

SECTION 23 73 13

MODULAR, INDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes constant and variable-volume, modular air-handling units with coils for indoor installations.

1.2 SUBMITTALS

- A. Product Data: For each type of modular indoor air-handling unit indicated. Include the following:
 - 1. Certified fan-performance curves with system operating conditions indicated.
 - 2. Certified fan-sound power ratings.
 - 3. Certified coil-performance ratings with system operating conditions indicated.
 - 4. Motor ratings, electrical characteristics, and motor and fan accessories.
 - 5. Material gages and finishes.
 - 6. Filters with performance characteristics (installation and removal, tool free).
 - 7. Dampers, including housings, linkages, and operators. Dampers and operators must comply with the requirements of Div 15 Building Automation System including the submittal requirements.
 - 8. Accessories.
 - 9. Required access clearances.
 - 10. Wiring Diagrams: Power, signal, and control wiring.
- B. Field Quality-Control Test Reports: Field Quality-Control Test Reports: Submit reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.
- C. Training Reports: Submit reports on training documenting dates and attendance.
 - 1. Credit EQ5: Certification that equipment has been provided with MERV 13 filters.

1.3 QUALITY ASSURANCE

- A. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. NFPA Compliance: Modular indoor air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."

- D. ARI Certification: Modular indoor air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI. Coils shall comply with ARI 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
- E. Air Handling Unit safety: ETL or UL 1995
- F. Air Handling Unit energy use: ASHRAE 90.1
- G. Fans: AMCA 210
- H. Filter media: ANSI/UL 900 listed Class I or Class II
- I. Control wiring: NEC codes & ETL requirements
- J. Motors: Federally mandated Energy Policy Act (EPACT).
- K. Airflow Monitoring Stations: AMCA 611-95

1.4 DELIVERY, STORAGE AND HANDLING

- A. Lift and support units with the manufacturer's designated lifting or supporting points.
- B. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.
- C. Deliver central-station air-handling units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.
- D. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).
- E. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from rain and other sources of moisture by appropriate in-transit and on-site procedures.
- F. Follow manufacturer's recommendations for handling, unloading and storage.
- G. Protect, pack and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.
- H. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.
- I. Separately enclose and protect control panels, electronic or pneumatic devices and variable frequency drives and pack with desiccant bags. Replace the desiccant bags every 60 days. For equipment stored in an environment with a relative humidity greater than 60%, change bags every 30 days. Do not store equipment in wet or damp areas even when they are sealed and secured.
- J. Seal openings to protect against damage during shipping, handling and storage.

- K. Provide shrink-wrap around entire exterior of indoor equipment. The membrane shall cover the entire top, side and end panel surfaces to fully protect the AHU during shipping and storage. Cover equipment, regardless of size or shape. Tarping is not acceptable.
- L. Shrink-wrap equipment including electrical components for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.
- M. Ship units that are not shrink wrapped in an enclosed truck or shipping container.
- N. Clearly mark each AHU section with its tag number, segment sequence number and direction of airflow. Securely affix safety-warning labels. Use a 3-language format for labels.
- O. Storage: Store per AHU manufacturer's written recommendations. Store AHUs indoors in a warm, clean, dry place where the units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will sit idle for more than 6 months, obtain written recommendations from the manufacturer for long-term storage. Follow these recommendations to ensure warranty coverage.
- P. Rigging: Follow manufacturer's written instructions for rigging, off-loading, and use of rigging tools such as spreader bars, forklifts, come-a-longs, and shackles.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
- B. Coordinate installation of equipment supports, and roof penetrations.
- C. Coordinate size and location of structural-steel support members.

1.6 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: One set for each modular indoor air-handling unit.
 - 2. Fan Belts: One set for each modular indoor air-handling unit fan.
 - 3. Gaskets: One set for each sectional joint.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide air handlers by one of the following:
 - 1. Carrier; Div. of United Technologies Corp.
 - 2. McQuay.
 - 3. Trane Company (The); Worldwide Applied Systems Group.

2.2 MANUFACTURED UNITS

- A. Air Handling Unit (AHU) consists of a base rail, structural base, insulated casing, access doors, internal components and accessories.

- B. Provide AHU to meet the specified levels of performance for scheduled items including airflow, static pressure, cooling capacity, heating capacity, sound, casing leakage, panel deflection and casing thermal performance, including panels and frame members.
- C. Provide internal components and accessories specified and scheduled. Components and accessories shall be installed by the AHU manufacturer in an ISO-9002 certified facility.
- D. Ship units in one piece. Split units only where necessary for shipping or installation.
- E. Manufacture and ship unit in segments small enough to fit through project specific building openings. See drawings.
- F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.
- G. For AHU segments that must be broken down for rigging and installation:
 - 1. Segment shall be disassembled and reassembled by manufacturer's factory-trained service personnel.
 - 2. Manufacturer shall perform a moisture carry over test as indicated below.
 - 3. Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.

2.3 BASE RAIL

- A. Provide a structural base rail under the full perimeter of the unit, formed from G-90 mill galvanized steel. Rail shall provide sufficient clearance to achieve proper external trapping of drain pans for coils and humidifiers taking into account dirty filter conditions. Lifting lug system shall not require additional support for rigging, and shall include lifting lugs at each side of each shipping split and at unit corners. The drain outlet height above the finished floor must be greater than or equal to pressure in inches of water at the coil outlet (P) with dirty filters plus the drain pipe diameter plus the greater of 5inches or (P/2+1). Conditions which allow standing water in the drain pan or require the floor to be chipped out to fit the trap are unacceptable.

2.4 CASING

- A. Provide AHU casing that is double wall in its entirety, including roof, walls, floor, drain pan and access doors.
- B. Panel assembly shall meet UL standard 1995 for fire safety. Panel insulation shall comply with the requirements of NFPA 90A.
- C. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.
- D. Encapsulate insulation with sheet metal.
- E. Provide casing with minimum thermal resistance (R-value) of 8.0 BTU/hr-ft²-°F.
- F. Liners shall be G90 galvanized steel.

2.5 PRIMARY DRAIN PANS

- A. Comply with the stated intent of ASHRAE Standard 62.
- B. Provide a stainless steel drain pan under each cooling coil and humidifier.
- C. Provide drain connection made of same material as liner at one or both ends of the pan. Weld drain connection to the drain pan. Threaded drain pan joints are acceptable if joints are easily accessible for inspection and service.
- D. Insulate plumbing associated with drain pan drains and connections.
- E. Provide drain pan under the complete width and length of cooling coil and humidifier sections.
- F. Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.
- G. Extend drain pan downstream of coil a minimum of 10”.
- H. Provide a minimum of 1” clearance between the drain pan and any coil casing, coil support or any other obstruction.
- I. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.
- J. Provide drain pan sloped in at least two planes by at least 1/8” per foot toward a single drain location. Locate drain connection at the lowest point of the pan. The pan shall have no horizontal surfaces.

2.6 ACCESS DOORS

- A. Provide access door(s) that meet requirements for the AHU casing.
- B. Provide inward opening doors on positive pressure areas on the AHU. If doors opening against positive pressure are not available, provide a safety mechanism and warning label to prevent injury to maintenance personnel.
- C. Provide a bulb-type gasket around the entire door or doorframe perimeter.
- D. Provide continuous stainless steel hinges that permit 180 degrees of door swing.
- E. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or “paw” latches are not acceptable.
- F. Provide each door with a single handle linked to multiple latching points or a separate handle for each latching point. Doors serving access segments shall have an interior latch handle.
- G. Provide access doors with a locking hasp to accommodate a lockout device.
- H. Provide non-condensing double-pane viewing windows.
- I. Access doors shall be provided on both sides of unit on all sections unless indicated otherwise on drawings or schedules.

2.7 FANS

- A. Provide double width double inlet (DWDI) housed fans or single width single inlet (SWSI) plenum fans. See schedule for specific project requirements.
- B. Provide fans with airfoil blades unless otherwise noted on the plans or schedules.
- C. Provide airfoil blades formed of extruded aluminum. Bent sheet metal blades are not acceptable. Provide an access door in the fan scroll.
- D. Provide only airfoil fans that comply with AMCA standard 99 2408 69 and 99 2401 82. Provide an AMCA Seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.
- E. Provide fans with the following accessories:
 - 1. Fan inlet screens in the inlets of fan housing (REQUIRED on SWSI plenum fans)
 - 2. Access door inlet screen (on AHU casing)
 - 3. OSHA-compliant belt guard enclosing the fan motor and drive
- F. Provide fans with polished steel shafts sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class. Shaft shall be factory coated after assembly with an anti-corrosion coating.
- G. Provide fan motor on an adjustable base to allow adjustable and consistent belt tension.
- H. Mount the fan and motor assembly on a common adjustable base. This common base shall attach to vibration isolators, which mount to structural support channels. These channels shall span the AHU floor and mount directly to the AHU frame.
- I. Provide vibration isolation springs as required by Division 23 Section, "Vibration Controls FOR HVAC."
- J. Connect DWDI fans to the unit casing or bulkheads with canvas flexible connection.
- K. Provide horizontal thrust restraints between AHU casing and fan housings with end discharge. This requirement applies to the following cases:
 - 1. SWSI fans operating at greater than 3" of total static pressure
 - 2. DWDI airfoil fans operating at greater than 6" of total static pressure
 - 3. DWDI airfoil fans operating at greater than 3" of total static pressure

2.8 BEARINGS AND DRIVES

- A. Provide bearings complying with ANSI/AFBMA 9 regarding fatigue life ratings.
- B. Provide fan bearings with an average life L10 of at least 200,000 hours.
- C. Provide permanently lubricated bearings on forward curved fans smaller than 18." On other fans, provide re-greaseable bearings with hydraulic grease fittings and lube lines extended to the motor side of the fan or to the exterior of the unit (motor side).

- D. Provide plenum fans with direct-drive transmissions.
- E. Select drives with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Provide a fixed pitch sheave on the motor.
- F. Provide fixed pitch sheaves on fans and motors. For fans with motors rated at 15 hp or less, variable pitch sheaves may be provided for start-up, if they are replaced with fixed pitch after final balance is complete.
- G. For fans with belt drives and motors rated at 10 hp or greater, provide multiple belt drives. Belts shall be V-type, precision molded, raw edge construction, anti-static, oil-resistant and heat-resistant.

2.9 ELECTRICAL MOTORS

- A. Motors are specified in Division 23 Section “Common Motor Requirements for HVAC Equipment.”

2.10 HEATING AND COOLING COMPONENTS

- A. Provide coils with ratings certified in accordance with ARI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at full design flow.
- B. Provide cooling coils with a maximum face velocity of 500 fpm or less as required to ensure that all condensate falls or drips into the drain pan. The coil and drain pan assembly must meet this requirement whenever the humidity ratio is equal to or less than the design entering conditions and the outlet temperature is at the design leaving condition . Face velocity calculations shall be based on the finned area of the coil only.
- C. Provide cooling coil segment design that does not require a drain pan in any downstream section to contain the coil condensate. Drain pan shall extend a minimum of 10” downstream of the face of the coil.
- D. Coil segment casing shall accommodate full-face height or reduced-face height coils.
- E. Provide a minimum of 24” of empty access plenum between coils in series and an easily removable access panel or door on both sides of the access plenum.
- F. Special casing considerations for coil segments:
 - 1. Provide panels that are easily removable with standard tools.
 - 2. Access doors adjacent to piping stub-outs shall be located with sufficient clearance for 2 inches of field-applied insulation and field-installed piping connectors and piping accessories. Space shall allow a minimum of 90 degrees of door swing.
- G. Provide coils built in their own casing frame. Coil casing frame shall be stainless steel. Tube sheets on each end shall have fully drawn collars to support tubes and to form a protective sheath at the tubes. Horizontal coil casing and support members shall be constructed to drain moisture. Casing and support members shall not block finned area.
- H. Coils shall be designed and installed to allow individual removal from the side of the AHU.

- I. Provide a stainless steel intermediate drain pan for stacked cooling coils in the downstream position. The intermediate drain pan shall slope in a minimum of two planes toward a single drain connection. Provide a welded drain connection for the intermediate drain pan. Threaded connections are acceptable if they are easily accessible for inspection and service.
- J. Extend pipe connections through the AHU casing. Provide a 1/4" FPT, plugged vent or drain tap on each connection. Circuiting shall provide free and complete draining and venting when installed in the unit. Vent and drain connections shall reside on the coil connection extension on the outside of the unit casing.
- K. Insulate gap between coil stub out connection and AHU casing with a spool-shaped sleeve grommet. Adhesive rings applied the casing walls are not acceptable.
- L. Water and glycol coils shall be designed to operate at 250 psig design working pressure and up to 300° F. Factory test water and glycol coils with 325 psig compressed air under water.
- M. **Provide water, glycol coils with a tube OD of 5/8" 1/2"**. Tubes shall be mandrel expanded to form fin bond and provide burnished, work-hardened interior surface. Tubes shall have a minimum tube wall thickness of 0.025". ~~Increase wall thickness to 0.035" for pre-heat coils.~~ **Addendum 01-22-13**
- N. Provide water, glycol coil headers constructed of heavy seamless copper or brass tubing. System piping connections shall be of steel or red brass. Connections shall have male pipe threads. Header connections (tubes and piping connections) shall be silver-brazed.
- O. Provide coils with extended surfaces (fins) of die-formed, continuous aluminum fins. The fins shall have fully drawn collars to accurately space fins, and to form a protective sheath for the tube. Fins shall be 0.01" thick, maximum spacing of 10 fins per inch.

2.11 FILTERS

- A. Provide side loading filters for filter segments located upstream of the coil segment(s) with an access door on both sides through which the filters can be easily loaded. The filters must be installed and removed tool free.
- B. Provide face loading filters for segments located downstream of the coil segment(s). Provide an 18" (minimum) access plenum and access doors on both sides of unit.
- C. Provide Class 2 or Class 1 filter media per U.L. 900.
- D. Provide filter racks constructed of galvanized steel.
- E. Provide a rigid filter segment with 12" rigid media rated in accordance with ASHRAE 52, with an efficiency of 80-85% (MERV 13). Provide a pre-filter rack in the rigid filter segment with 2" 30% pleated filters.
- F. Provide a flush mounted, factory installed magnahelic differential pressure gage on the drive side of the unit to measure pressure drop across each filter bank individually. Manufacturer shall provide fully functional gauges, complete with tubing.

2.12 DAMPERS

- A. Provide dampers by one of the manufacturers listed in Division 23 Section “Building Automation System (BAS) - Operator Interfaces.” Dampers shall be sized for the actual project specific design conditions and reviewed by the temperature controls contractor. Barn door damper sizing is unacceptable. If the AHU manufacturer cannot provide one of the exact dampers specified, properly sized for the project, the unit shall be shipped without dampers and contractor shall provide and field install dampers and blank offs.

2.13 FACTORY INSTALLED MOTOR STARTERS

- A. Provide motor starter panels and associated components that are UL or ETL listed and that comply with applicable provisions of the National Electric Code.
- B. Provide factory mounted and wired starter panels serving fans as indicated on equipment schedule and shown on the drawings. Each starter shall be mounted in a dedicated, NEMA 1 compartment located on the side of its associated fan section. Wiring to motor shall be provided in flexible conduit.
- C. Provide the following features in each starter panel:
 - 1. Non-overloading
 - 2. Main power block
 - 3. Motor contactor(s)
 - 4. Individual starter short circuit and overload protection devices
 - 5. Two primary control fuses, one secondary control line size fuse
 - 6. Three phase ambient compensated overload heater elements
 - 7. 115-volt control power transformer with primary and secondary protection
 - 8. Five-point terminal strip for field control connections
 - 9. Factory wired, non-fused or fused main power disconnect, integral with the starter panel
 - 10. Integrated on/off auto switch.
 - 11. Wiring to fan motor

2.14 FACTORY INSTALLED ELECTRICAL ACCESSORIES

- A. Provide factory mounted disconnect in a separate NEMA-1 enclosure. Manufacturer shall wire disconnect to motors.
- B. Provide a separate and independent power terminal for convenience receptacles and lights, with switches.
- C. Provide low temperature fluorescent lights in fan, access, coil, service, outdoor air and mixed air segments including wiring to switches and power.
- D. Provide a 120v convenience receptacle on the supply fan segment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIELD PERFORMANCE VERIFICATION

- A. AHU Cooling coil moisture carry over:
 - 1. With the AHU operating at maximum design airflow rate ,.
 - 2. Modulate return and outside air dampers to maintain a humidity ratio greater than or equal to the design coil entering conditions
 - 3. Modulate the chiller water valve to maintain a coil leaving temperature equal to or less than the design leaving temperature.
 - 4. Operate the AHU for 4 hours under the above conditions
 - 5. After 4 hours shut the AHU down and inspect the surface downstream of the coil and pan for moisture. If moisture is found determine the cause, repair and retest.
- B. Record test data and results in a report. Test data will include trend data at 5 minute intervals documenting the test conditions.
- C. Submit a field test report with testing data recorded. Include description of corrective actions taken.

3.3 INSTALLATION

- A. General Requirements: Install per industry standards, applicable building codes and manufacturer's written instructions.
- B. Temporary use: Use of AHUs for temporary heating, cooling or ventilation is strictly prohibited.
- C. Concrete base: Install AHUs on a minimum 4" thick reinforced concrete pad.
- D. Access clearance: Install AHUs with sufficient access space around the AHU to meet manufacturer's recommended clearances for regular service access, coil pull and fan removal. As a minimum, this clearance shall equal to the width of the AHU on one side.
- E. Filters: Install one complete set of filters for testing, balancing and commissioning. Install second complete set of filters at time of transfer to owner.
- F. Coil Segment: Install AHU plumb and level, to ensure free draining and venting through the manufacturer-provided vent and drain on each coil. Follow manufacturer labels for inlet and outlet of coil headers to ensure proper direction of coil fluid flow.

3.4 FIELD INSPECTION

A. AHU Inspection

1. Retain manufacturer's factory-trained and factory-employed service technician to perform an inspection of the AHU and the AHU installation prior to proceeding with fan assembly inspection and startup. Technician shall inspect and verify the following as a minimum:
 - a. Damage of any kind
 - b. Level installation of the AHU
 - c. Proper reassembly and sealing of unit segments at shipping splits.
 - d. Installation of shipped-loose parts, including filters, and mist eliminators.
 - e. Proper electrical, ductwork and piping connections
 - f. Tight seals around wiring, conduit and piping penetrations through AHU casing.
 - g. Supply of electricity from the building's permanent source
 - h. Integrity of condensate trap for positive or negative pressure operation
 - i. Condensate traps charged with water
 - j. Removal of shipping bolts and shipping restraints
 - k. Sealing of pipe chase floor(s) at penetration locations.
 - l. Tightness and full motion range of damper linkages (operate manually)
 - m. Complete installation of control system including end devices and wiring
 - n. Cleanliness of AHU interior and connecting ductwork
 - o. Proper service and access clearances
 - p. Proper installation of filters
 - q. Filter gauge set to zero
2. Resolve any non-compliant items prior to authorizing manufacturer to proceed with the inspection of the fan assembly

B. AHU Fan Assembly Inspection and Adjustment

1. AHU Inspection (fan assembly): Engage a manufacturer's factory-trained and factory-employed service technician to perform an inspection of the AHU fan assembly prior to startup. Technician shall inspect and verify the following as a minimum:
 - a. Fan isolation base and thrust restraint alignment
 - b. Tight set screws on pulleys, bearings and fan
 - c. Tight fan bearing bolts
 - d. Tight fan and motor sheaves
 - e. Tight motor base and mounting bolts
 - f. Blower wheel tight and aligned to fan shaft
 - g. Sheave alignment and belt tension
 - h. Fan discharge alignment with discharge opening
 - i. Fan bearing lubrication
 - j. Free rotation of moving components (rotate manually)
2. Should any of the above need adjustment, engage manufacturer to perform the necessary adjustments to return the items to within factory specifications.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to modular indoor air-handling units with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. Provide ½" thick insulation on condensate piping.
- E. Chilled Water & Hot Water Connections: At a minimum connect inlet to coil with isolation valve, y-strainer w/ hose connection, P&T tap, manual air vent, controller-bulb well, thermometer, pressure gauge, drain connection valve, flex connector, and union or flange. At a minimum connect outlet to coil with isolation valve, control valve, calibrated balance valve, P&T tap, manual air vent, thermometer, controller-bulb well, pressure gauge, drain connection valve, flex connector and union or flange. For multiple coils pipe similarly and provide additional calibrated balancing valves to individually balance each coil. See drawings for additional requirements. Utilize a single pressure gauge with isolation valves across the evaporator inlet and outlet in lieu of individual gauges to eliminate gauge error.
- F. Steam & Steam Condensate Connections: At a minimum connect inlet to coil with drip trap assembly, isolation valve, y-strainer (3 or 9 o'clock position) w/ hose connection, union, control valve union, isolation valve, bypass with globe valve, vacuum breaker, pressure gauge, and union or flange. At a minimum connect outlet to coil with isolation valve, check valve, union, inverted bucket trap, union, y-strainer w/ hose connection, isolation valve, bypass with isolation valve, stainless steel flexible connector, dirt leg and minimum 12" rise to coil and union or flange. For multiple coils pipe similarly with the ability to individually isolate each coil. See drawings for additional requirements.
- G. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.
- H. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 CLEANING

- A. Clean unit per manufacturer's recommendation.

3.7 CONTRACTOR STARTUP AND REPORTING

- A. Engage manufacturer's factory-trained and factory-employed service technician to startup AHUs. Startup service includes the testing, inspections and startup test reports. Technician shall perform the following steps as a minimum:
1. Energize the unit disconnect switch
 2. Verify correct voltage, phases and cycles
 3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
 4. Re-check damper operation; verify that unit will not operate without both an inlet and an outlet damper open.
 5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.
 6. If AHU is provided with a factory-mounted variable frequency drive (VFD), then retain the VFD manufacturer's factory-trained and factory-employed service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.
 7. Coordinate startup of AHU, controls and VFD with representative personnel from each supplier.
 8. Submit a startup report documenting all steps performed and summarizing findings and activities performed.

3.8 DEMONSTRATION AND COMMISSIONING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air handling units.
1. Train Owner's maintenance personnel on procedures and schedules for startup and shutdown procedures as well as regular operation, maintenance requirements, and troubleshooting of the AHU and factory mounted controls including starters, VFD,. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner's personnel during training including the startup report.
 2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided. A list of all required maintenance will be provided.
 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 4. Training will occur in two (2) separate two (2) hour sessions, neither on the same day the AHU is started up.
- B. Demonstrate proper operation of equipment to commissioning agent or designated owners personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23.

END OF SECTION