and designed to prevent entrainment of water.

2.11 AIR FILTRATION SECTION

- A. Filters:
 - 1. Prefilter: MERV 7, 4", pleated, replaceable filters. Comply with NFPA 90A.
 - 2. Where indicated in the Drawings: Final Filter: MERV-14, 6" 24-gauge galvanized steel frame, front loading replaceable filters, located downstream of all coils and fans.
- B. Filter Section: Provide filter holding frames arranged for flat orientation, with access doors as shown on drawings. Filters shall be removable front access sections.
- C. Filter Gauge: Each filter bank shall be furnished with Dwyer Series 2000 filter gauge or equal.
- D. Standard filter size shall be 24" x 12", 24" x 24", 20" x 20", or 20" x 25". Other odd size filters are NOT acceptable.
- E. Efficiency is based on ASHRAE Test Standard 52.1.
- F. MERV rating is based on ASHRAE Test Standard 52.2.

2.12 UV LIGHTS SECTION

- A. Provide factory-mounted and sired UV lights, sized for 90% or greater on-the-fly virus kill rate (first pass). Include safety door switches from factory.
 - 1. UV lights and controller to be interfaced with and controlled by Building Management System (BMS). Physical interface and control work to be accomplished under Section 23 0900 "Instrumentation and Control for HVAC".

2.13 ELECTRICAL

- A. Wiring to comply with NEC requirements and conform to applicable U/L standards and Electrical Specification Divisions.
- B. Each unit shall be wired and tested at the factory before shipment.
- C. All wiring shall be insulated copper wires.
- D. The unit shall feature a mounted permanent nameplate displaying at a minimum the manufacturer, serial number, model number and current and amps voltage. The unit must have an ETL or UL Listing and bear the appropriate mark.
- E. Conduit shall consist of a combination of EMT or flexible metal conduit as required. Liquid-tite flexible metal conduit may be used outside the air tunnel for wet locations.
- F. All units: Filter section, coil section, and fan section shall be equipped with a vapor-proof 100 watt service light with guard.
- G. Variable frequency drives for indoor air handling units:
 - 1. External power wiring to each variable frequency drive shall be by others.
 - 2. Variable frequency drives to be factory mounted and wired in full-length service vestibule.

3. Variable frequency drives to be interfaced with and controlled by Building Management System (BMS). Physical interface and control work to be accomplished under Section 23 0900 "Instrumentation and Control for HVAC".

H. Outlets:

1. Rounding up to the next highest number, provide a minimum of one factory installed double grounded GFCI receptacle per 20 foot of air handling unit length (For example, a 30 foot long unit would require 2 receptacles.). Outdoor units shall have weatherproof receptacles.
2. At all demounts and shipping sections, provide additional junction boxes on each section to allow the installer to make final connections in the field. Clearly label wiring to ease final interconnections.

- I. Convenience outlets and service access lights shall be tied to a junction box per AHU for single-point 120 volt single phase power per AHU.

J. Miscellaneous Conduit:

1. Provide 3/4 IN conduit stubbed through unit casing for controls wiring path. Locate on same side as drain and coil connection in wall near roof. Seal around conduit for water resistance and to meet air leakage requirement. Contractor to seal inside conduit once all controls cabling has been installed.

2.14 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
2. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI.
3. AHRI 1060 (I-P) Certification: Air-handling units that include energy wheels shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI.

B. AMCA Compliance:

1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in accordance with AMCA 205, "Energy Efficiency Classifications for Fans".
3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating".

4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
5. AMCA 301 Certification: Air-handling unit fans sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data".
6. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating".

C. NFPA Compliance:

1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

D. UL Compliance:

1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."
2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

2.15 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

A. Witness of Testing: Allow Architect, Engineer, Commissioning Agent, Construction Manager, and Owner access to place where air-handling units are being tested for witness testing.

1. Submit written notification at least 20 days in advance of testing.
2. Schedule testing at mutually agreeable dates and times.

B. Witness Testing Travel Expenses:

1. Include in bid the cost of travel expenses to witness factory testing. Total cost for travel expenses shall be clearly indicated separately in bid.
2. Expenses shall include roundtrip coach or first class airfare, out-of-town hotel accommodations, out-of-town meals (breakfast, lunch, and dinner), out-of-town ground transportation and parking, and all associated taxes and fees.
3. Exclude other incidental expenses not indicated.

C. Hydronic Piping Systems Testing: Pressure test factory-assembled piping systems with compressed air or water at a pressure to comply with governing codes and ASME B31.9, but not less than design pressure indicated.

1. Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.

2. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units to verify actual locations of connections before installation:
 1. Hydronic piping systems.
 2. Condensate drainage piping.
 3. Electrical services.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
 1. Units Mounted on Concrete Bases (Indoor Units):
 - a. Install air-handling units on concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration Controls for HVAC Piping and Equipment".
- B. Equipment Clearances and Access:
 1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
- C. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

- D. Install a pressure and temperature test port in each access door. Where access doors are not provided between components install pressure and temperature test port in housing wall. Install all test ports at least 6" below top of cabinet but no more than 72" above bottom of base rail.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 CONNECTIONS

A. DUCT CONNECTIONS

- 1. Coordinate duct installations and specialty arrangements with Drawings and with requirements specified in Section 233113 "Metal Ducts" and Section 233300 "Air Duct Accessories."
- 2. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."
- 3. Provide duct transitions required to make field connections to air-handling units. Make final duct connections with flexible connections.
- 4. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

B. PIPING CONNECTIONS

- 1. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- 2. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.
- 3. Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 - a. Make connections to air-handling unit connections with flanges or unions.
 - b. Extend drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 - c. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 - d. Install threaded cleanouts at changes in direction.
- 4. Chilled-and Hot-Water Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
 - a. Make connections to coils with a flange or union.
 - b. Connect to each coil inlet with shutoff valve and test plug.

- c. Connect to each coil outlet with 2-way balancing valve, shutoff valve, and test plug.
- d. Connect each coil drain connection with a drain valve, which is full size of drain connection.

C. ELECTRICAL CONNECTIONS

- 1. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
- 2. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- 3. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- 4. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- 5. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - a. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

D. CONTROL CONNECTIONS

- 1. Coordinate with Section 23 09 00 "Instrumentation and Control for HVAC" for locations of water valves, temperature sensors, damper operators and all other related control devices and equipment.
- 2. Coordinate intended AHU control sequence of operation with Controls Contractor. Verify all required unit components have been properly installed to allow the Controls Contractor to connect, signal and verify the control sequence of operation.
- 3. Install control and electrical power wiring to field-mounted control devices.
- 4. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- 5. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.
 - a. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:

1. Coil Leak Test: After field piping connections are complete, test hydronic coils and connections for leaks. Repair leaks and retest until no leaks exist.
 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Air handling unit manufacturer shall provide a factory-authorized service representative to perform startup service.
1. Installation supervision of all units and roof curbs.
 2. Conformation of proper unit seals located at factory shipment seams (demounts) (if any) as required for shipment
 3. Pre-start up inspection and set up for the air handling units and VFDs.
 4. Start-up services for all components within the air handling units (i.e. heat recovery components and VFDs).
 5. Warranty services for the entire air handling unit.
 6. Owner training for the air handling units, including heat recovery components and VFDs.
 7. Complete installation and startup checks according to manufacturer's written instructions.
 8. Verify that shipping, blocking, and bracing are removed.
 9. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete.
 10. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 11. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 12. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 13. Verify that face-and-bypass dampers provide full face flow.
 14. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.

15. Comb coil fins for parallel orientation.
16. Verify that proper thermal-overload protection is installed for electric heaters.
17. Install new, clean filters.
18. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.

3.7 CLEANING

- A. Clean modular indoor air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
- B. After completing system installation and testing, adjusting, and balancing modular indoor air-handling and air-distribution systems, clean filter housings and install new filters.

3.8 DEMONSTRATION

- A. Engage air-handling unit manufacturer or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain outdoor air-handling units. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION