PART I - GENERAL

1.01 WORK INCLUDED

A. Extent of air handling unit work is indicated by Drawings and schedules and by requirements of this section. Each unit shall include, fan system, heating coil, cooling and dehumidifying coil (if required), heat recovery coil (if required), drip pan, thermal insulation, and any other equipment specified or scheduled, all manufactured by one manufacturer.

B. Types of custom and packaged air handling units required for project include the following:

1. Outdoor Air Handling Units, (or indoor)

C. Flame-Smoke Ratings: Except as otherwise indicated, provide air handling unit thermal insulation with flame-spread index of 25 or less, fuel-contributed index of 50 or less, and smoke-developed index of 50 or less.

D. AMCA Standards: Comply with Air Movement and Control Association (AMCA) Standards as applicable to testing and rating fans.

E. SMACNA Compliance: Comply with Sheet Metal and Air Conditioning Contractors National Association (SMACNA) ductwork construction standards as applicable to air handling units.

F. ARI Certification: Coils shall comply with ARI Standard 410.

G. UL Compliance: Provide electric components for air handling units which have been listed and labeled by Underwriters Laboratories or by a testing organization of equal standing.

H. UL or ETL label required.

1.02 SUBMITTALS

A. Product Data: Submit manufacturer's specifications for air handling units showing dimensions, weights, capacities, ratings, certified fan sound, airflow, and electrical performance with operating point clearly indicated, motor electrical characteristics, gauges and finishes of materials, and installation instructions.

B. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, and spare parts lists. Include this data in maintenance manuals only.
1.03 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver air handling units with factory-installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers.

B. Handle air handling units carefully to avoid damage to components, enclosures, and finish. Do not install damaged components; replace and return components to air handling unit manufacturer.

C. UL Compliance: Provide electric components for air handling units which have been listed and labeled by Underwriters Laboratories or ETL.

PART II - MATERIALS

2.01 AIR HANDLING UNITS

A. Where shown on plans furnish and install Governair as scheduled, Alliance, Climate Craft or equal air handlers may be substituted if construction, sizes, sound levels, and performance are equal. The fans, coils and dampers shall be manufactured by the air handler manufacturer.

B. Provide factory-built and factory-tested air handling units as indicated, of sizes and capacities as scheduled, and as specified herein.

C. General: Factory fabricated air handling unit shall be constructed of solid steel, formed outer panels secured to a welded tubular steel frame. Outer panels shall be removable without affecting the structural integrity of the unit. All units shall come complete with a welded structural steel base around the entire perimeter. All units shall be suitable for Class II design conditions.

1. Multiple sectioned units shall be shipped demounted into modular sections to be reassembled in the field.

2. All units shall be ETL or UL listed.

D. Unit Base/Framework: Unit base frame shall be 14 gauge rectangular structural tubing and fitted with a 4-inch C-Channel cross support members. The base shall include a “Double Bottom” 4-inch thick insulated floor. Base rails shall be fitted with lifting lugs at the corner of the unit or section (if demounted). The unit base floor shall be heavy duty walk-on floor made from 20 gauge G-90 galvanized steel outer and 16 gauge G-90 galvanized steel inner.

1. Unit frame shall be from 14 gauge carbon tubular steel, mig welded to form a unitized assembly for support of all internal components. Base and unit frame shall be painted with an industrial direct to metal (DTM) finish with built-in rust inhibitors.
E. Exterior Casing: The air handling unit casing shall be of the “no-through-metal” design. The casing structure shall incorporate insulating thermal breaks as required so that, when fully assembled, there exists no path of continuous unbroken metal to metal conduction from inner to outer surfaces. Provide required structural frame and casing to withstand 8” static pressure with less than 1% leakage. Panels shall be gasketed and secured to the tubular steel frame with ¼” hex head, zinc plate fasteners and neoprene washers. Outer panels are to be removable without affecting the structural integrity of the unit. All exterior panels shall be constructed from 16 gauge G-90 galvanized steel. The exterior panels shall be coated with a painting system designed for long term corrosion resistance. The paint shall meet or exceed the following criteria:

1. (ASTM B-117) salt spray Passes 750 hr. resistance 5% at 95 degrees F.
2. (ASTM D-2247) humidity resistance Passes 1,000 hr. 100% salt for at 95 degrees F.

F. Unit Casing Insulation: Insulation shall not be disturbed if panels are removed. Insulation shall be secured to the entire panel with mechanical fasteners and adhesive over the entire panel surface. Entire unit to be insulated with 2” thick insulation. The fiberglass insulation shall have an effective thermal conductivity \( c \) of .24 (BTU in./sq.ft./F degrees) and a noise reduction coefficient (NRC) of 0.70/1” thick based on a type of “A” mounting. The coefficients shall meet or exceed a 3.0 P.C.F density material rating. Insulation shall meet the erosion requirements of UL 181 facing the airstream and fire hazard classification of 25/50 (per ASTM-84 and UL 723).

G. Liners: The units shall be double wall construction with a 16 gauge solid galvanized liner in all sections.

H. Access Doors: The unit shall be equipped with a double wall insulated, hinged access doors. The access door shall include an extruded aluminum doorframe. The doorframe shall incorporate a built in thermal break barrier along with a gasket around the entire perimeter of the door. The door shall be hinged using a minimum of two heavy-duty butt hinges. There shall be two heavy duty handles per door. Fan access doors shall be provided with a kill switch to de-energize fan prior to door opening. Provide dual pane window in every access door. All access shall be from one side of unit.

I. Condensate Pan: Condensate drain pan shall be 16 gauge, 304 stainless steel. All pans are to be insulated “Double Bottom” construction with welded corners. Drain pans are to be double sloped for complete drainage with no standing water in the unit. Compliance with the current version of ASHRAE IAQ Standard is required. Drain connections shall be standard 1-1/4” MPT connections. Drain pans shall be provided under all cooling and heat recovery coils.
J. Fanwall:

1. The supply and return fans shall be a fan array's that consists of multiple, direct driven, arrangement 4 plenum fans spaced in the air-way tunnel cross section to provide a uniform air flow and velocity profile across the entire air-way tunnel cross section and components contained therein. The fan array shall be constructed per AMCA requirements for the duty specified. All fans shall be selected to deliver design air flow at the specified operating TSP at the specified motor speed and as scheduled. 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 speed. Each fan/motor assembly shall be dynamically balanced to meet AMCA standard 204-96, category BV-2.5, Grade 1.0 with peak to peak deflection equal to or less than 0.8 mil at the design operating speed for the fan/motor cartridge. Each fan array shall include a fan blank off plate. In the event of a fan failure, the blank off plate shall be positioned in the non-functioning fan cube and allow removal of the non-functioning fan. The remaining fans shall have the capacity to meet design CFM.

2. Fans: Fans shall be single width, single inlet, arrangement 4, direct driven plenum fans with class III construction and total fan wall capacities as indicated on schedules. Provide the same quantity and size of fans on the schedule. A lesser amount of fans is not acceptable.

3. Fan Cube Enclosure: Each plenum fan shall be encased in a Coplanner Sound Attenuator enclosure. Enclosure shall be constructed of aluminum or galvanized steel mesh or expanded metal and sized to have no measurable system effect on fan performance. Cube enclosure shall be reinforced as required to maintain stable structure during fan operation. Access shall be provided for periodic service. Enclosure shall be designed and constructed to allow for complete removal of fan and motor by removing 4 bolts.

4. Inlet Cones: Inlet cones shall be precision spun. Inlet cones shall be aerodynamically matched to wheel side plate to insure full loading of blades. Inlet cones shall be heavy gauge steel.

5. Motors: Motors shall be standard pedestal mounted type T-frame motors. Motors shall include isolated bearings or shaft grounding.

6. Balance requirements: Each fan/motor cartridge shall be dynamically balanced to meet AMCA standard 204-96, category BV-5, to meet or exceed Grade 2.5 residual unbalance.

7. Painting: All metal parts to be painted with prime coat after metal cleaning and surface preparation. In addition, apply second coat of paint to all exterior surfaces.

8. Volume Controls: Each fan shall be individually wired to a control panel containing a single VFD rated for the total connected HP of all fan motors contained in the fan wall array. Redundant VFDs are preferred required. Refer to Unit Schedule.

9. Control panel will have external visual indication of individual fan operation (i.e. green light for fan on).
10. Acoustical Requirements: Provide rectangular or coplanar silencers to reduce supply fan section discharge sound levels to: (Engineer to determine)

Maximum supply fan discharge sound levels

<table>
<thead>
<tr>
<th>Hertz</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
<th>LWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply dB</td>
<td>83</td>
<td>79</td>
<td>88</td>
<td>82</td>
<td>81</td>
<td>80</td>
<td>76</td>
<td>70</td>
<td>87</td>
</tr>
</tbody>
</table>

Maximum inlet sound levels for the return fans

<table>
<thead>
<tr>
<th>Hertz</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>8000</th>
<th>LWA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return dB</td>
<td>88</td>
<td>85</td>
<td>82</td>
<td>85</td>
<td>81</td>
<td>80</td>
<td>79</td>
<td>70</td>
<td>87</td>
</tr>
</tbody>
</table>

11. Each fan assembly shall be supplied with a complete flow measuring system, which indicated airflow in Cubic Feet per Minute. 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 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. A surface mounted indicator, located on the unit exterior, Dwyer Digihelic II pressure controller shall provide a digital CFM readout, and a 4-20 ma output control signal for use in the BAS as specified elsewhere.

12. The manufacturer shall provide a complete spare fan/motor assembly for emergency replacement, one for each type of assembly provided on the project. Fan/motor assembly shall be easily removable for quick change out. Provide a detailed procedure for replacement as part of submittal.

K. Motors: IEEE Inverter duty premium efficiency, T frame motors. The motors shall be tested to IEEE standard 112 test method B and NEMA MG 12.58.2 and 12.59 table 12-10.

1. TYPE: Open Drip (ODP)
2. RPM: 1750
3. EFF: PREM (99% or better)
4. MAKE: Baldor or equal

L. Shaft Grounding: The VFD powered small AC motors (less than 300 hp) shall have a single shaft grounding system to protect the bearings from capacitive discharge through the bearings. The shaft grounding system shall be AEGIS or equal. The shaft grounding system shall reduce the shaft to frame voltage below 3 volts (as measured with Fluke 97 oscilloscope), have low drag, be field installable with hand held tools, sealed to be resistant to weather and contaminants and require no periodic adjustments or maintenance for a normal running life of five years at speed up to 1800 rpm. The grounding brush element must be changeable without shutting the motor down or using special tools.

M. Coils: All coil assemblies shall be leak tested under water at 315 PSIG and performance is to be certified under ARI Standard 410. Coils exceeding the range of ARI standard rating conditions will be as noted on a coil computer printout.
1. General:
   a. Water coils shall be constructed of seamless copper tubing mechanically expanded into fin collars. Fins are die formed plate type. Headers are to be seamless copper with die formed tube holes.
   b. Connections shall be male pipe thread (MPT) Schedule 40 Red Brass. 1/8” Vents and drains shall be provided for complete coil drainage. Coils shall be suitable of 44” fin length with an additional support every 42” multiple thereafter. Coils shall have 5/8” tube, .008” aluminum fins, 16 gauge galvanized G-90 steel casing.

2. Coil Sections: Common or individual, insulated, galvanized steel casings for cooling coils. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils. Provide an independent rack for individual coil removal.

3. Coil Construction: Rigidly supported across full face, pitched to allow drainage.
   a. Fins: Aluminum or copper, mechanically bonded to tubes.
   b. Tubes: Seamless copper.
   c. Coil Casing: 16 gauge, 304 stainless steel.
   d. Headers for Water Coils: copper header with red brass threaded connections. Provide drain valves and air with threaded piping connections vent.

4. Water Coils: Drainable with threaded plugs, serpentine with return bends in smaller sizes and with return headers in larger sizes.


N. Dampers: Units shall be provided with parallel-blade airfoil type, low-leakage dampers at inlet and outlet connections to units. Dampers shall be built-in to unit’s inlet and outlet connection flanges. Dampers shall be Ruskin Model CD60, or equal, complete with SP100 switch package and actuator bracket. Bracket shall be mounted on access side of unit flange for placement of actuator by control system contractor.

O. Filters: Provide filters of the type indicated on the schedule. Factory fabricated filter sections shall be of the same construction and finish as the unit. Internal tie-offs shall be provided by the air unit manufacturer as required to prevent air bypass around the filters. Provide pre-filters and final filters of quantity and size as scheduled. Provide and install complete set of filters for each unit prior to unit airflow testing and another set prior to turning units over to owner.

P. Filter Gauge: Each filter bank shall be furnished with one (1) magnehelic filter gauge Dwyer Series 2000, dial type.
Q. Minimum Outside Air Damper/AIR MONITORING STATION: The air monitoring station shall combine the functions of control damper and flow measurement station in one assembly. Air straightener is 3000 series aluminum alloy honeycomb contained in 5” long 16 gage galvanized sleeve attached to monitoring blade frame. Fixed anodized aluminum monitoring blades are mounted in 10” 16 gage galvanized frame. Control dampers feature airfoil shaped 6063T5 heavy gage extruded aluminum blades rotating on 1/2” plated steel hex axles, mounted in a 4”x 1” 6063T5, .081” thickness extruded aluminum channel with mounting flanges on both sides of frame. Jamb seals are flexible metal compression type. Blade seals are Ruskiprene seals along control damper blade edges. Bearings are molded synthetic. Linkage is galvanized steel, concealed in frame. The air monitoring station shall be tested to AMCA Standard 611-95 and qualified to bear the AMCA Ratings Seal for Airflow Measurement performance. Ruskin AMS50 is the basis of design. Provide with transducer. Controller by controls contractor.

R. Electrical: All fan motors shall be factory wired to a motor control panel containing electrical overload protection. Motor overload panel shall have an alarm contact for fan/motor failure. Each supply and return fan array shall be supplied with VFD. Each unit’s VFD shall be field installed and wired. Motors shall be wired to a junction box located on exterior of fan section. Provide 120-volt duplex outlet inside of fan section and on exterior. Power to duplex outlet circuit shall be provide by electrical contractor.

1. Provide a 100-watt marine light, with guard, in each accessible section of unit. Each lights shall be controlled by its own switch located adjacent to access door. Provide junction boxes on each side of section splits.

2. All internal and external wiring and conduit for lights and outlets shall be per Division 16 specification requirements

2.02 FACTORY TESTING: Provide all air handling units with the following factory testing; All parties traveling to witness testing shall pay their own airfare and hotel expenses.

A. Cabinet Leak Test:

1. The cabinet shall be tested at the unit design operating static pressures. Cabinet leakage is not to exceed SMACNA leak class 9 (or 1% of the specified air flow) on the operating airside of the unit.

2. Leak testing shall be performed by measuring the airflow into (or out of) the air handling unit at the designed operating static pressures. A chambered nozzle with a variable supply system, as described in AMCA STANDARD 210-90, shall be used as the airflow measurement system.

3. All supply and return air openings shall be sealed along with the air seal at the supply fan in order to isolate the high and low side of the unit.

4. The airflow measurement system shall be ducted to the unit. The airflow pumped into (or out of) the unit is measured at the appropriate operating pressures.

5. The pressure drop across the chambered nozzle shall be measured with a manometer. The airflow shall then be calculated using the AMCA STANDARD 210 equation 9.3.2.8 FLOW RATE FOR CHAMBER NOZZLES.

6. The testing shall be performed at the manufacturer’s factory and witnessed by the project engineer and/or the University’s representative.
B. Cabinet Sound Calculations:

1. The equipment manufacturer shall furnish calculations showing the estimated sound power levels at the supply connection, inlet connection and unit casing radiation for each air handling unit. Calculations shall be based on fan sound power levels which were determined in accordance with AMCA Standard 300. Sound power levels shall be determined for each octave band and shall not exceed the specifications.

2. A detailed report, including all data, shall be presented to the University Representative prior to equipment shipment.

C. Cabinet Airflow Test:

1. Eight weeks prior to testing, the air handling unit manufacturer shall submit a detailed test plan including facility and test equipment qualifications for approval.

2. The equipment manufacturer shall furnish calculations showing the estimated airflow, fan total static pressure and unit external static pressure. Calculations shall be based on fan performance ratings which were determined in accordance with AMCA Standard 210.

3. On equipment less than 60,000 CFM, smaller than 65 feet long, 18 feet wide and 16 feet tall, and with a linear air flow path, the unit air flow performance shall be measured using the methods outlined in AMCA Standard 210. The testing shall be performed at the factory and may be witnessed by the University's representative. Notice shall be given of the proposed test data a minimum of two weeks in advance.

4. In the event that the required levels are not met, the manufacturer shall do whatever is necessary to achieve the above specified ratings at no additional cost to the University. A detailed report, including all data and test methods, shall be presented to the University prior to equipment shipment.

D. Fan Vibration Test:

1. Fan wheel and shaft assemblies shall be dynamically analyzed after the fan, motor, and drive assemblies have been installed in each unit. The fan shall be analyzed with an electronic balance analyzer with a tunable filter. Vibration measurements shall be taken on each bearing housing in the horizontal, vertical and axial positions with the filter tuned to the fan RPM. The vibration shall be less than or equal to 0.0554 in/sec velocity for a centrifugal fan. Testing is to be performed at the manufacturer's factory and witnessed by the University's representative.

PART III - EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which air handling units and are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
3.02 INSTALLATION OF AIR HANDLING UNITS

A. Install air handling units where indicated in accordance with equipment manufacturer's written instructions and with recognized industry practices to ensure that units comply with requirements and serve intended purposes.

B. Provide units with seismic hold down hardware.

C. Provide wiring and connections between junction boxes to complete internal lighting circuit.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of piping, fittings, and specialties. The following are specific connection requirements.

1. Install piping adjacent to machine to allow service and maintenance.

2. Connect piping to air-handling units with flexible connectors.

3. Connect condensate drain pans using 1-1/4-inch NPS (DN32), 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.

4. Hot and Chilled Water Piping: Conform to applicable requirements of Division 15 Section "Hydronic Systems and Equipment." Connect to supply and return coil tapings with shutoff or balancing valve and union or flange at each connection.

B. Duct installation and connection requirements are specified in other Division 15 Sections. The Drawings indicate the general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.

C. Electrical: Conform to applicable requirements of Division 16 Sections.

1. Connect fan motors to wiring systems and to ground. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

2. Temperature control wiring and interlock wiring is specified in Division 15 Section "Building Automation Control System (BACS)."

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

3.05 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
3.06 PRE-START UP

A. Manufacturer's Field Inspection: Engage a factory-authorized service representative to perform the following:

1. Inspect field assembly of components and installation of central-station air-handling units including piping, ductwork, and electrical connections.

2. Prepare a written report on findings and recommended corrective actions.

B. Final Checks before Startup: Installing contractor to perform the following before startup:

1. Verify that shipping, blocking, and bracing are removed.

2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete. Verify that proper thermal overload protection is installed in motors, starters, and disconnects.

3. Perform cleaning and adjusting specified in this Section.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.

5. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

6. Set zone dampers to fully open position for each zone.

7. Set face and bypass dampers to full face flow.

8. Set outside-air and return-air mixing dampers to minimum outside-air setting.


10. Install clean filters.

11. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

3.07 START-UP TESTING

A. Upon completion of installation of air handling units and upon completion of BACS point to point testing, factory authorized representative shall start up and operate equipment to demonstrate capability and compliance with requirements. Field correct malfunctioning units, then retest to demonstrate compliance. Installing contractor shall assist factory representative with start-up procedures.

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

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.

   a. Replace fan and motor pulleys as required to achieve design conditions.
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.

C. Refer to Division 15, Section 15990 for air-handling system testing, adjusting, and balancing.

D. Refer to Division 15, Section 15010 for ‘Project Completion Tests.’ The air-handling units will be tested in this regard for functional performance over a period of not less than 5 working days for operational delivery in compliance with the requirements of the contract documents. The functional performance testing will commence following the preliminary testing, adjusting and balancing of the HVAC systems served by the units in question and following the successful completion of the BACS point by point verification testing of those service areas (5E, S, 12E, S, etc.)

1. As part of the completion tests for the air-handling units the contractor will employ, at his expense, a vibration technology technician, having been in the vibration technology business in the state of California for at least five years. The technician will verify, following the successful functional performance tests in the field, that the AHU installation complies with all vibration requirements of the contract documents and will perform its intended operations in service to the University with minimum vibration impact to the building structure, occupants, and health care operations. It will be expected to do so only when operated in the normal parameters as defined by the manufacturer and the contract documents.

2. The inability to provide an approved vibration test will indicate a failure of the functional performance test (and therefore the ‘Project Completion Test’) for the specific air handler or air handlers involved. As a result all necessary corrections will be made by the contractor at his expense and the ‘Project Completion Test’ will be performed again until satisfactory results in all categories of the contract documents including vibration can be obtained.

END OF SECTION 15850