

**PART 1 GENERAL****1.1 RELATED DOCUMENTS**

- A. The requirements of the General Conditions, Supplementary Conditions and the following Specification sections apply to all Work herein:
1. Section 23 00 10 - General Requirements
  2. Section 23 00 20 - HVAC Scope of Work
  3. Section 23 05 07 - Design Conditions
  4. Section 23 05 13 - Motor Requirements for HVAC Equipment
  5. Section 23 05 30 - Miscellaneous Equipment
  6. Section 23 05 48 - Vibration Isolation
  7. Section 23 05 93 - Testing, Balancing and Adjusting
  8. Section 23 31 00 - Ductwork and Sheet Metal
  9. Section 23 40 00 - Air Filtering

**1.2 SUMMARY**

- A. Furnish and install all custom factory-built tri-path multi-zone air handling units herein specified and as indicated on the Drawings.

**1.3 REFERENCE STANDARDS**

- A. All custom factory-built tri-path multi-zone air handling units and accessories shall be designed, manufactured and tested in accordance with the latest applicable industry standards including the following:
1. ASTM B-88-72 H23.1-59, E84, C423-90a and E795-83
  2. NFPA 90A, 90B and 255
  3. UL 723
  4. AHRI Standard 410
  5. AMCA 210-85, 211, 300 and 311
  6. ISO BS-848-1980 and 1940 G6.3
  7. IEEE 444 and 519-1992
  8. NEMA ICS-3-303
- B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the authorities having jurisdiction and suitable for its intended use on this Project.

**1.4 SUBMITTALS**

- A. The following submittal data shall be furnished according to the General Conditions and Section 23 00 10 and shall include, but not be limited to:
1. Custom Factory-Built Tri-Path Multi-Zone Air Handling Units\* complete with fan data for all fans, cooling coil selection data, hot water heating coil selection data for all zones, damper sizes and performance, static pressure calculations, physical dimensions for unit including base frame, motor horsepower and starting requirements, variable speed drives, motor manufacturer details and information, etc. Shop Drawings shall indicate specifically that the construction, fabrication, etc., of the units to be furnished complies with these Specifications.
  2. Variable Speed Drives\* complete with enclosure construction details, line reactor or tuned filter data, design features, accessories, disconnect, capacitor, mechanical bypass, if specified, and spare parts data.
  3. Acoustical and Performance Mock-Up Test Details complete with mock-up drawings and description of scope of work. Indicate air handling unit lead time required for mock-up unit, coordination requirements with Division 25 for mock-up unit, and name and location of the certified laboratory conducting the testing for approval by the Owner.
  4. Coil pressure test logs listing the air handling unit coils tested, date of test, pressure at start of each test, pressure at the end of each test, duration time for the test and the name of the test supervisor for each test.
  5. Factory fan balancing certifications.

6. Prior to execution of factory testing and lab testing, submit test procedures, recording forms, and test equipment cut sheets to Engineer for review. Refer to Section 23 00 20 titled "Scope of Work" for "Scheduling Procedures".
  7. Factory Test Schedule.
  8. Factory Test Reports.
  9. Lab Test Schedule.
  10. Lab Test Reports.
  11. One (1) spare motor and fan assembly or FWT fan "cartridge" of each size supplied for Owner stock.
- B. All items or equipment listed above with asterisks (\*) shall be certified by the manufacturer using Manufacturer Certification "MCA" as set forth in Section 23 00 10. See Section 23 00 10 for certification requirements.

## 1.5 WARRANTY

- A. Comply with the requirements of the General Conditions and Section 23 00 10.

## PART 2 PRODUCTS

### 2.1 ACCEPTABLE MANUFACTURERS

- A. If it complies with these Specifications, custom factory-built tri-path multi-zone air handling units manufactured by one of the following manufacturers will be acceptable:
1. CES Group / Temtrol
  2. ClimateCraft, Inc.
  3. Haakon Industries
  4. York / Custom
- B. If it complies with these Specifications, water coils manufactured by one of the following manufacturers will be acceptable:
1. Aerofin
  2. CES Group
  3. ClimateCraft, Inc.
  4. Heatcraft
  5. York
- C. If it complies with these Specifications, fans manufactured by one of the following manufacturers will be acceptable:
1. Acme Engineering & Manufacturing Corporation
  2. Buffalo Fan
  3. Greenheck Fan Corporation
  4. HUNTAIR, Inc.
  5. Loren Cook Company
  6. Twin City Fan & Blower

### 2.2 CUSTOM FACTORY-BUILT TRI-PATH MULTI-ZONE AIR HANDLING UNITS

- A. Custom factory-built tri-path multi-zone air handling units shall be three (3) compartment units with the following arrangement:
1. Blow through multi-zone top section for perimeter zone blending and heating service, with fan(s), filter section, zone dampers, and individual zone heating coils.
  2. Blow through multi-zone middle section for cooling service, with fan(s), filter section, individual zone dampers, transfer air damper, return air inlet plenum with outside air economizer damper and return air damper, cooling coil(s), and drain pan.
  3. Horizontal draw through down flow bottom section for underfloor air service with fan(s), filter section, and blending panel section.
  4. Refer to the drawings and schedules for exact air handling unit configuration, dimensions, and capacities as listed in the schedules on the Contract Documents.

- B. Unless otherwise noted, each air handling unit shall be complete with air handling unit casings, multiple Arrangement 4 direct drive centrifugal plenum wheel fans or fan arrays, outside air ductwork connections as indicated on the Drawings, multi-zone damper sections, floor stand, internal and external vibration isolation, insulation, sound absorbing sections (where required), stainless steel drain pans, chilled water cooling coils, transfer deck cold air damper, blending panel, casing section(s) for air filters as listed in the schedules and in the Contract Documents, and variable speed drive controllers. The units shall comply with the following minimum requirements.
- C. Thermal, Capacity and Sound Rating Mock-up Testing:
- Each air handling unit shall be constructed and shall operate for all conditions of air flow to provide an NC environment in the occupied tenant space as specified in Section 23 05 07 titled "Design Conditions", except these units shall not produce higher than a NC 40 within 6' from the air handling unit room wall in the adjacent tenant space when operating at all design conditions. Sound ratings shall be achieved adjacent to the air handling unit room in occupied Tenant areas with the discharge ductwork from the unit constructed as per the Drawings and Specifications. Sound rating required for the completed installation shall be achieved with the air handling unit designed, constructed and installed to comply with the sound criteria listed herein with the room construction as indicated on the Architectural and Structural Drawings for this Project and with the ductwork and vibration isolation as indicated in these Specifications and on the Contract Documents.
  - The air handling unit manufacturer shall conduct testing in a certified laboratory approved by the Owner to demonstrate the acoustical performance of the air handling unit in a mock-up matching the Project's typical floor air handling unit fan room, with one (1) 15' x 15' (minimum) tenant test office constructed immediately adjacent to the air handling unit room, raised floor and ceiling matching the floor and ceiling specified for the Project, and with supply and return air wall openings as shown on the Contract Documents. Refer to Architectural Drawings for exact mechanical room configuration and wall construction.
  - The Engineer and Project Acoustical Consultant shall select the typical floor mechanical room and air handling unit to be used in the mock-up. Submit drawings and details of the test mock-up to the Engineer and Project Acoustical Consultant for review. The air handling unit manufacturer shall include all costs for the mock-up in his bid proposal, except, travel expenses for Project Acoustical Consultant and other Project Team members to coordinate and witness the tests shall not be included for the first witness test. If the first mock-up test fails, for any reason, the air handling unit manufacturer shall bear the additional costs of all additional mock-up tests for the Project Team's travel expenses.
  - Each individual fan assembly for the mock-up air handling unit only, shall be equipped with a Piezometer ring airflow measuring system which can be used to indicate airflow in cubic feet per minute (CFM). The flow measuring system shall consist of a flow measuring station with four static pressure taps and four total pressure tubes located at the throat of the each fan inlet cone. The flow measuring station shall not obstruct the inlet of the fan and shall have no effect on fan performance (flow or static) or sound power levels. Pneumatic tubing shall be securely routed from the high and low pressure static pressure taps on each flow measuring station to barbed fittings on the exterior of the casing for use by the Division 25 BMCS Subcontractor and the testing laboratory.
  - Acoustical test measurements shall be taken for all unit sections, both individually and during simultaneous design condition operation. Readings shall be taken for all sections at the minimum and maximum operating conditions of the outside air economizer section. Acoustical measurements shall be made in the mock-up tenant test office at various locations selected by the Project Acoustical Consultant and Engineer with, a 1/3 octave band or octave band analyzer, and with the unit operating at the following percent of design air flow capacity for all fans:

Test No.	Top Fans * (Heating Section)	Middle Fans * (Cooling Section)	Bottom Fans (UFAD Section)
1	100%	Off	Off
2	Off	100%	Off
3	Off	Off	100%
4	25%	100%	100%
5	25%	85%	100%
6	50%	70%	100%
7	50%	70%	85%
8	25%	70%	70%
9	100%	70%	100%
10	75%	70%	100%

11	50%	50%	70%
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(\*) Zone dampers and transfer damper shall be proportionally adjusted to achieve the fan air flow required for each set of tests. Damper position and zone air flow shall be recorded for each test.

6. Thermal testing shall be performed using chilled water at the design temperatures and flow rates specified. If laboratory chilled water is not available at the selected laboratory and at the above specified conditions, the air handling unit manufacturer shall include mock-up costs for equipment needed for thermal testing include chiller, pump, piping, valves, flow measuring devices, and temperature measuring devices. Supply thermocouples and instrumentation for reading and recording various airflows and temperatures throughout the test unit. The following areas shall be monitored for temperature:
  - a. Return air temperature entering each section of the unit.
  - b. Outside air temperature and flow rate entering the return air/outside air mixing plenum section of the unit.
  - c. Chilled water cooling coil leaving air temperature. Refer to "Chilled Water Cooling Coil" requirements specified hereinafter for allowable variation.
  - d. Discharge plenum temperature downstream of the underfloor fan section. The blending section supplying transfer air to the lower fan plenum shall be adjusted and calibrated during testing to ensure even blending of transfer air and return air at various load conditions in the lower section.
  - e. Air temperature in the underfloor plenum at the unit discharge. Temperature variation shall not exceed 0.5°F over the full dimension of the discharge opening of the unit into the raised floor plenum, with a fan operating range of one hundred (100%) percent to fifty (50%) percent of fan design air flow and with transfer damper modulation from one hundred (100%) percent to ten (20%) percent design air flow at each fan setting. Fan air flow shall be adjusted in 10% increments, and transfer damper shall be adjusted in 20% increments, resulting is thirty (30) sets of readings. A thermocouple array sensing temperature and air velocity, with associated instrumentation shall be installed in the unit discharge opening for reading and recording various airflows and temperatures. The array shall have no less than one thermocouple per 1.0 square foot of discharge opening and sensors shall be evenly placed in the opening.
7. Each perimeter zone multi-zone damper shall be cycled through the specified control sequence to verify full cooling CFM, minimum CFM set point, heating CFM, zone damper mixing, and hot water heating coil modulation. Tests shall be performed with all zones in full cooling, all zones in full heating, all zones at minimum zone CFM, and with a mix of zones in full cooling and heating. Laboratory shall provide thermocouples, instrumentation, and perimeter zone air flow monitoring stations for reading and recording various airflows and temperatures throughout the test unit. The following areas shall be monitored for temperatures and air flows:
  - a. Return air temperature entering the top section of the unit.
  - b. Chilled water cooling coil leaving air temperature. Refer to "Chilled Water Cooling Coil" requirements specified hereinafter for allowable variation.
  - c. Zone temperature in each zone 15'-0" downstream of multi-zone dampers.
  - d. Zone air flow at set points listed above.
8. Outside air and return air dampers on the inlet to the cooling section of the unit shall be cycled from minimum outside air flow and maximum return air flow to full outside air economizer air flow as scheduled. Outside air ductwork shall be extended from the mock-up as shown and for a distance as necessary to provide accurate air flow measuring station performance. The outside air duct lab inlet shall be provided with an air flow restrictive mesh or cover (not a manual damper) as required to simulate inlet louver, plenum, and ductwork static pressure losses of 0.50 inches of static pressure external to the mechanical room, when at the maximum scheduled outside air flow.
9. The mock-up test air handling unit shall be fully equipped with the Division 25 specified control components as part of the manufacturer's mock-up. Air handling unit manufacturer shall include all cost to provide and install all control components, programming, and graphics as necessary for the testing. Air handling unit manufacturer shall include BMCS requirements and coordinate delivery and installation of all control components, such as, chilled water control valve, heating hot water zone control valves, temperature sensors, zone air flow sensors, damper actuators, differential pressure sensors, from his selected BMCS vendor. The mock-up shall include programming and graphics for the specified control sequence. Refer to Division 25 for BMCS requirements.

10. If air handling modifications are required and implemented during testing to meet performance requirements, or for any reason, the testing process shall be repeated to provide a complete set of test data based on the final unit configuration.

D. Unit Casings:

1. Each unit shall have an airtight sectionalized casing constructed of "lock forming" quality bright spangled galvanized steel, phosphatized steel or bonderized steel. Galvanized metal will not require painting. Phosphatized or bonderized metal shall be finished with rust-inhibiting polyester resin paint designed for long term corrosion protection. Air handling unit casings shall be minimum 3" thick double wall construction with a 16 gauge galvanized outer sheet and 22 gauge galvanized inner perforated sheet with twenty-five (25%) percent openings in all casing sections except the coil section. The casing section interior panels in the cooling coil section shall be 20 gauge stainless steel. All casing sections shall be fabricated with thermal breaks and gasketed screws to prevent condensation formation on the outside of the air handling unit during normal operation. The air handling unit casing shall have a "no-through-metal" design.
2. Unit perimeter base shall be completely welded and fabricated using heavy gauge structural steel tubing. Bolted bases are not acceptable. Cross supports shall be welded to perimeter base steel tubing and located on maximum 24" centers to provide support for internal components. Base rails shall include lifting lugs welded or bolted to perimeter base at the corner of the unit, or each section if de-mounted. Internal walk-on floor shall be 16 gauge galvanized steel. The minimum 3" double wall floor shall be gasketed for thermal break and sealed for airtight and watertight construction. The outer floor skin of the unit shall be made from minimum 20 gauge galvanized steel and sealed and secured to the underside of the unit. Single wall floors with glued and pinned fiberglass insulation and no sub floor are not acceptable. Base frame shall be attached to the unit at the factory.
3. The construction of the air handling unit shall consist of a galvanized steel frame with formed 16 gauge galvanized steel exterior casing panels. All casing panels shall be completely removable from the unit exterior without affecting the unit's structural integrity.
4. Entire unit to be insulated with 3.0 lb. density fiberglass insulation the full thickness of the casing panels. The insulation shall have an effective thermal conductivity (C) of 0.24 (BTU in./sq.ft. F°). All insulation shall be encapsulated within the panel. Foam insulated casing panels or a combination of foam insulated and fiberglass insulated panels are not acceptable.
5. The unit shall be equipped with a solid double wall insulated, hinged access doors as shown on the plans. The door frame shall have built in thermal break barrier and dual full perimeter gasket. The door hinge assembly shall be die cast zinc with stainless steel pivot mechanism, completely adjustable or continuous stainless steel piano hinges. There shall be a minimum of two heavy duty handles per door. Provide access door handles which are operable from both sides and lockable. Access doors on the air handling unit shall be a minimum 24" wide by height of unit section unless the unit size dictates a smaller door. Access doors shall be the same thickness as the unit casing. The access door shall be hinged and allow for access to the fan, coil, filter and fan discharge section. The access doors shall be located on the coil piping access side of the unit or as shown on the drawings. Doors shall be double wall construction with 16 gauge galvanized steel on the outer panel and 20 gauge galvanized steel on the inner panel with fiber glass as specified for the casing. All unit nameplates shall be mounted on the middle fan compartment access door.
6. The air handling unit casing shall not exceed the maximum dimensions shown on the Drawings. No exceptions will be allowed.

E. Floor Stands:

1. Each air handling unit shall be provided with a factory-built floor stand with length and width sized to accommodate each unit provided. Floor stands shall be fabricated of heavy gauge welded structural 2" (minimum) tube steel and gusset plates. Floor stands may be shipped loose for field installation. If shipped loose, air handling unit manufacturer shall coordinate floor stand installation at job site with Division 23 Subcontractor so unit is completely assembled when hoisted into the building. Air handling unit manufacturer shall provide gasket material to be installed between floor stand and air handling unit to provide an air tight seal with the bottom of the unit.
2. Floor stand height shall account for thickness of floor vibration isolation pads and the Project raised floor height, and shall be determined by the air handling unit manufacturer so that top edge of floor stand is approximately 1/2" above the finished raised floor. The bottom edge of the horizontal floor stand structure shall be aligned with the bottom of the Project raised floor panels. Refer to Section 23 05 48 titled "Vibration Isolation" for isolation pad details. Refer to Drawings for floor stand details.
3. Floor stand length and width shall be provided with a shroud sized 3" wider than the unit dimensions on all sides to create a flange around the base of the unit. The flange shall be used to form a seal between

the unit base and the raised floor and mechanical room walls. Air handling unit manufacturer shall provide gasket material to be field installed between flange edge of the floor stand and the mechanical room walls and floor tile. Refer to drawings for details.

4. Air handling unit manufacturer shall provide at one (1) set of detachable swivel plate heavy duty casters and jack assemblies, designed to temporarily attach to the floor stand / unit base and allow the Division 23 Subcontractor to raise / lower the unit and set the unit in place. Wheel assemblies shall be designed for the shipping weight of the heaviest units. Wheel assemblies shall not obstruct the placement of the units. Wheel assemblies shall be removed for reuse.
  5. Floor stand drawings and details, and detachable swivel plate heavy duty casters and jack assemblies shall be submitted with the air handling unit submittals.
- F. Chilled Water Cooling Coil:
1. Coil frame shall completely enclose all connections, coil headers and return bends. Coil frames shall not be used as structural members of the coil section. The entire channel coil frame support shall be stainless steel. The coil section shall be constructed in such a manner that the coils can be removed without affecting the structural integrity of the casing. Coil piping internal to the unit may be ASTM B-88-72H23.1-59 Type "L" or Type "K" hand drawn copper pipe.
  2. All internal coil piping not installed over the drain pan shall be insulated with minimum 1/2" thick Armstrong Type AP or Rubatex R-180-FS 25/50 flexible elastomeric pipe insulation with foil facing. Insulation shall have a fire and smoke hazard rating as tested by ASTM E 84 and UL-723 not exceeding: Frame spread 25 and smoke developed 50. All insulation shall be foil faced or coated with UVc resistant coatings.
  3. Internal copper piping shall be extended through the side of the unit near the top of the unit unless otherwise indicated on the drawings. Piping shall be terminated outside the unit with a threaded, flanged or grooved connection and an air seal device. Provide labels for the coil "INLET" and "OUTLET" connections on the exterior of the unit. Before each air handling unit is shipped from the factory all factory piping shall be hydrostatically or air pressure leak tested. The test pressure shall be as specified hereinafter. Field installed chilled water shall be installed so as to not block or restrict maintenance access to the unit. Piping escutcheon plates shall be installed on the inside of the unit and on the exterior at all coil piping penetrations. The internal piping shall be sized to limit the velocity to no more than 5 fps at maximum design flow.
  4. Coils shall be tested by air pressure under water at the coil manufacturer's factory. Coils shall be tested at the specified pressure classification herein and as indicated on the riser diagrams, but the test pressure shall in no case be less than 250 psig or more than 500 psig. The factory air pressure test shall be continuously maintained for a minimum of two (2) hours after which each piping joint, connection, etc., shall be examined to verify there is no evidence of weeping or leakage. The air handling unit manufacturer shall maintain a pressure test log listing the air handling unit tested, date of test, pressure at start of test, pressure at the end of the test, duration time for the test and the name of the test supervisor for each test. If liquid is used for the pressure testing, it shall be completely drained and blown out of all coils and the internal piping system prior to shipment. The factory test log shall be submitted to the Engineer and Owner for record prior to installation of the air handling units at the Project Site.
  5. The automatic control valve will be furnished by Division 25 to the Division 23 Subcontractor for field installation in the piping outside of the air handling unit. The stop valves for the unit shall be field installed by the Division 23 subcontractor outside the unit. All piping and fittings shall be suitable for the working pressure shown on the Contract Documents.
  6. Coils shall be constructed with copper tubes and aluminum plate fins. Supply and return connections shall be on the same end of the coil. Fins shall be bonded to the tubes by means of mechanical expansion of the tubes.
  7. Coils shall have stainless steel casings all around no lighter than 16 gauge and shall have intermediate stainless steel or aluminum stiffeners if over 5'-0" in length. All intermediate and end tube sheets shall be stainless steel. The coil sections shall be supported above the main drain pan with stainless steel channels.
  8. Tubes shall be 5/8" O.D. shall be spaced approximately 1-1/2" apart and shall have a minimum wall thickness as specified herein. Configured plate fins shall have a minimum thickness of 0.0075".
  9. Coils shall have copper pipe or red brass headers as required for working pressure specified and have a valved manual air vent connections except on those return connections where the coil header piping is designed to be self-venting. Coils shall be furnished with a valved manual drain connection located over the unit drain pan at an accessible location. Coil construction shall be:
    - a. 150 psig working pressure:
      - 1) 5/8 x 0.020" minimum wall thickness copper tubes

- 2) Minimum 0.065" wall thickness copper headers
  - 3) Copper end caps
  - 4) Vent and drain located as required to facilitate service
  - 5) Coil tubes extended into header
  - 6) Test pressure – 250 psig
  - b. 300 psig working pressure:
    - 1) Heavy duty header construction required
    - 2) 5/8 x 0.020" minimum wall thickness copper tubes
    - 3) Vent and drain located on face (vent and drain not allowed in end cap)
    - 4) 5/8 x 0.049" wall thickness copper adapter tubes between coil tube and header
    - 5) Heavy duty end caps
    - 6) Type "K" copper headers (.095 wall)
    - 7) Test pressure – 350 psig
  10. Chilled water cooling coil shall be not less than six (6) rows deep with not more than 148 fins per foot, but shall be more rows if required to meet or exceed the specified design load for the sensible heat removal requirements as well as the total heat removable. Chilled water cooling coil ratings shall be in accordance with AHRI Standard 410 certified data except capacity shall meet design capacity without any design tolerance and the temperature variation tested as specified herein-after. Cooling coil capacity shall be in accordance with chilled water flow and temperatures scheduled on the Contract Documents. Water velocity in the tubes shall not exceed five (5) feet per second and the water pressure drop through the coil shall not exceed 25 feet w.g. at design conditions. Water velocity in the tubes shall not be laminar flow at thirty-six (36%) percent of the design water quantity scheduled on the Contract Documents. Coils shall be equipped with bronze spring type turbulators, if required, to meet the specified capacity. Cooling coil face velocities shall be limited to a maximum face velocity of 500 fpm unless otherwise indicated in the schedules on the Contract Documents.
  11. The cooling coil shall be tested under laboratory conditions at thirty-five (35%) percent, fifty (50%) percent, seventy-five (75%) percent and one hundred (100%) percent load conditions of water flow and air flow, unless previous test data has been submitted and accepted by the Engineer. The test shall be run in accordance with AHRI test procedures at the ETL laboratory facilities or approved equal. The test shall be with the design capacities listed in the schedules on the Contract Documents. The test at one hundred (100%) percent capacity shall be with the design air flow and water flow and the total heat transfer and leaving air temperature shall be determined. Tests at other load points shall be at the test CFM and design leaving air temperature and the water quantity required shall be determined. Capacities shall be corrected for altitude effects when applicable.
  12. The total variation of the supply air temperature in a plane perpendicular to the air flow direction at the outlet of the discharge plenum shall not exceed 1.5°F at one hundred (100%) percent design air flow.
  13. Coil calculations and selection data certified to AHRI Standard 410 shall be submitted with Shop Drawings.
- G. Hot Water Duct Heating Coils:
1. Zone hot water heating coils shall be furnished and installed on the discharge of the neutral zone dampers as indicated on the drawings and shall have the capacities listed in the "Schedule of Capacities" on the Contract Documents.
  2. Hot water heating coils shall be constructed and rated the same as specified for chilled water cooling coils specified herein.
  3. Each zone hot water heating coil shall be field installed and pipe to a common supply and return headers. Refer to Contract Document for piping details. Zone hot water coils shall be packed and shipped with the air handling units served.
- H. Electrical:
1. The Division 23 Subcontractor shall coordinate the installation of variable speed drives with the air handling unit manufacturer and Division 26.
    - a. Each air handling unit shall require three (3) VFDs, one (1) for each compartment fan array.
    - b. Unit mounted VSDs shall be supplied by the air handling unit manufacturer and shall be factory installed and wired to the motors. Each fan array fan motor shall be individually wired to a control panel containing the individual fan motor overloads and disconnect switches to be wired to a single VSD. Each fan array VSD shall be sized for the total connected HP for all fan motors contained in the fan array served. Wire sizing shall be determined, and installed, in accordance with applicable NEC standards.
    - c. Field installed VSDs shall be coordinated with the Division 26 Electrical Subcontractor. The Division 26 Subcontractor shall provide all wiring from the Division 23 provided VSDs to the unit

mounted motor control panel for field mounted VSDs. The air handling unit power wiring, except the motor wiring, (460 volt and 120 volt) and the control wiring shall terminate in a NEMA 1 enclosure terminal panels with tagged terminal strips. See Division 26 specifications for additional installation requirements.

- d. Refer to drawings to determine if VSDs are unit mounted or wall mounted.
  2. The air handling unit manufacturer and the Division 23 Subcontractor shall coordinate with the Division 25 Subcontractor the installation of holes for grommets, conduits, raceways, etc., through the unit casings, as necessary for the installation of the Division 25 control components. All holes shall be cut by the air handling unit manufacturer such that the thermal and sound performance of the unit are not compromised. All Division 25 control wiring raceways shall be installed by the Division 25 Subcontractor.
  3. The entire air handling unit as assembled at the factory shall be UL or ETL labeled.
- I. Drain Pan:
1. The main drain pan shall extend under each complete coil section and shall be rigid and watertight with a 1-1/4" stainless steel pipe drain connection on the coil piping connection side. Intermediate drain pans shall extend at least 8" beyond the leaving side of the chilled water coil. The main drain pan shall extend the full distance from the coil support to the next component wall. If the distance from the coil support to the next component wall exceeds 52" the main drain pan shall extend at least 12" beyond the leaving side of the coil. The main drain pan and all intermediate drain pans shall be of dual slope design within the unit as required to allow each drain pan to drain completely dry upon unit shutdown when the air handling unit is installed on a level surface.
  2. The intermediate drain pans shall have 1/4" thick foil faced Armstrong AP Armaflex elastomeric insulation installed on the bottom of the pan. The drain pans shall be minimum 16 gauge 304 stainless steel construction with continuously welded corners and joints. The exterior of the main drain pan shall be covered with minimum 1.5 lb. density fiberglass or closed cell foamed-in-place insulation. The main drain pan insulation shall be covered with 20 gauge galvanized metal. Stainless steel drain pans installed on top of an insulated bottom casing panel do not require insulation. Minimum insulation thickness at main drain pans shall achieve the same R-value as unit casing.
  3. The main drain pan and all intermediate drain pans shall be graded within the unit as required to allow the drain pan to drain completely dry upon unit shutdown. Intermediate drain pan drain piping shall be anchored and terminate three (3) inches above the lower main drain pan to allow for cleaning. If the air handling unit as installed in the field is not graded to permit complete condensate drainage, the entire unit must be shimmed by the Mechanical Subcontractor. The Mechanical Subcontractor shall shim the air handling unit base frame with Shear-flex pads as required to level the unit or to provide a slope of the drain pan toward the drain point of 1/16" per 1'-0" if required by the unit design to cause the drain pan to drain completely dry on unit shutdown.
- J. Fan and Drives:
1. Each fan system shall consist of multiple, direct driven, Arrangement 4 plenum fans constructed per AMCA requirements for the duty specified, (Class I, II, or III). All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed. Each fan system 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.
  2. Fan assemblies shall consist of either unhooded plenum fans mounted on structural steel frames or fan arrays as specified below:
    - a. Centrifugal Unhooded Plenum Fans:
      - 1) Fans shall be centrifugal unhooded plenum fans with single thickness airfoil backward curved aluminum wheels with aluminum inlet flow ring. The fan motor shall be located on a factory structural frame. The fan motors shall be standard pedestal mounted type TEFC or TEAO T-frame motors selected at the specified operating voltage, RPM, and efficiency as specified in Section 23 05 13 titled "Motor Requirements for HVAC Equipment". Fans shall be licensed to bear the AMCA seal. Fans, motors, and vibration isolation shall be factory assembled within the fan section casings.
      - 2) Fan and motor assembly using internal isolation shall be internally isolated from the air handling unit casing with spring isolators. See Section 23 05 48 titled "Vibration Isolation" for isolator requirements. Internal vibration isolators shall be sized for 2" static deflection and shall be a non-housed spring isolator unless seismic requirements are specified. Fans shall be equipped with thrust resistors to limit horizontal motion to 1/4" upon fan startup and shutdown.
    - b. Fan Arrays:



- 1) Fan arrays shall have standard pedestal mounted type TEFC or TEAO T-frame motors selected at the specified operating voltage, RPM, and efficiency as specified in Section 23 05 13 titled "Motor Requirements for HVAC Equipment". Fans shall be licensed to bear the AMCA seal. Fans, motors, and acoustic silencer modules shall be factory assembled within the fan section casings.
  - 2) The fan array shall be provided with integral acoustical silencers that reduce the bare fan discharge sound power levels as required to achieve the Project required fan intake and discharge sound power levels. The silencers shall not increase the fan total static pressure, nor shall it increase the airway tunnel length of the air handling unit when compared to the same multiple fan array style unit without the integral silencers.
  - 3) Each fan/motor assembly shall be dynamically balanced to meet AMCA Standard 204-96, category BV-5, to meet or exceed Grade 1.0 residual unbalance. Factory fan balancing data shall be so certified in writing by the manufacturer to the Engineer. Should the air handling unit develop vibration and/or balance problems after installation and prior to the expiration of the guarantee period, in the sole opinion of the Engineer or Owner, the unit manufacturer or an independent testing agency shall perform a field balancing test using a portable IRD (or approved equal) to verify compliance with the hereinbefore specified balancing requirements. See Section 23 05 93 titled "Testing, Balancing and Adjusting". The air handling unit manufacturer shall replace all components that cannot meet these balance and vibration requirements without additional cost to the Owner.
  3. All metal parts of the fan framework shall be galvanized or cleaned and painted with UVc resistant enamel primer and finish coat. All metal parts of the fan framework shall be galvanized or cleaned and painted with UVc resistant enamel primer and finish coat. In order to establish fan test curves, each type of fan shall be tested in an AMCA certified laboratory in accordance with referenced AMCA Standards. Certified unit test curves shall be submitted by the unit manufacturer for review by the Engineer. Acoustical testing shall be in accordance with AMCA 300. Acoustical test data for the fan shall be submitted to the Engineer for review.
  4. Motors for direct drive multiple fan arrays shall be Premium™ efficiency, inverter duty rated, TEFC or TEAO motors and shall be factory mounted directly on the fan framework, internal to the unit. All motors shall be one (1) speed, one (1) winding, 4-pole (1,800 RPM Synchronous Speed), unless indicated otherwise in the schedules on the Contract Documents. The fans/motors shall be selected to operate at a maximum of 3,600 rpm and 120 Hz. Refer to Section 23 05 13 titled "Motor Requirements for HVAC Equipment" for additional requirements.
  5. Air handling unit manufacturer shall provide one (1) spare motor and fan assembly or FWT fan "cartridge" of each size supplied for Owner stock to be used for emergency replacement. Air handling unit manufacturer shall provide a five (5) year, parts and labor, fan and motor extended warranty, for repair or replacement at no expense to the Owner. Warranty shall include freight charges (including expedited shipping) and labor (including overtime) for air handling unit disassembly and re-assembly.
  6. Variable Speed Fan Drive Controllers: Variable speed drives shall be provided for all fans as required in the schedules on the Contract Documents and Section 23 05 13. Refer to Section 23 05 13 titled "Motor Requirements for HVAC Equipment".
- K. Control Dampers:
1. Cold deck and neutral deck multi-zone dampers and cooling transfer air dampers shall be arranged as shown on Drawings. Air handling unit manufacture shall confirm sizing of all dampers based on maximum air flow listed in the schedules and as shown on the contract drawings.
  2. Transfer air dampers shall be constructed with damper blades spanning the short dimension of the damper. Dampers constructed using one or two blades running the length of the damper will not be acceptable.
  3. Dampers shall meet the following requirements:
    - a. Modulating dampers shall be horizontal opposed blade type.
    - b. Maximum leakage rate shall not exceed 10 cfm per square foot at 4" W.C. differential pressure.
    - c. Frames shall be 16 gauge welded galvanized steel channel or 0.125" extended aluminum channel. Corner bracing of frames of height or width larger than 3.25 ft. Channel dimensions shall be a minimum of 5" by 1".
    - d. Blades construction shall be:
      - 1) 21 gauge galvanized steel, with four (4) breaks or,
      - 2) 22 gauge double galvanized sheets, with four (4) breaks in each sheet. Sheets shall be spot welded together or,
      - 3) 14 gauge airfoil shaped double skin galvanized steel or,
      - 4) 16 gauge airfoil shaped double skin extruded aluminum.

- 5) 8" maximum width for galvanized steel.
  - 6) 6" maximum width for aluminum.
  - 7) 60" maximum blade length.
  - e. Replaceable edge seals made of one of the following:
    - 1) Neoprene.
    - 2) Vinyl.
    - 3) Polyurethane.
    - 4) Silicone rubber.
    - 5) Synthetic elastomer.
  - f. Side seals shall be one of the following:
    - 1) Continuous spring stainless steel strip.
    - 2) Synthetic elastomer.
    - 3) Flexible aluminum compression type.
  - g. Axles materials construction shall be:
    - 1) 0.5" square zinc plated steel or,
    - 2) 0.5" hexagonal zinc plated steel.
  - h. Bearings shall be one of the following:
    - 1) Oil impregnated sintered bronze,
    - 2) Stainless steel, or
    - 3) Polycarbonite.
  - i. Extend axle beyond the frame as necessary to match up with actuator.
4. Actuators shall be provided for each damper section by the Division 25 BMCS Subcontractor. The use of jackshafts is not allowed.
- L. Air Filters: An integral casing section for filter media and galvanized or painted frames suitable to accommodate the specified air filters at maximum filter face velocity of 500 fpm shall be furnished by the air handling unit manufacturer. Filter media for the air handling units shall be as specified in Section 23 40 00 titled "Air Filtering" and as noted in the schedules on the Contract Documents.
- M. A representative from the Owner and/or Engineer may witness factory testing and/or construction of the equipment for this Project at the time of manufacture. The HVAC Subcontractor shall notify the Owner and Engineer in writing at three (3) weeks prior to the day of factory testing or first air handling unit production date. The HVAC Subcontractor shall have a representative attend the factory testing and/or manufacturing visit with the Owner and/or Engineer.

### **PART 3 EXECUTION**

#### **3.1 INSTALLATION**

- A. All custom factory-built tri-path multi-zone air handling units shall be completely wrapped with reinforced Griff-Shrink® 3-ply Clear heat-shrinkable internally reinforced polyethylene laminates, with grid of high strength cord providing a uniform loading resistance in all directions, contains at least 50 strands per square foot, and UV stabilized outside layer film, prior to shipment.
- B. All custom factory-built tri-path multi-zone air handling units shall be installed in accordance with the latest industry standards, per the manufacturer's recommendations and as indicated on the Drawings.
- C. All custom factory-built tri-path multi-zone air handling units shall be installed using metal shims under the floor stands, if required, leveling the units to allow for proper cooling coil condensate drainage through the traps. Shims, if required, shall be installed in a manner as to not interfere with seismic restraints.
- D. Install each unit on isolation as specified in Section 23 05 48 titled "Vibration Isolation".

#### **3.2 FACTORY TESTING**

- A. All factory-built air handling units shall be tested in accordance with the latest applicable industry standards as specified herein and be UL or ETL listed.

- B. The Owner and/or Engineer may observe the air handling units for this Project under manufacture at the factory prior to shipment, if he so desires. The Mechanical Subcontractor shall notify the Owner and Engineer in writing at three (3) weeks prior to the first air handling unit production date.

**3.3 FIELD TESTING**

- A. Prior to execution of field testing, submit test procedures, recording forms, and test equipment cut sheets to Engineer for review. Refer to Section 23 00 20 titled "Scope of Work" for "Scheduling Procedures".
- B. Refer to Section 23 05 93 for additional testing requirements for custom factory-built tri-path multi-zone air handling units.

**END OF SECTION 23 73 63**