University of Kentucky
Purchasing Division

REQUEST FOR PROPOSAL

UK-1987-20, Project #2446.1
Facilities Renewal, Modernization and Deferred Maintenance – Chemistry/Physics 3rd Floor, BP2
Custom Air Handling Units (AHU) and Exhaust Fans
ADDENDUM # 1
8/23/2019

ATTENTION: This is not an order. Read all instructions, terms and conditions carefully.

IMPORTANT: BID AND ADDENDUM MUST BE RECEIVED BY 09-12-2019 @ 3:00 P.M. LEXINGTON, KY TIME

Bidder must acknowledge receipt of this and any addendum as stated in the Invitation for Bids.

1. An opportunity to visit the site has been scheduled for trade contractors on 8/27/2019 at 2:00 pm. Attendees will meet first in room 114A of the Chemistry -Physics Building then proceed to tour the site, located at 505 Rose Street, Lexington, KY 40508. Please allow extra time for travel as it is difficult to find a parking space. For Additional Parking Information please visit the following web site: https://www.uky.edu/transportation/park/visitorparking/visitoroptions

2. Please refer to and incorporate within the Offer the attached Addendum Number One dated August 20, 2019 from Omni Architecture.

3. Finally, an incorrect version(s) of the Specification Section 230200, HVAC Equipment was issued with the bid documents. Replace the section in its entirely with the attached Specification, SECTION 23 0200 – HVAC EQUIPMENT AND HYDRONIC SPECIALTIES dated August 20, 2019, 63 pages.

OFFICIAL APPROVAL

Mike Mudd / (859) 257-5409

SIGNATURE

Typed or Printed Name

University of Kentucky
Purchasing Division
322 Peterson Service Building
Lexington, KY 40506-0005
ADDENDUM NUMBER ONE

Bidders shall conform to the following changes, as same shall become binding on the Contract to be issued in response to this Invitation to Bid.

PROJECT INFORMATION

1. Pre-bid Walkthrough – A second pre-bid conference has been scheduled for bidders on 8/27/19 at 2:00-3:00pm. Attendees will meet first in room 114A of the Chemistry-Physics Building.

PRODUCT INFORMATION

2. Substitution Requests – The design team’s goal is to have an open and competitive bidding process, and we welcome substitution requests. We will issue contact information for alternative products by addendum, but bidders are reminded that it is their responsibility to determine whether or not their products comply with the specified criteria. If there is a specific requirement that prevents a bidder from complying with the specifications, bidders are encouraged to contact the design team to see if this requirement could be reconsidered. (Any changes to the specified requirements will be issued by addendum.) Bidders are also reminded that it is not necessary for their products to be listed in the specifications; anyone may bid the project as long as their products comply with the specifications. Substitution requests may be submitted via email. We will respond to each request when we receive it so bidders know the request has been delivered successfully. If a bidder does NOT receive a response, the bidder should contact the design team by telephone to make sure the email message has not been lost in a spam filter along the way.

CORRECTIONS / CHANGES

3. Specification Section 230200 HVAC Equipment – An incorrect version of the Specification Section 230200 HVAC Equipment was issued with the bid documents. Replace the section in its entirety with the attached specification (63 pages).

END OF ADDENDUM NO. 1
1. GENERAL

A. The Contractor's attention is directed to the General and Special Conditions, General Conditions-Mechanical and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified herein.

B. The Contractor shall provide in complete working order the following heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.

C. Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer’s Checklist.

D. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include air handling units, boilers, chillers, cooling towers, VFDs, etc.

E. All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90 and/or International Energy Conservation Code 2006, whichever is more stringent.

F. Installation of all heating, ventilating and air conditioning systems shall be performed by a master HVAC contractor licensed in the state the work will be performed.

G. For all systems requiring anti-freeze solutions, the Contractor shall be responsible for providing the propylene glycol solution to the percentage specified and confirming the mixture at Substantial Completion. All make-up tanks shall be full of water and the specified anti-freeze mixture at Substantial Completion.

H. Note to Suppliers and Manufacturers Representative furnishing proposals for equipment for the project:

   (1) Review the Controls Section of these Specifications (if applicable) to determine controls to be furnished by the equipment manufacturer, if any. The Contractor shall provide all controls with equipment unless specifically listed otherwise.

   (2) Review the section of these specifications entitle: SHOP DRAWINGS, DESCRIPTIVE LITERATURE, MAINTENANCE MANUALS, PARTS LISTS, SPECIAL KEYS, TOOLS, ETC., and provide all documents called for therein.

   (3) Ensure that the equipment which you propose to furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.

   (4) Determine from the Bid Documents the date of completion of this project and ensure that equipment delivery schedules can be met so as to allow this completion date to be met.

   (5) Where manufacturers’ temperature controls are specified, they shall be in full compliance with International Mechanical Code Section 606 including automatic smoke shut down provisions.
(6) Provide factory start-up on site by a factory representative (not a third party contractor) for all HVAC equipment, including pumps, VFDS, boilers, chillers, cooling towers, heat pumps, rooftop units, etc. Submit factory start-up reports to the Engineer.

(7) Provide training to the Owner by a factory representative for each type of equipment. Training shall be a minimum of eight (8) hours on site and the Engineer shall be notified one (1) week in advance of the training. Training shall only occur when the systems are complete and 100% functional. All training shall be video taped.

(8) Review the Section on Motor Starters and Electrical Requirements for Mechanical Equipment.

(9) Requirements for motors controlled by variable frequency drives:

   a. All motors shall be inverter duty rated.

   b. Motors less than 100 HP in size shall be furnished with shaft grounding kit, Aegis SGR Bearing Protection Ring or equal. One shaft grounding ring and related hardware shall be provided on drive end or non-drive end of motor per manufacturer’s instructions. These shall be factory mounted and installed on the exterior of the motor to allow for visual inspection. Ground motor frame per manufacturer’s instructions. Install kit in strict accordance with manufacturer’s instructions.

(10) All condensate producing equipment shall be provided with a condensate trap as recommended by the equipment manufacturer and a condensate overflow switch.

(11) Provide low ambient and all required controls and accessories on all HVAC equipment to ensure they can provide cooling during the winter season.

(12) Provide a complete air tight enclosure with opening door that seals air tight for all filters on air moving equipment.

(13) All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.

(14) Commissioning: This section specifies a system or a component of a system being commissioned as defined in Section 019113 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

2. EQUIPMENT

   A. CUSTOM AIR HANDLING UNIT

      a) The air handling units on the project are being direct purchased by the University outside of this contract. The Contractor shall be responsible for coordinating delivery, receiving them either offsite or on the jobsite and ultimately responsible for the installation.
1.2 REFERENCES
   A. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
   B. AMCA Publication 99 – Standards Handbook
   C. AMCA Standard 203 – Field Performance Measurement of Fan Systems
   D. AMCA Standard 210 – Laboratory Methods of Testing Fans for Performance Rating
   E. AMCA Standard 300 – Reverberant Room Method for Sound Testing of Fans
   F. AMCA Standard 500 – Laboratory Methods for Testing of Dampers and Louvers
   G. ARI Standard 410 – Forced Circulation Air-Cooling and Air-Heating Coils
      Building HVAC Systems
   I. ASHRAE Standard 52.1 – Dust-Spot Procedures for Testing Air-Cleaning Devices
   J. ANSI/ASHRAE Standard 52.2 – Method of Testing Air-Cleaning Devices for Removal Efficiency by
      Particle Size
   K. ANSI/ASHRAE 15 – Safety Standard for Refrigeration Systems
   L. ANSI/ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality
   M. ANSI/ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential
   N. ARI 1060 – Performance Rating of Air to Air Energy Recovery Ventilation Equipment
   O. ASTM A-653 – Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by
      the Hot-Dipped Process
   R. NEMA MG1 – Motors and Generators
   S. NFPA 70 – National Electric Code
   T. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems
   U. UL 900 – Test Performance of Air Filters
   V. UL 1995 – Standard for Heating and Cooling Equipment

1.3 SUBMITTALS
   A. Submit shop drawings and product data in accordance with Division 1
   B. Submittals shall include the following:
      1. Dimensioned plan and elevation view drawings, including motor starter and control cabinets,
         required clearances, and location of all field connections.
      2. Cabinet material, metal thickness, finishes, insulation and accessories.
      3. Ladder-type schematic drawing of the power and auxiliary utility field hookup requirements,
         indicating all items that are furnished by the manufacturer.
      4. Manufacturer’s performance of each unit. Selection shall indicate, as a minimum, the following:
         a. Fan curves with system operating conditions indicated.
         b. Certified coil performance ratings with system operating conditions.
         c. Calculations required for base rail heights to satisfy condensate trapping requirements of
            cooling coil.
         d. Filters with performance characteristics.
         e. Rated load amp draw.
         f. Approximate unit shipping weight.
1.4 OPERATION AND MAINTENANCE DATA
   A. Include data on design, inspection and procedures related to preventative maintenance. Operation and maintenance manuals shall be submitted at the time of unit shipment.

1.5 QUALIFICATIONS
   A. Manufacturer shall be a company specializing in the design and manufacture of custom air handling equipment and in business for no less than 15 years.
   B. Each unit shall bear an ETL label, conforming to UL Standard 1995.
   C. Units shall comply with the requirements of UL 1995 and NFPA 90.
   D. Each unit shall have a prominently displayed IBC Seismic Compliance Label issued by an independent third-party approval agency which is specific for the size of the component and tested acceleration levels.

1.6 DELIVERY, STORAGE, AND HANDLING
   A. Deliver, store, protect and handle products to site under the supervision of the owner in accordance with the manufacturers Operation and Maintenance Instructions.

1.7 SEQUENCING AND SCHEDULING
   A. Coordinate work performed under this section with the receipt and delivery of the air handling units.

1.8 WARRANTY
   A. The complete unit shall be covered by a parts-only warranty issued by the manufacturer covering the first year of operation. The warranty period shall start on the date of Substantial Completion.
   B. The installing contractor shall provide labor warranty during the unit’s first year of operation starting at Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURER
   1) Basis of design is ClimateCraft. To be approved, manufacturers shall meet or exceed performance and construction aspects as described and detailed herein. Requests for prior approval must be submitted 10 days prior to bid date. Submittal is to be in sufficient detail to determine equivalency. Substitution requests must originate from a bidder which is a general contractor or mechanical contractor plan record holder.

2.2 GENERAL
   A. Units shall be completely factory assembled and tested with the exception of unit splits as required for shipping or installation requirements as indicated on the schedule and drawings. The equipment's cooling, heating, humidifying, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or to indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and Maintenance manuals shall be furnished with each unit.

2.3 CABINET CONSTRUCTION
   A. Cabinets shall be constructed in a watertight and airtight manner. The manufacturer's standard cabinet construction shall result in an ASHRAE/ANSI Standard 111 Leakage Class 5 rating, or better, as measured in accordance with AMCA Standard 210. A leakage rate as a percent of airflow shall only be submitted following calculation at specific project conditions. Maximum casing leakage (cfm/100 ft² of casing surface area) = CL X P⁰.⁶⁵. Published leakage rates at generic conditions shall not be submitted.
B. Casing deflection shall not exceed L/200 at +12.0 w. g. in all positive pressure sections and -12.0 w. g. in all negative pressure sections where L is defined as the panel span. Panels shall be designed to deflect no more than 1/200 (.0005” per inch) of span under operating design conditions when measured at the panel span. Casing shall be rated for 1% leakage at 1.5 times the operating pressure with a maximum overall pressure of 12” w. g.

C. The unit shall be constructed on an 8” welded structural tubular steel base. Base tubing shall be cold-formed carbon steel, electric resistance welded. Equipment using a die-formed sheet metal base is not acceptable. Formed intermediate cross members shall be constructed of hot rolled 12-gauge galvanized steel. After fabrication, the base frame shall be thoroughly cleaned and coated with high solids, polyamide epoxy paint system for superior corrosion resistance.

D. Units shipped in multiple sections shall be engineered for ease of field assembly. Gasket supplied with the unit shall be a high-quality weather resistant closed-cell EPDM sponge rubber. Each section shall include a permanent label to aid in proper field assembly. All gasket and necessary assembly hardware shall ship loose with unit. Floors shall be designed to deflect no more than 1/200 of span under operating conditions.

E. Floors
   a. Shall be fabricated of 3/16” aluminum tread plate. All floor sheets shall be mechanically fastened to the unit base structure and isolated from the base assembly with an EPDM thermal break gasket.
   b. Floors shall be insulated with a two-part polyurethane water impervious foam insulation. A 20-gauge G90 galvanized steel under liner shall be provided.

F. Wall and roof panels
   a. Panels shall be 4” thick double wall construction. Panel joints shall be sealed with an industrial EPDM gasket to form a water and airtight seal. Air handling manufacturers using caulk to seal panels must include an owner witnessed field leakage test. The test shall require the unit to be field design air flow tested and cabinet leak tested for 1% at 1.5 times the operating pressure.
   b. Panels shall be individually removable for service without removing the roof or compromising the integrity of the cabinet wall. Panels shall be joined with 5/16” bolts that can be removed and refastened. Panel attachment with screws is not acceptable. All panels shall utilize thermal break construction between the exterior panel and the interior liner and between the panels and the base and roof frames.
   c. For long term durability, exterior panels shall be a minimum 16-gauge G60 galvanized steel pre-painted with a baked-on polyester-ceramic paint system that passes a 1,000-hour ASTM B-117 salt spray resistance test and 3000-hour ASTM G-23 accelerated weathering test.
   d. Interior liners shall be a minimum 20-gauge G90 galvanized steel. Panel liners shall be of a single piece construction and attached to the exterior panels with a full thermal break. To allow for cleaning, no fasteners shall be used on the exposed liner surface. Single wall units are not acceptable.

G. Insulation
   a. All wall and roof panels shall be insulated with an injected foam insulation with an R value of 6.6/inch. Panels shall be designed to deflect no more than 1/200 of span under operating design conditions when measured at the panel seam. Insulation shall fill the panel without voids. Panels shall have a minimum 20-gauge G90 galvanized steel solid interior liner. The composite R-value of the 4” unit casing shall be no less than R-26.4.

H. Access doors shall be provided into all sections of the air-handling unit as indicated in the plan documents. Doors shall be sized as shown on plan drawings, shall be a minimum 4” thick with R26.4 polyurethane foam insulation and shall be double wall construction using the same material type as the corresponding section. Doors shall comply with the requirements of UL 1995 and NFPA 90. The door frame shall be 0.125” extruded 6063-T5 aluminum. Each door shall be mounted with adjustable die cast aluminum hinges. All doors and mounting frames shall incorporate a thermal break design and the doors shall seal to a replaceable extruded EPDM sponge rubber gasket. Doors shall open against static pressure or shall include a pressure relief feature on the door latch.
The door latch assembly shall consist of a roller cam compression arm with a chrome plated steel inner handle and glass fiber/nylon composite outer handle. One tool operated lock shall be provided on each fan section access door. All doors shall have a minimum of two latches.

A 10”x12” thermal pane viewing window with one wire mesh safety glass pane and one clear pane shall be provided. The frame shall have a no-through-metal thermal break design. Viewing windows shall be on all doors serving a lighted section. Windows on doors exposed to unit mounted UVC light shall use glass that is resistant to UVC transmission.

The entire unit, including walls, roof, doors, joints, and seams shall include thermal break construction. This construction shall be supported by tested performance producing no condensation on the exterior surface when the air tunnel temperature is 50°F DB under the following exterior conditions:

- \((T_h - 50) / (T_h - T_{dp}) < 3.4\)
- \(T_h =\) Ambient dry bulb temperature (°F) external to housing
- \(T_{dp} =\) Ambient dew point temperature (°F) external to housing

### 2.4 FAN ASSEMBLIES – GENERAL

The fan shall be of the size and type specified in the unit schedule. To assure maximum performance, fans shall be supplied by a manufacturer specializing in fan design and production.

All fan assemblies shall be designed for heavy-duty industrial applications. Fan framing assemblies shall be fabricated from structural steel electrically welded to form a rigid, integral base. Individual fan assemblies shall be independently isolated.

All motors shall be NEMA design B with Class F insulation. Electrical characteristics and horsepower shall be as specified on the project schedule. All motors shall have a minimum service factor of 1.15. Motors shall have ball bearings. Motors shall be premium efficiency ODP type and shall be factory wired to a fan array motor overload panel. The motor shall be located within the unit and mounted on an adjustable heavy steel base. The motor base shall be fastened securely to the structural steel framing of the fan assembly.

All fans shall meet the minimum efficiency and maximum brake horsepower values as scheduled. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed. Manufacturer must ensure maximum fan RPM is below the first critical speed.

Each fan shall be provided with a factory installed airflow measuring device. Airflow device to be mounted out of the direct air stream so as not to affect system static pressure or sound performance. Sensor accuracy shall be +/- 3%. Factory installed assembly shall include flow sensors for field connection to a transducer provided by others.

### 2.5 FAN ASSEMBLIES – DIRECT DRIVE FAN ARRAY

1) Approved manufacturers: ClimateCraft, Greenheck, Hunt Air, and Twin City Fan & Blower

   a) Fan Arrays shall be direct-drive, non-overloading SWSI plenum fans designed for industrial duty and suitable for continuous operation.

   i) Fans shall be arranged in an array using one or more welded structural steel assemblies and shall be of the size and quantity specified in the unit schedule. Screwed or riveted frames are unacceptable. Fan assemblies shall be attached directly to base structural members.

   ii) Fan wheels shall have a minimum of 12 airfoil blades for superior sound characteristics and shall be constructed of aluminum to reduce rotational weight and vibration. Fan blades shall be extruded aluminum for uniformity and improved vibration characteristics.

   iii) Each fan and motor assembly shall be independently isolated within the structural assembly using 1-inch deflection spring isolators. Isolators shall be mounted in a three-point arrangement that provides both vertical and horizontal (thrust) isolation and shall not require field adjustment. If hard mounted or rubber in shear is used in place of internal spring isolations, external isolation of the entire air handling unit is required, no exceptions. Isolation system shall be seismic rated to
withstand seismic forces in excess of 4G horizontally and vertically to satisfy specified IBC seismic requirements.

iv) A fan inertia base shall be provided or the fan structure shall exceed an equivalence of 2x mass of the total rotating parts of the fan array. Fan and motor assemblies shall be designed such that no natural frequencies exist within the operating RPM range of the fan, eliminating the need for “lockout” frequency settings in the variable speed drive. The purchasing contractor will be responsible for all costs associated with externally isolating any unit that does not include individual fan isolation.

v) All fan arrays shall meet the minimum motor efficiency, maximum brake horsepower and total motor horsepower values scheduled. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed. Manufacturer must ensure maximum fan RPM is below the first critical speed. Fans shall be Class 2 construction.

vi) All fan and motor assemblies shall be dynamically balanced by the manufacturer to a maximum allowable vibration of 0.040 inches per second at design RPM and a maximum 0.080 inches per second overall vibration limit to bring the fan balance in conformance to a BV-5 Grade G1 per ANSI/AMCA 204. In addition, the manufacturer shall insure that no critical frequencies exist in the fan operating range by varying motor speed in 1Hz increments from design RPM to 50% of design RPM.

b) Unloading

i) Supply fans shall be provided with unloading capability to allow fan modulation without surge from 100% to 25% with a duct static pressure control set point of 1.5” w. g. There shall be no static pressure or intake plenum losses or any horsepower penalty associated with the system.

ii) The technology shall be a self-contained system independent of the building system temperature controls. No powered actuators or control signals shall be required. Any control points required to operate the unloading sequence shall be wired by the AHU manufacturer to a single point of control for the building automation system to interface. If control points are required, coordination with the BASD manufacturer on control sequence responsibilities shall be required at time of submittal approval.

iii) They system shall provide a positive shutoff for each fan in case of a fan failure. Each fan shall be provided with an isolation or backdraft damper to prevent bypass in the event of a motor failure. Blank off plates requiring manual installation are not acceptable.

iv) Fan cycling to allow stable part load operation shall be allowed only if a maximum of 50% of the fans will be cycled off at any time. Each fan is to be cycled in such a manner that all fans operate an equal number of hours in any given 168 hour (1-week) operating period. Control system shall indicate the individual fans operating and not operating. A separate control signal shall be required to indicate fan failure, separate from an indication that a fan is intentionally controlled to be off.

v) Fan curves shall be submitted; with the system curve indicating the minimum system operating static pressure and the point of fan surge.

c) Motors

i) Electrical characteristics and horsepower shall be as specified on the project schedule.

ii) Motors shall be Premium Efficiency per NEMA MG1 Table 12-12 type, shall have NEMA Class F insulation, shall meet NEMA Standard MD-1 Inverter Duty rating and shall be designed to withstand 1600V peak voltage spikes and rise times ≥0.1 microseconds.

iii) Motors shall have grease lubricated ball bearings designed to deliver a minimum L10 life of 250,000 hours at full load and the maximum operating RPM of the associated fan. Grease zerk and spring-loaded grease relief valves shall be provided in each motor to allow easy bearing lubrication without damaging the seals due to over lubrication. Permanently lubricated bearings are allowed if a spare motor per fan array is provided.

iv) For efficient operation in a direct drive application, motors shall be capable of operating greater than 60HZ to at least the design operating speed of the fan.
v) Motors shall be factory wired to a motor control center for connection to a VFD. The motor control center shall include for each motor circuit a control device providing overload protection, short circuit protection and a manual disconnect means, and all circuits shall be wired to a common main panel terminal block. Each control device shall include an auxiliary output capable of providing remote notification of a motor failure. All motors shall operate at all times and be controlled in unison, maintaining a consistent and uniform airflow pattern over coils, filters and other devices.

vi) Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

d) Warranty
i) All rotating parts shall be warranted by the unit manufacturer for a full five (5) years from date of unit start-up. Parts warranties provided by third parties are not acceptable.

e) Options
i) In the fan section, provide an overhead motor removal system to facilitate motor replacement.
   (1) The assembly shall include a manually operated winch, capable of being easily moved to any motor location and a structural steel I beam for mounting a trolley to assist in fan motor removal. The beam system shall be mounted overhead of the fan and motor. The beam system shall be supported and mounted to the unit’s base support system. The motor removal system shall be capable of removing the motor out of the air handling unit so it can be safely lowered to the mechanical room floor.

ii) Outlet safety screens shall be provided for all fans to prevent injury from rotating equipment.

2) Fan Array Controls
A. Fan arrays shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.
B. Each fan array in the air handling unit shall be provided with a factory installed airflow measuring instrument. Every fan in the array will have an airflow measuring device that is guaranteed by the unit manufacturer to have no impact on the fan airflow performance and will not increase the fan sound power. The output of the airflow measurement device on each fan shall be wired by the unit manufacturer back to a central processor mounted on the cabinet exterior that will add the flow from each fan to provide a total airflow for the fan array. Using one air flow measuring device and multiplying by the number of fans provided is not acceptable due to lack of accuracy. The central processor shall be able to detect and report a fan failure. Auxiliary contacts on the motors starters are not acceptable as fans can fail without tripping overloads. Current sensors wired into the central processors can be utilized. Acceptable manufactures are: AccAMP series ACSX, CR Magnetics model CR439, Greenheck FMS, NK Technologies series AS1. Piezometric volume taps with pressure transducers are acceptable. Transducer accuracy shall be 1% of pressure reading from full scale down to 30% of full scale reading to improve accuracy to less than 0.5% of calculated flow from 100%-30% of flow. The square root linearization and conversion of the pressure signal to flow shall be done at the central processor. Acceptable pressure transducers are: MatrixMonitor™ Fan Sensor, Omega PX656, Greenheck FMS, Setra Model 239.
C. Measure the airflow back flowing through all failed fans in the array. The backflow shall be subtracted from the sum of the operating fans to provide an accurate delivered airflow for the entire fan array. The system measurement accuracy shall be ±5% of measurement throughout the entire operating range of the fan array down to 15% of design flow. Systems with accuracy rated as a percentage of full scale are not acceptable. The system shall adjust for changes in barometric pressure and temperature to maintain accuracy in changing atmospheric conditions and at any altitude. The system shall be able to measure airflow and report it in units of ACFM or SCFM as selected by the user. The system shall have the capability to communicate to the BMS with discretely wired analog signals or through an RS485 two wire multi drop network using the MODBUS or BACnet protocols. All information available through the local keypad display unit shall be made available.
through the MODBUS interface. At a minimum, there shall be two locally scalable 0 to 10 VDC signals to report airflow and array pressure rise to the BMS. In addition, there shall be three SPDT relay outputs to report on the condition of the fan array. One relay will switch when the control is energized, one will switch in the event of fan failure detection and one will switch if fan surge is detected.

D. In addition to fan failure detection the system shall also be able to detect and report when any fan is in surge. The system shall have self-diagnostic capabilities and be able to report measurement and system errors. Individual and total flow measurements, entering air temperature and fan array pressure rise shall be available at a unit mounted keypad display.

E. Unit manufacturer shall supply and mount for each fan in the air handler a tri-axial accelerometer used to measure fan vibration. The output of each accelerometer shall be processed in real time through a FFT processor to provide frequency domain vibration for each fan. The vibration readings shall be reported in velocity and available for a frequency range that is a minimum of 3 times the operational speed of the fans. The system shall be capable of checking the fan vibration against user selectable vibration limits and reporting when those limits are exceeded. Each fan vibration sensor will be tied back to the airflow monitor where the individual fan vibration levels can be displayed on the local keypad display and the alarms and data can be transmitted to the BMS through the MODBUS or BACnet communication link. Acceptable manufacturers are: MatrixMonitor™ Fan Sensor, IMI Sensors model 685B, Greenheck FMS, Metrix Instrument Co. model 440.

F. Each fan array in the air handler shall be equipped with a grease monitoring system to track the intervals between motor bearing greasing. The system shall monitor the motor shaft speed for every fan motor in the array and integrate this data over time to determine the optimum elapsed time between bearing greasing. The system shall maximize the time interval between motor bearing greases while maintain proper lubrication of the bearings to maximize the motor life. The system shall notify the operator when it is time to grease the motor bearings through a locally mounted keypad display. The system will also estimate the number of days remaining until the motor bearings need to be greased. The system shall be capable of reporting the grease life information to the BMS through an RS485 two wire multi drop network using the MODBUS or BACnet communication protocol.

2.6 FAN SPEED CONTROL

A. Each variable air volume supply and return fan array shall be provided with an individual variable frequency drive as specified under another specification section.

2.7 UNIT SOUND POWER

A. Fan sound power levels (dB) for the unit shall not exceed values as specified on the equipment schedule.

B. Unit manufacturer shall provide certified inlet, supply and casing radiated, sound power levels based on the final unit configuration.

2.8 COILS

A. Provide complete coil section(s) with service access door(s) as shown on the plan drawings. Coil connections shall extend through the section casing for ease of installation. Coil connections must be sealed from both the inside and exterior surfaces of the panel with the sleeve of the inner seal covering the pipe within the depth of the panel, all to minimize leakage and condensation. An integral double wall stainless steel air seal which completely seals around the cooling coil casing and extends to the unit pressure bearing surface shall be provided. Air seals/safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gage materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches.

B. Multiple, “stacked” coil arrangements must be constructed so as to allow independent removal of any coil without the removal of another within the coil bank.
C. All coils shall meet or exceed the capacities specified on the mechanical schedule and all water coil performances shall be certified in accordance with the AHRI Forced Circulation Air Heating and Air Cooling Coil certification program which is based on AHRI Standard 410. Face velocities shall not exceed those specified on the mechanical schedule.

D. All cooling coil sections shall include a double sloped drain pan constructed from 304L stainless steel. All corners shall be welded watertight. Coils shall rest on stainless steel supports. The pan shall have a minimum pitch of 2” from high point to the bottom of the drain outlet connection, providing at least a 1/8” per foot slope. The drain pan shall be insulated with a 2-part sprayed on polyurethane, water impervious foam. Insulation shall be applied to the entire under side of the drain pan and coil section base assembly. If multiple stacked coils are used, intermediate drain pans are required. Intermediate pans shall be insulated and drained with 3/4” copper down-comers to the main pan.

E. Water coils shall be of a staggered tube design with high efficiency die formed corrugated plate-type fins for maximum performance. All coils shall be tested with 400 psig compressed air under clear water. Coils shall be designed to operate at 300 psig internal pressure and up to 250ºF. Tubes shall be 5/8” diameter, seamless 0.035” wall copper, mechanically expanded into full drawn fin collars for a continuous compression bond over the full finned length for high efficiency performance. Cooling coil casings shall be a minimum 16-gauge stainless steel. Heating coil casings shall be a minimum 16-gauge galvanized steel. Coil casing reinforcements shall be required for fin lengths over 42”. Coil fins shall be 0.0095” thick aluminum. Coils shall be serviceable using 0.25” M.P.T. drain and vent taps on the supply and return headers. Threaded seamless red brass coil connections shall be brazed to copper supply and return headers.

2.9 FILTERS

A. Provide complete filter section(s) with filter racks and service access door(s) as shown on the plan drawings. Holding frames provided for medium efficiency applications will be accessible. Holding frames provided for high efficiency applications will be upstream accessible. Holding frames shall be constructed from heavy gauge galvanized steel and shall be equipped with polyurethane foam gaskets. Frames shall be installed with vertical stiffeners and appropriate frame-to-frame sealant to provide a rigid leak tight assembly. An integral air seal which completely seals around the filter frame assembly and extends to the unit pressure bearing surface shall be provided. Air seals/safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gage materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches

Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. The filter rack shall be designed to use standard 24”x24” and 12”x24” filters only. Odd sized filters are not allowed. Holding frame assemblies shall be sized to meet or exceed the face area specified by the mechanical schedule.

B. Gauges

   a. A Magnehelic differential pressure gauge shall be provided factory installed for measuring the pressure drop across each filter type. The gauge shall be a diaphragm-actuated dial type, 4¾” O.D., with white dial, black figures and graduations and pointer zero adjustment.

C. Medium efficiency pleated filters shall be 4” thick MERV 10 as rated by ASHRAE Standard 52.1 test methods. Filter media shall be of the non-woven cotton fabric type. Filters shall be UL900 Class 2 listed

D. High efficiency rigid filters shall be 12” deep, high capacity, pleated, totally rigid disposable type. Filters shall consist of micro-fine synthetic media laminated to a non-woven backing, media support grid, contour stabilizers and enclosing frame. The filter media shall be MERV 14 as rated by ASHRAE 52.1 test methods. The enclosing frame shall be constructed of galvanized steel. It shall be constructed and assembled in such a manner that a rigid and durable enclosure for the filter pack is affected. The enclosing frame shall be equipped with protective diagonal support members on both the entering air and air leaving sides of the filters. Upstream of the main filter in the same frame provide 4”
pleated pre-filters. The pre-filter media shall be MERV 10 as rated by ASHRAE Standard 52.1 test methods and shall be of the non-woven cotton fabric type. The filters shall be UL900 Class 2 listed.

2.10 DAMPERS
A. Mixing box and economizer outdoor air, return air, and exhaust air openings shall be airfoil low-leak dampers. Damper shall be opposed (exhaust air) and parallel (outdoor air and return air) blade type. The frame shall be fabricated from 16-gauge galvanized steel. Damper shall meet the leakage requirements of ASHRAE Std. 90.1 and of the International Energy Conservation Code by leaking less than 3 CFM/sq. ft. at 1” of static pressure and shall be AMCA licensed as a Class 1A damper.
B. The dampers shall be equal to Ruskin CD60.

2.11 STATIC AIR MIXERS
A. Aluminum air blender plates shall be provided immediately downstream of the outside air / return air damper plenum and upstream of the pre-filter rack where shown to be provided on the plans.
B. The air blenders shall be equal to Blender Products, Inc.

2.13 ELECTRICAL POWER AND CONTROLS
A. Unit operating voltage shall be 460V, 3-phase, 60Hz. All wiring and electrical equipment supplied by the manufacturer shall conform to and be installed in accordance with the requirements of UL1995. Provide copper wires, bus bars, and fittings throughout, except internal wire of the control transformer may be aluminum if copper termination is provided. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating. Wiring shall be run in plated EMT and Liquid Tight conduit. Mount a permanent nameplate on the unit to display the manufacturer, serial number and model number, date of manufacture, horsepower, current rating and voltage.
B. Each section provided with a service access door, or as indicated on the plan drawings, shall be equipped with a vapor proof LED service light. All lights shall be completely installed and wired to a single 60-minute timer switch. All switch boxes shall include a GFCI convenience receptacle. Lights and GFCI outlets shall be wired to a separate 115VAC power connection.

2.14 UNIT TESTING AND QUALITY CONTROL
A. The fans shall be factory run tested to insure design integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass all quality control checks and be thoroughly cleaned prior to shipment.
B. The unit cabinet shall be tested to verify its cabinet leakage rating at design both positive and negative operating static pressure(s). Cabinet leakage shall not exceed a Leakage Class rating of 5 as defined by ANSI/ASHRAE Standard 111. Leak testing shall be performed by measuring the airflow pumped into and out of the air-handling unit at the cabinet design operating static pressure. All unit openings shall be sealed. The air shall then be pumped into and out of the unit until the appropriate operating pressures are achieved. Airflow measurements shall be performed in compliance with AMCA Standard 210. The testing shall be performed at the factory. A detailed report, including all data and test methods, shall be presented to the owner or his representative prior to equipment shipment.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Install in strict accordance with manufacturer’s requirements, shop drawings, and Contract Documents.
B. Equipment rigging and assembly to be supervised by the manufacturer’s representative. Provide for as long a period of time as is necessary to ensure proper assembly or onsite training but no less than 2 full days.

C. Adjust in alignment on concrete foundations, sole plates or other supporting structure. Level, grout, and bolt in place.

D. Coordinate electrical installation with electrical contractor.

E. Coordinate controls with control contractor.

F. Provide all appurtenances required ensuring a fully operational and functional system.

3.2 START-UP

A. Equipment start-up is to be supervised by the unit manufacturer’s representative service organization. Physical connections and start-up are provided by the installing contractor. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. The start-up engineer shall submit a written report to the owner and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.

B. Provide complete Operation & Maintenance Manuals with descriptive literature, model, and serial number of all equipment, performance data, manufacturer’s instructions for operating and maintenance, lubrication recommendation and schedule, and winter shutdown procedure.

B. CONSTANT AND VARIABLE VOLUME TERMINAL UNITS

a) Qualifications
   a. Manufacturer: The company manufacturing the products specified in this section shall have a minimum of ten years experience producing products of this type.
   
b) System Responsibility
   a. The Contractor shall be responsible for any and all costs associated with any and all changes resulting from the use of a supplier other than the listed acceptable manufacturers.

   c) Warranty
   a. Provide parts and labor warranty for one year.

   d) Manufacturers
   a. General
      1) Manufacturer shall participate in the ARI Certification program. Unit performance data shall be rated in accordance with ARI Standard 880. The manufacturer shall display the ARI Symbol on all units.
      2) Single and dual duct terminal units shall be UL listed as an entire assembly.
      3) Acceptable Manufacturers
         (a) Nailor
         (b) Trane
         (c) Titus
         (d) Environmental Technologies
         (e) Johnson Controls
      4) Manufactured Units
         (a) Single duct terminal units.
            i. Ceiling mounted primary air control terminal units for connection to a single medium pressure duct of a central air distribution system. Terminals units will be provided with controls. Heating coils shall be separate duct mounted coils.
         (b) Single duct terminal units.
            i. Identify each terminal unit with clearly marked identification label and airflow indicator. Label shall include unit nominal air flow, maximum
factory-set air flow, minimum factory-set air flow, and coil type. Double wall construction is required.

5) Fabrication
(a) Casings: Units shall be completely factory-assembled, manufactured of corrosion protected steel, and fabricated with a minimum of 18-gauge metal on the high pressure (inlet) side of the terminal unit damper and 22-gauge metal on the low pressure (outlet) side and unit casing.
(b) Insulation – Completely enclosed - The interior surface of unit casing is acoustically and thermally lined with a minimum of 1” (one) inch, 1.0 lb./cu. ft. density glass fiber enclosed by interior sheet metal wall (26 gauge minimum). The insulation R-Value shall be a minimum of 3.8.
(c) Assembly: Primary air control damper, airflow sensor, fans, controls and optional heating coil in single cabinet.
(d) Rectangular Supply Air Outlet Connections: Rectangular outlet connections for single duct units shall be slip and drive type.

6) Primary Air Control Damper Assembly
(a) Locate primary air control damper assembly inside unit casing. Construct the damper assembly from extruded aluminum and/or a minimum 20 gauge galvanized steel components. Maximum damper leak rate shall not exceed 1% of damper nominal CFM at 4 inch wg. differential.
(b) Provide damper assembly with integral flow sensor. Flow sensor shall be provided regardless of control type. Flow sensor shall be a multi-point, averaging, ring or cross type. Bar or single point sensing type is not acceptable.

7) Heating Coils – Duct Mounted, refer to separate specification below.

8) Direct Digital VAV Controls
(a) Direct Digital Controls
i. Multi-point, multi-axis flow ring or cross sensor to be furnished and mounted by terminal unit manufacturer. Single point or flow bar sensors are not acceptable. Flow sensing device shall be capable of maintaining airflow to within +/- 5 percent of rated unit airflow setpoint when installed with 1.5 duct diameters straight duct, of the same size as the primary airflow inlet, upstream from the unit.
(b) Variable Air Volume (VAV) Terminal Unit Calibration
i. The VAV terminal units shall be individually controlled by a DDC VAV controller per VAV terminal unit.
   a) To assure proper operation and control, the Contractor as part of this bid shall recalibrate the transducers six (6) months after acceptance of the BAS system to correct any deviations as a result of transducer drift.
   b) The Contractor shall submit a copy of the calibration report to the Engineer.

9) Testing Verification
(a) Factory set and check all controllers to within 5% of scheduled maximum and minimum settings. Base performance on tests conducted in accordance with ARI 880.
(b) Maximum Casing Leakage: 1 percent of nominal air flow at 0.5 in wg inlet static pressure.
(c) Maximum Damper Leakage: 1 percent of design air flow at 4 in wg inlet static pressure.

10) All VAV boxes and control valves must have, at minimum, a 24" x 24" access space for maintenance, damper arms, reheat valves, etc. Space must be maintained to top of acoustical ceiling grid.
C. REHEAT COILS

a) Coils shall consist of aluminum plated fins and seamless copper tubes. Fins shall have full fin collars to provide accurate fin spacing and maximum fin-to-tube contact. Tubes shall be mechanically expanded into the fin collars. Coils shall be leak tested under water to 450 psig pressure. Supply and return water connections shall be on the same side of the coil.

b) Capacity: Provide coils in capacities as scheduled on the drawings. All coils shall be 2-row minimum.

c) Control Valves - All reheat valves for terminal heating are to be ball type valves with upper thrust bearing, resilient seat. The valve is to be rated for 300°F max temperature and 175 psig max pressure with a carbon steel body and stainless steel ball. The valves are to be equipped with an electric modulating actuator. Actuators or output transducers shall accept proportional milliamp, millivolt or voltage. Use of floating or incremental open loop control actuators or pneumatic transducers that do not provide positive position feedback to the DDC controller shall be unacceptable.

d) Control valves must have, at minimum, a 24" x 24" access space for maintenance. Space must be maintained to top of acoustical ceiling grid.

e) Installation
   a. Install in accordance with manufacturer's instructions.
   b. Insulate exterior of hot water coils.

D. DUPLEX STEAM CONDENSATE PUMP

1. General:

   a) Furnish and install according to drawings and manufacturer’s instructions the quantity of DUPLEX condensation pump(s) as shown on the drawings. Each unit shall consist of (1) cast iron receiver, (2) water pumps, (1) mechanical alternator, electrical controls and accessories.

   b) The condensate receiver shall be manufactured of close-grained cast iron with a 20 year warranty against corrosion failure. The receiver shall be equipped with: (1) inlet strainer, (1) externally adjustable 2-pole mechanical alternator, top and bottom shut-off water level gauge with automatic shut-off if glass is broken, dial thermometer, (2) pressure gauges for pump discharge, (2) bronze isolation valves between pump and receiver plus a valve in each bleed line installed for maintenance, and (2) lifting eye bolts (on receivers 25 gallon and larger). The receiver size shall be as shown on the drawings.

   c) A cast iron basket inlet strainer with vertical self-cleaning bronze screen shall be provided for the receiver inlet.

   d) The centrifugal water pumps shall be flange mounted on the receiver. The pumps shall be close coupled vertical design, and shall have a cast bronze impeller that is bronze fitted to the cast iron pump housing with a renewable bronze wearing ring. The mechanical seal shall be rated for at least 250°F service. The entire pump assembly shall be permanently aligned and dynamically balanced to deliver its full rated capacity. The pump shall be driven by an industry standard motor available "off the shelf." The motor shall have a NEMA standard shaft. The horsepower and electrical characteristics shall be as shown on the drawings.

   e) The pump manufacturer shall furnish, mount on the pump unit, and wire a U.L. labeled NEMA 12 control cabinet with hinged door, containing:
      2 Combination magnetic starters (each having 3 overload relays) with circuit breakers and cover interlock for lock-out tag-out capability
      2 "Automatic-Off" selector switches
      2 Momentary contact “Test” push buttons
      2 Pilot run lights
      1 Numbered terminal strip
      1 Removable control mounting plate

   f) Each pump control circuit shall be completely independent of the other. The NEMA 1 mechanical alternator shall (1) change the operating sequence automatically after each cycle, (2) provide
simultaneous operation under peak load conditions, and (3) operate the second pump automatically, should the active pump or its control fail.

g) The unit shall have a float switch assembly NEMA 1 to turn on a high water alarm mounted in control panel with bell, light and silencing relay with dry contacts to access the building management system alarm.

h) A control circuit transformer for each circuit shall be provided when the motor voltage is three phase or code requires 115 volt controls. All factory installed wiring shall be numbered for easy identification and the numbers shall coincide with those shown on the wiring diagrams.

i) The unit shall have a single point power connection.

j) The entire pump package will be U.L. labeled when a control panel is furnished.

k) The manufacturer shall furnish a certified pump performance test. The pump manufacturer shall furnish complete elementary and connection wiring diagrams, piping diagrams, and installation and operation instructions.

l) Manufacturer shall be Shipco® PUMPS or equal.

m) Capacity Schedule (Required to complete suggested specifications).

2. Installation

(1) Install per manufacturer’s printed instructions and as indicated on drawings.

(2) Coordinate electrical connections with work of Division 26.

3. QUALITY CONTROL/STARTUP: Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

4. FUNCTIONAL PERFORMANCE TESTS: System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

5. DEMONSTRATION AND TRAINING: Training of the owner’s operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

E. GENERAL EXHAUST FAN

(1) Fans shall be Type BCV Backward Inclined Ventilating Sets, as manufactured by Twin City Fan & Blower, Minneapolis, Minnesota.

(2) PERFORMANCE - Performance ratings shall conform to AMCA Standard 205 (fan efficiency grade), 211 (air performance) and 311 (sound performance). Fans shall be tested in accordance with ANSI/AMCA Standard 210 (air performance) and 300 (sound performance) in an AMCA accredited laboratory. Fans shall be licensed to bear the AMCA certified ratings seal for both sound and air, and fan efficiency grade (FEG).

(3) Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation. Fans shall have a non-overloading design with self-limiting horsepower characteristics and shall reach a peak in the normal selection area. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA Standard 99.

(4) HOUSING - Fan housings shall be heavy gauge, continuously welded construction. Housings with lock seams or partially welded construction are not acceptable. Housings shall be suitably braced to prevent vibration or pulsation. Housings shall have tapered spun, aerodynamically designed inlet cones or shrouds providing stable flow and high rigidity. Housings shall be of the rotatable design, convertible to eight standard discharge configurations.

(5) WHEELS - BCV backward inclined wheels shall be single thickness plate type designed for maximum efficiency and quiet operation and shall be of the non-overloading type. Class I wheels
riveted and welded to the spun wheel cone and backplate. Provide Arrangement 10. All wheels shall be statically and dynamically balanced.

(6) SHAFT - Shafts shall be AISI 1040 or 1045 hot rolled steel, accurately turned, ground, polished, and ring gauged for accuracy. Shafts shall be sized for the first critical speed of at least 1.43 times the maximum speed.

(7) BEARINGS - Bearings shall be heavy duty, grease lubricated, anti-friction ball, self-aligning, pillow block type and selected for a minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum fan RPM.

(8) DRIVE - Motor sheaves shall be cast iron, and supplied as either variable pitch or fixed pitch. Drives and belts shall be rated for a minimum of 120% of the required motor HP.

(9) FINISH AND COATING - The entire fan assembly, excluding the shaft, shall be thoroughly degreased and deburred before application of a rust-preventative primer. After the fan is completely assembled, a finish coat of paint shall be applied to the entire assembly. The fan shall be coated with a petroleum-based rust protectant. Aluminum components shall be unpainted.

(10) ACCESSORIES: Provide belt guards, weather covers (if mounted outdoors), outlet shutters, and spring isolators.

(11) FACTORY RUN TEST - All fans prior to shipment shall be completely assembled and test run as a unit at operating speed or maximum RPM allowed for the particular construction type. Each wheel shall be statically and dynamically balanced in accordance with ANSI/AMCA 204-96 "Balance Quality and Vibration Levels for Fans" to Fan Application Category BV-3, Balance Quality Grade G6.3. Balance readings shall be taken by electronic type equipment in the axial, vertical, and horizontal directions on each of the bearings. Records shall be maintained and a written copy shall be available upon request.

(12) GUARANTEE - The manufacturer shall guarantee the workmanship and materials for its BCV Ventilating Sets for at least one (1) year from startup or eighteen (18) months from shipment, whichever occurs first.

(13) COMMISSIONING: This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

(14) QUALITY CONTROL/STARTUP: Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 019113 Commissioning.

(15) FUNCTIONAL PERFORMANCE TESTS: System functional performance testing is part of the Commissioning Process as specified in Section 01 9113. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

F. LABORATORY EXHAUST FANS

PART 1 - GENERAL

1.1 References:
   A. Performance ratings: Conform to AMCA standard 210, 260 and 300. Fans must be tested in accordance with AMCA 210, 260 and 300 in an AMCA accredited laboratory and certified for air and sound performance. Fan shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210), sound performance (AMCA 300), and induced flow fan for high plume dilution blowers (AMCA 260).
   B. Fans shall be UL and CUL listed per UL 705 safety standard.
   C. Fans shall meet the criteria of NFPA-45.
   D. Classification for Spark Resistant Construction shall conform to AMCA 99.

1.2 Acceptable Manufacturers:
   A. The plans and specifications for the laboratory fume hood exhaust system are based on systems and equipment manufactured by Strobic Air Corporation. Also acceptable: Twin City and Greenheck.
   B. In strict accordance with this specification, alternative laboratory exhaust systems and equipment shall only be considered for approval provided that the equipment be equal in every respect to energy consumption,
sound levels, vibration levels, footprint, maintenance requirements, operational characteristics, capacities, and intent specified herein. Approval to bid does not relieve the alternate exhaust system supplier from complying with the minimum requirements or intent of this specification.

C. The engineer and owner shall be the sole judges of quality and equivalence of equipment, materials, methods, and life cycle cost.

D. Only those systems specifically named in this specification or by addendum shall be considered for approval. Other systems submitted after the bid opening will be returned without review.

1.3 Submittals:
A. Submit shop drawings and product data sheets including performance data, fan performance curves, vibration levels, maintenance requirements and sound power levels.
B. Fan manufacturer shall furnish a certificate of guarantee stating that the fan, mixing plenum, outlet nozzle, acoustical silencer nozzle, stack extension if any, and all related accessories specified herein have been pre-tested at the factory and that the curves supplied in 1.3.1 have been de-rated for any and all system effects created by the accessories.

1.4 Warranty:
A. Fan manufacturer shall provide a 7 year parts warranty from time of purchase to include fan, plenum, motor and drive mechanisms including pillow blocks, sheaves, shafts, couplings and belts. This warranty shall be held solely by the fan manufacturer. It is unacceptable to extend the warranty of a provided component supplier (i.e. motors, dampers, actuators). All warranty claims shall be the sole responsibility of the fan manufacturer.

2. PART 2 - PRODUCTS

2.1 Mixed-flow induced dilution fans:

2.2 Fan Performance:
A. Fan Performance shall be as stated on the schedule. The Static Pressure stated on the schedule shall be at the inlet to the "Fan System" and does not include any losses of equipment provided by the fan manufacturer (i.e.: HRU, Filters, Silencers, etc…). All losses for the equipment provided by the fan manufacturer shall be detailed in the fan manufacturers technical proposal and or submittal.
B. Fan and all drive components shall have a combined bearing life of a minimum of L10 = 150,000 hours.
C. Fan dynamic balance not to exceed 0.5 mil, peak-to-peak for nominal 900RPM, 1200RPM, and 1800RPM fans, or 0.055 in/sec -peak for 1800 RPM, 0.035 in/sec - peak for 1200 RPM, and 0.030 in/sec-peak for 900 RPM fans measured at the blade pass area when operating at fan frequency. Vibration isolation shall be limited to rubber-in-shear pad type isolators unless otherwise specified.
D. Factory test reports detailing vibration levels at the blade pass area shall be provided. Vibration levels shall be reported in both the axial and radial direction. If fan vibration is greater than 0.5 mils peak-to-peak at the blade pass area, fan manufacturer shall be responsible for providing vibration isolators on each fan and flexible connection at each duct inlet. Manufacturer shall add 0.5" additional static pressure to the fan system to compensate for losses through the flexible connection. Vibration isolators, 2" deflection seismic rated spring, must be installed on each individual fan with a minimum of four per fan. In addition, fan manufacturer shall be responsible for providing a method to repair or replace flexible connection or vibration isolators without shut down of the fan system. This includes any engineering, additional ductwork, and isolation dampers required to perform repairs while the system is still fully operational. Fan manufacturer shall also provide labor to change out or repair flexible connection and vibration isolators for a seven (7) year period from shipment.
E. The Acoustical Silencer Nozzle shall provide the attenuation values as specified in the following schedule. The published insertion loss values shall be obtained from an AMCA 300 test with the silencer installed on the fan specified. Ratings based on separate silencer and fan testing is not acceptable.
F. The fan supplied must meet the system exhaust CFM and the motor BHP shall not be larger than that shown on the fan schedule.
G. The static pressure shown on the schedule is based on the static pressure requirements at the inlet to the mixing box. Any system deviating from the basis of design shall include and detail in their proposal additional losses for flexible connectors, fan losses, elbows, mixing box, etc. that are not included in their fan curves. In addition any deviation from the basis of design shall be subject to requirements stated in sections 1.3.2, 2.1.8 and 2.1.23.

2.3 Fan Maintenance:
A. If a belt drive fan is supplied the fan manufacturer shall include a seven (7) year service contract for maintaining the belts, sheaves and drive mechanism. This is to include monthly inspections as noted in the ANSI Z9.5, 4.14.7.2 and any tensioning, and belt replacement during the seven (7) year period. This contract shall be detailed in the proposal and included in its total value.
B. Maintenance shall only be required on a minimum of 18 month intervals. This maintenance shall be limited to re-greasing of the motor bearings.
C. Extended motor lube lines of Teflon tubing covered with braided stainless steel shall be provided. Extended lube lines shall be mounted to a bracket located on the fan housing with grease relief fittings on each line.

2.4 Fan Construction:
A. Impellers shall be mounted directly to the motor shaft to provide Arrangement 4 Direct Drive. Motors shall be isolated from the primary exhaust air stream and shall be visible and accessible from the fan exterior for inspection and service. Models that are not Arrangement #4 will be rejected.
B. Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impellers shall have non-stall and non-overloading performance characteristics with aerodynamically stable operation at any point on the fan curves.
C. Stationary discharge vane sections shall be provided to increase fan efficiencies.
D. Fan shall be constructed to AMCA "C" standards per AMCA 99 with a non-ferrous inlet bell provided in order to reduce sparking in the event of a motor bearing failure.
E. Fan assemblies shall be designed for mounting on conventional roof curb without the need for guy wire supports.
F. Fans shall be modular construction and capable of being assembled on the roof.
G. Chemical resistant gaskets shall be provided at all companion flanged joints.
H. Fasteners shall be 316 stainless steel.
I. A bolted access door shall be provided for impeller inspection on each fan.

2.5 System Color:
A. EF-1, EF-2, EF-3, EF-4 – Color shall be selected by the architect.

2.6 Fan Coating:
A. EF-1, EF-2, EF-3, EF-4 - All steel and aluminum surfaces components within the airstream that are not stainless steel or fiberglass must be surface prepped by abrasive blast clean to SSPC-SP10. Chemically cleaning of these components as a form of surface preparation is not acceptable. These components must be coated with a high solids epoxy with low VOC chemical resistant barrier coating epoxy. The coating system, a total thickness of up to 12 mils, is not affected by the UV component of sunlight (does not chalk), and has superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 7000 hour ASTM B117 Salt Spray Resistance.

2.7 Nozzle:
A. Discharges shall include twin FRP nozzles with passive third central stacks that are capable of generating aspiration. The FRP shall be chemically and UV resistant.
B. EF-1, EF-2, EF-3, EF-4 - Acoustical Silencer Nozzle shall be designed as an integral component of the exhaust fan discharge nozzle and shall not increase the height of the overall assembly. Integral Acoustical Silencer Nozzle with a minimum of 12dBA insertion loss. Lining the interior of the wind band is not an acceptable method of attenuation due to line of site sound in the free area between the nozzle and wind band.

2.8 Motor:
A. EF-1, EF-2, EF-3, EF-4 - Electric motors shall be TEFC Mill & Chemical duty with a 1.15 service factor and an L10 bearing life of 150,000 hours. Premium Efficient motors shall have regreasable bearings with grease relief fittings in every NEMA frame. Fan motors shall be C-Face and foot mounted.

2.9 Disconnect Switch:
A. EF-1, EF-2, EF-3, EF-4 - A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to the motor.

PART 3 - ACCESSORIES

3.1 Plenum:
A. Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirement of the number of fans listed on the schedule. Unless otherwise specified, plenums shall be suitable for mounting on roof curbs. Safety screens shall be supplied over inlet of fan. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors. The primary air inlets shall be located on the bottom or side as noted on construction drawings.
B. Fan and Mixing Box systems supplied by the manufacturer must have a footprint as shown on the drawings / schedule. Exhaust systems with larger footprints shall not be acceptable.
C. Fans and accessories shall have internal drain systems to prevent rain water from entering building duct system.
D. EF-1, EF-2, EF-3, EF-4 - Single fan plenums shall be of continuously welded, heavy gauge steel construction. For single thickness plenums, coatings shall be the same as specified for the fans.

3.2 Plenum Coating:
A. EF-1 - Powder Coating - Weather resistant powder coating baked onto plenum exterior - 2.5-3.5 mils. Plenum interior uncoated 304SS.

3.3 Vortex Breaker:
A. EF-1, EF-2, EF-3, EF-4 - Vortex breakers shall be provided on all side inlet and multiple fan plenums.

3.4 Isolation Damper:
A. EF-1, EF-2, EF-3, EF-4 - Aluminum Airfoil Opposed Blade Vertically Mounted, Coated (Spec D) - For use with a damper actuator.

3.5 Isolation Actuator:
A. EF-1, EF-2, EF-3, EF-4 - Electric Isolation Actuator - Two position 24v electrical actuator. Fail safe spring close. Mounted directly on isolation damper control rod.

3.6 Bypass Damper:
A. EF-1, EF-2, EF-3, EF-4 - Bypass dampers shall be provided with all mixing plenums for outside air with primary exhaust. Bypass damper(s) shall be sized to bypass the airflow capacity of one fan at the required static pressure of the system. Dampers will be opposed blade low leakage air foil control dampers with extended shaft for connection to an operator. The dampers shall be all aluminum construction.

3.7 Bypass Actuator:
A. EF-1, EF-2, EF-3, EF-4 - The dampers shall be controlled by a 24v electric proportional control damper actuators shall be electronic direct-coupled type, which require no crank arm and linkage. Actuators must provide proportional damper control in response to a 2 to 10 VDC or, with the addition of a 500Ω resistor, a 4 to 20 mA control input from an electronic controller or positioner. Actuators shall have Brushless DC motor technology and be protected from overload at all angles of rotation. Actuators shall have reversing switch and manual override on the cover. Run time shall be constant and independent of torque. A 2 to 10 VDC feedback signal shall be provided for position indication.

3.8 Rain Hoods:
A. EF-1, EF-2, EF-3, EF-4 - Rain hoods shall be provided with each damper.

3.9 Roof Curb:
A. EF-1, EF-2, EF-3, EF-4 - A galvanized steel roof curb shall be provided to support the fans/plenums. The
curb shall be minimum 14 gauge and canted for rigidity in wind loads. The curb shall include a rigid fiberglass liner and a wood nailer.

F. VARIABLE FREQUENCY DRIVES

a. The work includes all labor, materials, and related items to completely furnish and mount the VFD. The controls contractor is responsible for all required start up and testing of the drives. All power wiring to the VFD shall be the responsibility of the electrical contractor. This shall include all drives shown on the drawings and described in the specifications.

b. Variable Frequency Drives shall be Pulse Width Modulation adjustable frequency AC drives as manufactured by ABB, Allen Bradley, Eaton, or Danfoss. The drives shall be 6 pulse drives at a minimum, with 3% impedance. The drive and bypass unit shall be UL listed as a complete assembly.

c. All VFD's shall be able to communicate BACnet via MS/TP.

d. Each drive shall include the following features:

1) Factory mounted fused disconnect for overcurrent protection.

2) A selectable automatic/manual bypass feature. (For motors greater than 25 HP the bypass feature shall be provided with a solid state, “soft start” starter)

3) Human interface module (HIM) keypad factory mounted (not hand held). Panel mounted Hand/Off/Auto switch to allow manually switching between hand (manual control via HIM); off (drive off, motor off; and automatic (control via temperature control signal).

4) A panel mounted drive/bypass switch for manually selecting between drive (drive operation); and bypass (full bypass, motor at full speed operation). Both hand (manual control via HIM) and automatic (control via temperature control signal) shall be available as control methods in both drive and bypass modes.

5) Air handling unit VFD’s shall include a fully redundant drive in lieu of the bypass. NOTE THAT THESE SHALL BE PROVIDED UNDER THIS TRADE CONTRACT AND IS NOT PROVIDED BY THE CONTROLS CONTRACTOR OR THE AHU MANUFACTURER.

6) A mechanical interlock between the bypass and drive contactors.

7) A control transformer.

8) UL/CSA/CE labeled.

9) The rectifier stage shall convert fixed voltage, fixed frequency, AC line power to fixed DC voltage. The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The rectifier shall be insensitive to phase rotation of the AC line. The DC voltage shall be filtered. The DC bus shall have external connections for standby battery back-up or for linking multiple AC drive buses. The inverter shall change fixed DC voltage to variable frequency AC. The inverter shall utilize IGBT’s as required by the current rating of the motor.
e. The drives shall operate a variable torque load. The speed range shall be from a minimum of 0.5 Hz @ 100% breakaway torque to a maximum speed of 250 Hz.

f. The drives shall have UL Type 1 listed enclosures that allow operation in a Pollution Degree 3 environment and shall meet NEMA Type 1/IP30 or NEMA Open/P20. The drives shall meet IEC 664-1 and NEMA ICS 1-111A Part 3 standards.

g. The drives shall be designed to operate in an ambient temperature of 0 degrees C to 40 degrees C.

h. The drives shall meet IEC 68-2-6 vibration specification.

i. Drives 75 HP and smaller shall be designed and constructed for finger safe operation with the enclosure open to operator access according to IP20 standards.

j. The drives shall be designed to operate from an input voltage ranging from 380+-10% to 480 +/- 10%; and from an input frequency form 48 to 63 Hz.

k. The displacement power factor shall not be less than 0.98 lagging under any speed or condition.

l. The efficiency of the AC drive at 100% speed and load shall not be less than 97%.

m. Variable torque over-torque capacity of 110% for 1 minute.

n. The output carrier frequency of the drive shall be randomly modulated and selectable at 4 kHz, or 8 kHz.

o. The output frequency shall be from 0.1 to 400 Hz for AC drives up to 75 HP. At horsepowers above 75 HP, the maximum output frequency shall be 200 Hz.

p. Upon power-up, the drives shall automatically test for valid operation of memory, option module, loss of analog reference input, loss of communications, dynamic brake failure, DC to DC power supply, control power, and the pre-charge circuit.

q. The drives shall be protected against short circuits between output phases; between output phases and ground; on the outputs, on the internal supplies, and on the logic and analog inputs.

r. For a fault condition other than a ground fault, short circuit, or internal fault, an auto restart function will provide a minimum of 5 programmable time delays before restart attempts; trial time will range from 1 second to 180 seconds.

s. The deceleration mode of the AC drive shall be programmable for normal and fault conditions. The stop modes shall include ramp to stop, free-wheel stop, fast stop, and DC injection braking.

t. A synchronized restart shall be provided that will catch a spinning motor by sensing the motor frequency and rotational direction and synchronize the AC output prior to restarting.

u. The drive shall be able to receive the control inputs for the smoke detection system to shut the fans down.

v. The manufacturer shall offer 24 hour product and application response via a nationwide network of factory certified technical support personnel.
w. A parts and labor warranty of **2 years from the date of substantial completion** shall be included. Warranty shall include travel time and expenses.

x. Factory-authorized startup for each drive is mandatory. Provide a written record of the startup of each unit.

y. Auxiliary contacts for connection to local disconnect to shut down drive when disconnect is off.

z. **INSTALLATION:** Install all equipment in accordance with the manufacturers’ recommendations. Drives are to be wall mounted.

aa. Start up and programming by a factory-authorized technician.

bb. **MAINTENANCE AND OPERATING INSTRUCTIONS:** Provide one (1) hard copy and (1) electronic copy of maintenance and operating instructions for each piece of equipment furnished. The (1) hard copy shall be in a 3-ring binder, and both hard copy and electronic copy shall contain a copy of the approved shop drawings or catalog cuts of all equipment, as well as maintenance and operating instructions from the equipment manufacturers.

cc. Instruct Owner’s personnel in the operation of the equipment.

G. **SPLIT SYSTEM INDOOR UNIT**

Part 1 - General

1.01 Related Documents

1.02 General Description

A. This section includes the design, controls, and installation requirements for indoor air handling units.

1.03 Quality Assurance

A. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.

B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

C. Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

D. Unit shall be safety certified by ETL and ETL US listed. Unit nameplate shall include the ETL/ETL Canada label.

1.04 Submittals

A. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics, and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided. Run test report shall be supplied with the unit in the control compartment’s literature packet, and also available electronically after the unit ships.

B. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with detail for power and control systems and differentiate between factory installed and field installed wiring.

1.05 Delivery, Storage, and Handling
A. Unit shall be on a wooden pallet with skeleton crating prior to shipment to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Unit shall be handled carefully to avoid damage to components, enclosures and finish.

D. Unit shall be stored in a clean, dry place protected from weather and construction traffic in accordance with Installation, Operation and Maintenance manual instructions.

1.06 Warranty

A. Provide a full 12-month warranty on the system starting at substantial completion and a five year compressor warranty. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation, and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters.

Part 2 - Products

2.01 Manufacturer

A. Products shall be provided by the following manufacturers:

1. AAON, Trane, York, Daikin

2. Substitute equipment may be considered for approval that includes at a minimum:

   a. R-410A refrigerant

   b. ECM driven direct drive backward curved plenum supply fans

   c. Double wall cabinet construction

   d. Insulation with a minimum R-value of 6.25

   e. Double-sloped stainless steel drain pans

   f. Hinged access doors with lockable handles

   g. LED service lights in the control panel

   h. Designed, engineered, and manufactured in the United States of America

   i. All other provisions of the specifications must be satisfactorily addressed

2.02 Air Handling Units

A. General Description

1. Indoor air handling units shall include filters, supply fans, DX evaporator coil, mixing box, and unit controls.

2. Unit shall have a draw-through supply fan configuration and discharge air vertically.

3. Unit shall be factory assembled and tested including leak testing of the coils and run testing of the supply fans and factory wired system. Run test report shall be supplied with the unit in the control compartment’s literature packet, and also available electronically after the unit ships.
4. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

5. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

6. Installation, Operation and Maintenance manual shall be supplied within the unit.

7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s hinged access door.

8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s hinged access door.

B. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

2. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel and prevents exterior condensation on the panel.

3. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

4. Access doors shall be flush mounted to cabinetry.

6. Unit shall include a 5-inch forklift base.

7. Units with a cooling coil shall include double-sloped 304 stainless steel drain pan. Drain pan connection shall be on the right hand side of unit with a 1" MPT fitting.

8. Cooling coil shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.

9. Unit shall include factory wired control panel compartment LED service lights.

C. Electrical

1. Unit shall be provided with an external control panel with separate low voltage control wiring with conduit and high voltage power wiring with conduit between the control panel and the unit. Both side walls of the control panel shall include louvered vents. Control panel shall be field mounted and shall include a piano hinged service access door with tooled entry.

2. Unit shall be provided with standard power block for connecting power to the unit.

3. Unit shall include a factory installed 24V control circuit transformer.
4. Unit shall have a 5kAIC SCCR.

5. Unit shall be provided with remote safety shutdown terminals for wiring to a field installed smoke detector, firestat, or building safety automatic shutdown system.

D. Supply Fans

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.

2. Blower and motor assembly shall be dynamically balanced.

3. Motor shall be a high efficiency electronically commutated motor (ECM).

4. Blower and motor assembly shall be mounted on rubber isolators.

5. ECM driven supply fan speed shall be controlled with the factory installed AAON controller.

6. Access to supply fan shall be through an access door with removable pin hinges and lockable quarter turn handles.

E. Cooling Coil

1. Access to cooling coil shall be through hinged access door with lockable quarter turn handles.

2. Evaporator Coil

   a. Coil shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

   b. Coil shall be 6 row high capacity and 12 fins per inch.

   c. Coil shall be hydrogen leak tested.

   d. Coil shall be furnished with factory installed thermostatic expansion valves. The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.

   e. Coil shall have right hand external piping connections. Liquid and suction connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

F. Refrigeration System

1. Air handling unit and matching condensing unit shall be capable of operation as an R-410A split system air conditioner.

2. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.

G. Filters

1. Unit shall include 2 inch thick, pleated panel filters with MERV rating of 8, upstream of the cooling coil.

H. Mixing Box
1. Unit shall contain a mixing box with front return air opening and top outside air opening.

2. Return air opening shall contain an adjustable, motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Dampers shall be fixed position.

3. Outside air opening shall contain an adjustable, motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Dampers shall be fixed position.

I. Controls

1. Unit shall be provided with a proof of airflow switch. When airflow is not detected, the supply fans will shut down.

2. Unit shall be provided with an external control panel with separate low voltage control wiring with conduit and high voltage power wiring with conduit between the control panel and the unit. Control panel shall be field mounted.

3. Access to external control panel shall be through hinged access door with tooled entry.

4. Factory Installed and Factory Provided Controller
   a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
   b. Controller shall be capable of stand alone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
   c. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
   d. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
   e. Variable Air Volume Controller
      1. Unit shall utilize a variable capacity compressor system and a variable speed supply fan system to modulate cooling and airflow as required to meet space temperature cooling loads and to save operating energy. Supply fan speed shall modulate based on supply air duct static pressure. Cooling capacity shall modulate based on supply air temperature.
      2. Hot gas bypass shall be required on the lead refrigeration circuits of systems without variable capacity compressors.
         a. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit.
controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a LonWorks or BACnet network.

Part 3 - Execution
3.01 Installation, Operation and Maintenance
   a. Installation, Operation and Maintenance manual shall be supplied with the unit.
   b. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.
   c. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

H. SPLIT SYSTEM OUTDOOR UNIT

Part 1 - General
   Related Documents
   General Description
   A. This section includes the design, controls and installation requirements for air-cooled condensers / condensing units.

Quality Assurance
   b. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
   c. Energy Efficiency Ratio (EER) shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
   d. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL/ETL Canada label.

Submittals
   a. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, factory supplied accessories, electrical characteristics, and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided.
   b. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, clearances, and connection details. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

Delivery, Storage, and Handling
   a. Unit shall be shipped on a wooden pallet with skeleton crating prior to shipment with doors bolted shut to prevent damage during transport and thereafter while in storage awaiting installation.
   b. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.
c. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.

Warranty

a. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance and refrigerant.

Part 2 - Products

Manufacturer

A. Products shall be provided by the following manufacturers:

1. AAON, Trane, York, Daikin

2. Substitute equipment may be considered for approval that includes at a minimum:
   a. R-410A refrigerant
   b. Hinged access doors with lockable handles
   c. Variable capacity compressor with 10-100% capacity
   d. 2,500 hour salt spray tested exterior corrosion protection
   e. Designed, engineered, and manufactured in the United States of America
   f. All other provisions of the specifications must be satisfactorily addressed

Condensing Units

A. General Description

1. Air-Cooled condensing unit shall include compressors, air-cooled condenser coils, condenser fans, filter driers, and suction and liquid connection valves.

2. Unit shall be factory assembled and tested including leak testing of the coil and run testing of the completed unit. Run test report shall be supplied with the unit in the control compartment.

3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

4. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

5. Installation, Operation and Maintenance manual shall be supplied within the unit.

6. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s access door.

7. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s access door.

B. Construction
1. Unit shall be completely factory assembled, piped, and wired and shipped in one section.

2. All cabinet walls, access doors, and roof shall be fabricated of G90 galvanized steel panels.

3. Unit shall be specifically designed for outdoor application.

4. Access to compressors and control components shall be through hinged access doors with quarter turn, lockable handles.

5. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

6. Unit shall include forklift slots.

C. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage provided to the unit.

3. Unit shall have a 5kAIC SCCR.

D. Refrigeration System

1. Unit shall be provided with one independently circuited R-410A variable capacity scroll compressor with thermal overload protection. Variable capacity scroll compressor shall be capable of modulation from 10-100% of its capacity.

2. Each compressor shall be furnished with a crankcase heater.

3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged access doors shall provide access to the compressors.

4. Compressors shall be isolated from the base pan with the compressor manufacturer’s recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.

5. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and service valves for liquid and suction connections. Liquid line filter driers shall be factory provided and installed. Field installed refrigerant circuits shall include the low side cooling components, refrigerant, thermal expansion valve, liquid line and insulated suction line.

6. Unit shall include a factory holding charge of R-410A refrigerant and oil. Adjusting the charge of the system will be required during installation.

7. Unit shall include 1 stage of capacity control.

8. The unit shall be capable of stable cooling operation to a minimum of 55°F outdoor temperature.

E. Fans

1. Condenser fan shall be horizontal discharge, axial flow, direct drive fans.
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2. Fan motor shall be weather protected, single phase, direct drive, and semi-enclosed air over with thermal overload protection.

F. Coils

1. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

2. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.

3. Coils shall be hydrogen leak tested.

G. Controls

1. Unit shall be provided with factory supplied and factory installed VAV controller in the matching air handling unit.

Part 3 - Execution

Installation, Operation, and Maintenance

A. Installation, Operation and Maintenance manual shall be supplied with the unit.

B. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation and Maintenance manual instructions.

C. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

I. MINI-SPLIT WALL MOUNT UNIT

   1. The indoor unit shall be capable of the following ambient operating range.

      a) Cooling: 53°F WB to 75°F WB

      b) Heating: 60°F DB to 86°F DB

   General

      1. Unit shall be manufactured by LG.

      2. Unit shall be factory assembled, wired, piped and run tested.

      3. Unit shall be designed to be installed for indoor application.

      4. Unit shall be attached to an installation plate/bracket that secures unit to the wall.

      5. The depth of the unit shall not exceed 9 inches.

   Casing/Panel

      1. Unit case shall have a pearl white finish: Munsell 7.5BG 10/2 (RAL 9016).

      2. The front surface of the unit shall have an architectural curved panel with pearl white finish and integrated digital display.

   Cabinet Assembly

      1. Unit shall have one supply air outlet and one return air inlet.

      2. Unit shall be equipped with factory installed temperature thermistors for
a) Return air
b) Refrigerant entering coil
c) Refrigerant leaving coil

3. Unit shall have a built-in control panel to communicate with the outdoor unit.
4. Unit shall have the following functions as standard
   a) Self-diagnostic function
   b) Auto restart function
c) Auto changeover function
d) Auto clean function
e) Dehumidifying function
f) Hot Start
g) Sleep mode

5. Unit shall be capable of refrigerant piping in 4 different directions.
6. Unit shall be capable of drain piping in 2 different directions.

Fan Assembly
1. The unit shall have a direct drive, cross flow fan made of high strength ABS plastic.
2. The fan motor is Brushless Digitally controlled (BLDC) with permanently lubricated and sealed ball bearings.
3. The fan/motor assembly shall be mounted on vibration attenuating rubber grommets.
4. The fan speed shall be controlled using microprocessor based direct digitally controlled algorithm.
5. In cooling mode, the indoor fan shall have the following settings: Low, Med, High, Power Cool, and Auto.
6. In heating mode, the indoor fan shall have the following settings: Low, Med, High, Power Heat, and Auto.
7. The Auto fan setting shall adjust the fan speed to most effectively achieve the set-point.
8. Unit shall have factory installed motorized louver to provide flow of air in up and down direction for uniform airflow.
9. Unit shall have factory installed motorized guide vane to control the direction of flow of air from side to side.

Filter Assembly
1. The return air inlet shall have a factory supplied primary removable, washable filter.
2. The unit shall be equipped with factory supplied secondary Dust Filter.
3. The filter access shall be from the front of the unit.

Coil Assembly
1. Unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
2. Unit shall have minimum of 2 rows of coils.
3. Unit shall have a factory supplied condensate drain pan below the coil.
4. Unit shall be designed for gravity drain.
5. Unit shall have a factory insulated drain hose to handle condensate.
6. Unit shall have provision of 45° flare refrigerant pipe connections
7. The coil shall be factory pressure tested at a minimum of 551 psig.
8. All refrigerant piping from outdoor unit to indoor unit shall be field insulated.

Microprocessor Control
1. The unit shall have a factory installed microprocessor controller capable of performing functions necessary to operate the system.
2. The unit shall be able to communicate with the outdoor unit using a field supplied minimum of 18 AWG, 4 conductor, stranded, shielded or unshielded power/communication cable. If shielded, it must be grounded to chassis at ODU only.
3. Central control shall be available through an optional control board for the outdoor unit.
4. The unit shall be capable of setting Cooling Only and Heating Only operation.
5. The unit controls shall operate the indoor unit using one of the five operating modes:
   a) Auto changeover
   b) Heating
   c) Cooling
   d) Dry
   e) Fan only

Electrical
1. The unit electrical power shall be 208-230/1/60 (V/Ph/Hz)
2. The unit shall be capable of operating within voltage limits of +/- 10% of the rated voltage.

Condensate Sensor Connection
1. The unit shall include a factory installed condensate sensor connection compatible with the condensate sensor.

Controls
1. The indoor unit shall be supplied with a wireless handheld controller.
2. An optional wired controller shall be available as an additional accessory.

Warranty
1. Please refer to the respective outdoor unit for applicable warranty.

J. MINI-SPLIT OUTDOOR UNIT
Part 1. PRODUCT(S) – Outdoor Units (Single Zone Systems- Wall Mounted)

1.01 Single Zone Heat Pump Outdoor Unit (Wall Mounted)

A. Product Design

1. The Single zone HVAC system shall be a variable capacity, direct expansion (DX) heat pump system consisting of a single outdoor unit and single indoor unit. The outdoor unit shall have a single inverter compressor. The outdoor unit shall be connected to the indoor unit with piping and control wiring.

2. The LG heat pump system shall be an air cooled system consisting of a single outdoor unit connected to a single indoor unit.

3. Single zone system requires the indoor unit to be piped with the outdoor unit to complete the refrigeration system

4. The heat pump system will be available in 208/230V, 60Hz, 1 phase

B. Operating Conditions

5. The outdoor unit shall be capable of the following ambient operating range.

   i. With optional low ambient kit from 0°F DB to 118°F DB

   ii. Heating: -4°F WB to 65°F WB

C. General

6. Unit shall be manufactured by LG, Sanyo, Daikin, or Approved Equivalent.

7. The air-conditioning system shall use R410A refrigerant.

8. The system shall have one air source outdoor unit.

9. The refrigerant circuit shall be field piped to a single matching indoor unit to effectively and efficiently control the heating or cooling operation of the system.

10. All refrigerant piping from outdoor unit to indoor unit shall be field insulated.

11. Factory installed microprocessor controls in the outdoor unit and indoor unit shall perform functions to efficiently operate the single zone system and communicate via minimum 18 AWG, 4 conductor, stranded, shielded or unshielded power/communication cable. If shielded, it must be grounded to chassis at ODU only.

12. The outdoor unit shall be internally assembled, wired and piped from the factory.

13. The factory assembled system shall have the outdoor unit fitted with refrigerant strainer, check valves, oil separator, accumulator, 4-way reversing valve, electronic expansion valve, high side and low side refrigerant charging ports, and a service port.

D. Piping Capabilities

14. The outdoor unit shall be capable of operating at an elevation of 49.2 feet above or below the indoor units.

15. The outdoor unit shall be capable of operating with up to 114.8 feet of total equivalent refrigerant piping length.

E. Defrost Operations

16. The outdoor unit shall be capable of auto defrost operation to melt accumulated ice off the outdoor unit heat exchanger. The defrost cycle control shall be based on outdoor ambient temperatures and outdoor unit heat exchanger temperatures.

F. Oil Management
17. The outdoor unit shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts at low speed.
18. The outdoor unit shall have an oil separator to separate oil mixed with the refrigerant gas during compression and return oil to the compressor.

G. Cabinet
19. The outdoor unit cabinet shall be made of pre-coated metal (PCM).
20. The front/side panels of the outdoor unit shall be removable type for access to internal components.
21. Outdoor unit cabinet shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.

H. Fan Assembly
22. The outdoor unit shall be equipped with one direct drive variable speed propeller fan with Brushless Digitally Controlled (BLDC) motor with a horizontal air discharge.
23. The fan blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
24. The fan shall be equipped with permanently lubricated bearings.
25. The fan motor shall have variable speed to a maximum of 950 RPM.
26. The fan shall have a raised guard to help prevent contact with moving parts.

I. Outdoor Coil
27. The outdoor unit shall have a factory built coil comprised of aluminum fins mechanically bonded on copper tubing.
28. The aluminum fins shall have factory applied corrosion resistant material.
29. Coil coating shall be tested in accordance with ASTM B-117 salt spray test procedure for a minimum of 1000 hours.
30. The outdoor unit coil shall be factory tested to a pressure of 600 psig.
31. The coil for each outdoor unit shall have a minimum of 14 Fins per Inch (FPI).
32. The coil for each outdoor unit shall have a 2 row heat exchanger.
33. The outdoor unit cabinet shall have a coil guard.

J. Compressor
34. Each 1.5 to 3 ton outdoor unit shall be equipped with one hermetically sealed, digitally controlled, inverter driven twin-rotary compressor.
35. The compressor shall be mounted on vibration attenuating rubber grommets.
36. The compressor shall use a factory charge of Polyvinyl Ether (PVE) oil.
37. The compressor bearing(s) shall have Teflon™ coating.
38. The compressor shall be equipped with over-current protection.

K. Sound Levels
39. The outdoor unit shall have sound levels not exceeding 57 dB(A) tested in an anechoic chamber under ISO 3745 standard.

L. Sensors
40. The outdoor unit shall have
41. Suction temperature sensor
42. Discharge temperature sensor
43. High pressure sensor
44. Low Pressure sensor
45. Outdoor temperature sensor
46. Outdoor unit heat exchanger temperature sensor

M. Wind Load Installations for Outdoor Units
47. LG FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010

N. Warranty
1. Limited Warranty Period
   a) STANDARD FIVE (5) YEAR WARRANTY FOR A QUALIFIED SYSTEM - The Part(s) of a qualified System, including the compressor, are warranted for a period (the “Standard Parts Warranty Period”) ending five (5) years after the date of substantial completion.
   b) ADDITIONAL TWO (2) YEAR COMPRESSOR PART WARRANTY - The Compressor is warranted for an additional two (2) year period after the end of the applicable Standard Part Warranty Period (the “Compressor Warranty Period”).

48. Extended Warranty
   a) The Standard Warranty Period and the Compressor Warranty Period are extended to a total of ten (10) years (the “Extended Warranty Period”) for qualified Systems that have been (a) installed by a party that has completed the Training Requirements, (b) installation is pursuant to LG’s published instructions, and (c) product is registered within 60 days of startup at www.lg-dfs.com or www.lg-dfs-warranty.com.

K. HUMIDIFIER

Part 1 - General

1.1 Work Included
   a) Humidifier[s] as indicated on drawing[s] and as indicated on schedule[s].
   b) Complete and operable humidification system [which meets applicable building codes].
   c) Equipment start-up and project inspection by qualified factory trained representative.

1.2 Quality Assurance:
   a) ISO 9001-2000.
   b) ANSI/NFPA 70 - National Electrical Code.
   c) ARI 640, "Standard for Commercial and Industrial Humidifiers.

1.3 Submittals:
   a) Submit product data under provisions of Section 23 01 00. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes. Include rated capacities, operating weights, furnished specialties, and accessories.
   b) Submit manufacturer's installation instructions.
   c) Submit operation and maintenance data.
   d) Submit coordination drawings. Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, and dispersion tubes. Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, and required clearances.
e) Submit wiring diagrams including power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

f) Submit minimum water quality requirements and water pressure requirements.

1.4 Schedules:
   a) Refer to information contained in schedule[s] attached to this specification.
   b) Humidifiers to be of type, capacity, and arrangement as listed in schedule[s].
   c) Include accessories listed in schedule[s] and those accessories required for type of unit.

2.0 Part 2 - Products

2.1 STEAM EXCHANGE HUMIDIFIER – SETC

2.1.1 The CONDAIR SETC Outdoor steam exchange system uses all water types including, De-Ionized (DI), Reverse Osmosis (RO), potable and softened water.

2.1.2 Packaged unit, wall mounted, steam exchange humidifier operating with boiler steam pressures between 5 psi to 15 psi, with output capacities up to 1050 lbs/hr (477 kg/hr).

2.1.3 Unit [s] to be complete with:

   a) Enclosed cabinet, powder painted steel construction and air gap between cabinet and insulated humidifier tank ensures safe surface temperature.

   b) All tank surfaces shall be insulated with minimum 1" (25 mm) thick insulation and enclosed within unit cabinets to ensure safe surface temperature, high overall efficiency, and fast unit response time. Units with exposed insulation shall not be acceptable.

   c) Standard internal drain water cooler to ensure drain water tempering to 140° F [60° C]. If external drain water cooler required, provide factory cross-braced unit stand and factory supplied stainless steel water seal.

   d) Blow-down p-trap, factory installed, enclosed in cabinet, prevents steam leakage to drain. Field installation not acceptable.

   e) Humidifier to prevent “back-siphoning” using an internal air gap for supply water, to meet local plumbing codes.

   f) Drain line to include a vacuum breaker to prevent siphon drainage of the tank.

   g) Stainless steel heat exchanger[s] shall have flat surfaces to retard scale build-up. Tubular heat exchangers are not acceptable.

   h) Stainless Steel heat exchanger[s] shall be heat treated to protect against possible stress corrosion cracking. Heat exchanger[s] that are not heat treated stainless steel are not acceptable.

   i) Stainless steel tank lid with gasket, easily removed for maintenance.

   j) Tank must have replaceable magnesium alloy sacrificial anode.

   k) Float and thermostatic (F & T) trap[s], must be included internal to the unit.

   l) Automatic water level control within a separate float chamber, isolated from the boiling action, to prevent false water level indication.

   m) Dual magnetic electronic float system, located outside of the boiling water to ensure accurate water level
control and reduced maintenance. Cool fill water is to be supplied into the sensing chamber to keep the device cool. Systems using conductivity probes or floats located within hot reservoir water are not acceptable.

n) Humidifier shall have a dual fill valve to feed water to the tank and float chamber, to reduce scaling and mineral build up on the magnetic floats.

o) Float chamber to include LED indication of five possible water level indications.

p) Pre-cleaning flushing feature shall be provided to reduce maintenance time.

q) Must include end of season blow-down feature to evacuate contained water and minerals after 72 hours with no demand for humidification.

r) Factory mounted, full size, backlit, Liquid Crystal Display provides full operational status. Display to include a keypad for user interface and adjustment of operational parameters.

2.2 SHORT ABSORPTION STEAM DISTRIBUTOR

2.2.1 Steam Distribution – Condair Short Absorption Manifold complete with:

a) Steam dispersion panel consisting of a (one) horizontal stainless steel header supplying steam to a bank of vertical tubes, spaced closely as necessary to meet absorption distance requirements, and to reduce condensation loss. Refer to schedule[s] for project specifics.

b) Single horizontal stainless steel header to provide steam to vertical distributor tubes and to reduce condensation losses. Dual header systems creating unnecessary heat loss, or systems needing to be installed on a partition or requiring blank off plates are not acceptable.

c) Headers shall be welded stainless steel construction.

i) Header design is primarily round tube to minimize pressure drop. Square headers are not acceptable. (Full size SAM-e only).

iii) Steam inlet and condensate return located on same side of header to allow single point entry and floor mounting. Condensate return shall be located at lowest point of header.

d) Vertical stainless steel distribution tube to promote condensation evacuation. Horizontal distributor tubes are not accepted.

e) Tubes shall be primarily stainless steel construction.

i) Distribution tubes shall include provisions for a top bracket. Factory supplied top bracket shall be provided to ensure adequate support of tubes in duct.

ii) Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Tubes without nozzle inserts are not acceptable.

iii) Stainless steel nozzles shall be made from similar material as the tubes to ensure similar expansion and contraction coefficients. Tubes with nozzles made from dissimilar metals or polymers are not acceptable.

iv) Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
f) Steam Inlet

  g) Steam inlet configuration selection based on pressurized or atmospheric steam applications. Refer to schedule[s] for project specifics.

    a) For pressurized steam, inlet is determined by the size of the selected steam valve.
    
    b) For atmospheric steam, inlet is determined by the selected humidifier.

h) Insulation

  i) Tubes and headers include insulation for increased energy efficiency. Uninsulated tubes and headers not acceptable.

    i) Tube and header insulation constructed from stainless steel shielding for increased energy efficiency and reduced airstream heat gain. Stainless steel shields to be isolated from distributor using plenum rated synthetic foam strips. Insulation to provide air-gap to minimize conduction and convection, as well provide reflective surface to minimize radiating heat transfer. Tubes and/or headers insulated with ceramic or foam wrap type insulations not acceptable.

L. LABORATORY AIRFLOW EXHAUST VALVES

PART 1 - GENERAL

A. Laboratory Airflow Control System (LACS) shall be bid as a separate equipment package and installed by the Contractor. An allowance shall be carried by the controls contractor for the start-up and commissioning of the system. The Contractor shall be responsible for the coordination of the installation and shall coordinate the final material order with the Owner to verify the valves ordered are the correct orientation per the BIM coordination drawings.

B. The LACS shall be capable of operating as a standalone system and shall be completely independent of the building DDC System.

1.01 SUMMARY.

A Laboratory Airflow Control System (LACS) shall be furnished and installed under this section. The LACS shall be capable of operating as a standalone system or as a system integrated with the Building Management System (BMS) or Building Automation System (BAS).

1.02 REFERENCES.

A. Abbreviations and Acronyms

    ATC – Advanced Temperature Control
    BMS – Building Management System
    BAS – Building Automation System
    LACS – Laboratory Airflow Control System
    UBC – Usage Based Controls
    VAV – Variable Air Volume
    TTW – Through The Wall (sensor)
    ZPS – Zone Presence Sensor
    PIN – Personal Identification Number

B. Reference Standards

1. Air Conditioning and Refrigeration Institute
   ARI 880 Performance Rating of Air Terminals

2. American Society of Heating, Refrigeration, and Air Conditioning Engineers / American National Standards Institute
ASHRAE/ANSI Standard 130, Methods for Testing Air Terminal Units
3. American National Standards Institute / American Society of Heating, Refrigeration, and Air Conditioning Engineers

1.03 ADMINISTRATIVE REQUIREMENTS
A. Coordination
   The LACS representative shall coordinate all details of the installation with the successful mechanical contractor. This effort shall include complete coordination of the sheet metal layout drawings to assure that the ductwork layout and sizing is based on the actual sizes of the airflow control valves for this project.
B. Pre-installation Meetings
   1. The LACS representative shall review the proper installation of the system with the sheet metal contractor and the building management system (BMS) contractor.
   2. Project Installation Phase – The LACS representative shall make periodic visits to the project jobsite to assure that the system is being installed properly to assure optimal performance and that the location and orientation of the control valves is consistent for proper operation and future owner maintenance. Any discrepancies shall first be brought to the attention of the appropriate subcontractor. If no action is taken by said contractor, the representative shall bring these issues to the project manager, engineer or owner’s representative for resolution.

1.04 SUBMITTALS
A. General: Submit listed Submittals in accordance with Conditions of the General Contract and Division 1 Submittal Procedures Section. LACS submittals shall contain, at a minimum, the following information:
   1. Product Data Sheets
   2. Equipment Schedule Sheets containing Room#, Tag#, Min/Max flows, Catalog# and other configuration data as required to provide a fully engineered LACS.
   3. Installation Instructions
   4. Project-specific Wiring Diagrams
   5. Points Lists

1.05 CLOSEOUT SUBMITTALS
A. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided as closeout submittals.
B. Integration checklists are encouraged; once the integration to the BMS or BAS is completed, it is recommended that the Phoenix Controls Representative Partner meet with the BMS or BAS contractor to do a final acceptance test of the integration. This testing should include:
   1. Testing points to ensure communication
   2. Testing setpoints such as temperature, occupancy, room offset, etc
   3. Testing various alarms in different parts of the system
   4. Testing to ensure that equipment will cycle after a power loss

1.06 QUALITY ASSURANCE
A. Certifications
   1. The laboratory airflow system provider shall be an entity that designs, develops, manufactures and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001:2008.
   2. The Laboratory airflow system provider shall be ROHS compliant in all its products
   3. The Venturi valves shall be calibrated on NVLAP accredited air stations.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Storage and Handling Requirements
   1. Prior to installation, the LACS shall be stored in dry conditions within an environment complying with LACS product specifications as shown on product data sheets within the submittals.
   2. The LACS products shall be handled and transported in a manner consistent trade practices for control systems and instruments.

1.08 SITE CONDITIONS
The ambient environmental conditions during installation and operation shall comply with LACS product specifications as shown on the product data sheets within the submittals.

1.09 WARRANTY
The Warranty shall commence upon the date of shipment and extend for a period of 60 months for all airflow control devices and 36 months for all other control system components.

PART 2 - PRODUCTS

2.01 LABORATORY AIRFLOW CONTROL SYSTEMS
A LACS shall be furnished and installed to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator’s presence in front of the fume hood. The laboratory control system shall vary the amount of make-up/supply air into the room to operate the laboratories at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates and maintain laboratory pressurization in relation to adjacent spaces (positive or negative). The LACS shall be capable of operating as a standalone system or as a system integrated with the Building Management System (BMS). An optional locally mounted user interface terminal shall be available to allow room-level control variables to be displayed, and where appropriate, edited to adjust control operation.

2.02 COMPONENTS
A. USAGE BASED CONTROL® EQUIPMENT
1. For variable air volume (VAV) systems, a sash sensor shall be provided to measure the height of each vertically moving fume hood sash. A sash sensor shall also be provided to measure the opening of horizontal overlapping sashes. Control systems employing sidewall-mounted or through the wall (TTW) velocity sensors to control the fume hood exhaust airflow shall be unacceptable. Sidewall-mounted or through the wall (TTW) sensors shall only be used as a reference or to provide a secondary alarm indication relative to operating face velocity.
   a. The sensor shall define an adjustable detection zone that extends approximately 20 inches (50 cm) from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within 30 to 3,000 seconds, it shall command the system to the user-adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in-use face velocity within 1.0 second.
   b. The sensor shall sense an inanimate object when placed in the detection zone and remain in the standard mode of operation for 30 to 3,000 seconds, after which it will return to a standby mode. Operators shall enter and leave the zone with the unit adjusting automatically between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall adapt to the change automatically.
   c. The sensor shall have an adjustable detection zone capable of covering a fume hood up to eight feet wide and be mounted from six to 12 feet above the floor surface.
   d. The sensor shall be configurable for varying levels of lighting intensity and motion sensitivity.
   e. The sensor shall have the ability to operate on either AC or DC power sources.
   f. Wide area motion detectors (on the hood or at the room level) shall be unacceptable.
   g. Motion detectors that rely solely on Doppler shift radar or similar technology for motion detection shall be unacceptable.
2. A Zone Presence Sensor (ZPS) shall be provided to determine an operator’s presence in front of a hood by detecting the presence and/or motion of an operator, and to command the LACS from an in-use operating face velocity (e.g., 100 fpm) to a standby face velocity (e.g., 60 fpm) and vice versa.
   a. The sensor shall define an adjustable detection zone that extends approximately 20 inches (50 cm) from the front of the fume hood. If the sensor does not detect presence and/or motion in its detection zone within 30 to 3,000 seconds, it shall command the system to the user-adjustable standby face velocity. When the sensor detects the presence and/or motion of an operator within the detection zone, it shall command the system to the in-use face velocity within 1.0 second.
   b. The sensor shall sense an inanimate object when placed in the detection zone and remain in the standard mode of operation for 30 to 3,000 seconds, after which it will return to a standby mode. Operators shall enter and leave the zone with the unit adjusting automatically between in-use and standby modes. If the inanimate object is moved or taken out of the zone, the unit shall adapt to the change automatically.
   c. The sensor shall have an adjustable detection zone capable of covering a fume hood up to eight feet wide and be mounted from six to 12 feet above the floor surface.
   d. The sensor shall be configurable for varying levels of lighting intensity and motion sensitivity.
   e. The sensor shall have the ability to operate on either AC or DC power sources.
   f. Wide area motion detectors (on the hood or at the room level) shall be unacceptable.
   g. Motion detectors that rely solely on Doppler shift radar or similar technology for motion detection shall be unacceptable.
3. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow set points to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to assure flow through the fume hood even with the sash fully closed.

B. AIRFLOW CONTROL DEVICE - GENERAL
1. The airflow control device shall be a Phoenix Controls Accel II pressure independent venturi valve.
4. All Components of the valve, its controllers, and wiring shall be ROHS compliant.
5. The airflow control device shall be mechanically pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change (within product specifications) or quantity of airflow controllers on a manifolded system.
6. The airflow control device shall maintain accuracy within ±5% of signal to set point over an airflow turndown range of no less than:
   a. 12.5 to 1 (medium pressure all valve sizes)
   b. 16 to 1 (medium pressure w/o 14” valve)
   c. 7 to 1 (low pressure all valve sizes)
   d. 11 to 1 (low pressure w/o 14” valve)
   e. 8 to 1 (medium pressure shut-off all valve sizes)
   f. 14 to 1 (medium pressure shut-off w/o 14” valve)
   g. 5 to 1 (low pressure shut-off all valve sizes)
   h. 9 to 1 (low pressure shut-off w/o 14” valve)
7. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
8. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence.
9. The airflow control device shall maintain pressure independence regardless of loss of power. “Electrically pressure independent” devices will not be acceptable.
10. Airflow control devices utilizing ASHRAE 130 minimum operating pressure as a rating for minimum design pressure at required flow will not be acceptable on basis on minimum operating pressure alone. Valve manufacturer will provide minimum required differential pressure in writing for each size valve they offer.
11. Airflow control device shall be able to achieve its maximum turndown ratio at its stated minimum operating differential pressure. I.E. if minimum operating pressure is 0.6” wc dp, a 10” air valve must be able to achieve its minimum of 50cfm and its maximum of 1000 cfm at stated 0.6” wc dp. Devices that require duct static pressure to be increased to achieve maximum flow shall not be acceptable.
12. The airflow control device shall be constructed of one of the following four types:
   a. Class A—The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of 16-gauge aluminum. The device's shaft and internal “S” link shall be made of 316 stainless steel. The shaft support brackets shall be made of galvanneal (non shutoff valves) or 316 stainless steel (shutoff valves). The pivot arm shall be made of aluminum (for non shutoff valves) and 303/304 stainless (for shut off valves). The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene) or PPS (polyphenylene sulfide) composite. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used.
   b. Class B—The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal “S” link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene) or PPS (polyphenylene sulfide) composite.
13. Actuation
   a. For high speed electrically actuated VAV operation, a CE certified, UL Listed, IP56 rated for dust and water, electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate fail-safe state. Options for these fail-safe states include: normally open-maximum position, normally closed-minimum position and fail-to-last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).

   In fail-safe conditions the Airflow Control Device must remain pressure independent and in control of airflow at its failed position. I.E. if a device fails in position at 500 cfm, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 500 cfm at that given control point regardless of duct pressure. Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.

   b. During normal operation, the high speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less.

   c. For Standard Speed electrically actuated VAV operation, a CSA certified, UL recognized (IP54 rating and CE certification optional on single valves, standard on dual valves) electronic actuator shall be factory mounted to the valve. The fail-safe state for standard speed operation valves shall be fail to last position unless otherwise noted.

   In fail-safe conditions the Airflow Control Device must remain pressure independent and in control of airflow at its failed position. I.E. if a device fails in position at 500 cfm, the airflow control device must remain pressure independent regardless of having power/controller operating and will deliver the 500 cfm at that given control point regardless of duct pressure. Airflow control devices with single or dual blades that fail in position or fail open will not be acceptable as the airflow delivered cannot be guaranteed due to device not being mechanically pressure independent.

   d. During normal operation, the standard speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 60 seconds (90 seconds for a shutoff valve from shutoff to maximum flow or vice versa).
      i. Standard speed actuation should not be used for valves that are connected to VAV fume hoods.
      ii. Standard speed actuation can be used on 2-state fume hoods or vented cabinets or snorkels with on/off conditions.
      iii. Constant volume valves do not require actuators.

14. The controller for the airflow control devices shall be microprocessor based and operate using peer-to-peer control architecture. The room-level airflow control devices shall function as a standalone network. The room-level control network shall utilize a LonTalk communications protocol.

15. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each laboratory control system shall have the capability of performing fume hood control, pressurization control, standard and advanced temperature control, humidity control, and implement occupancy and emergency mode control schemes. A Room controller or PLC performing these functions shall not be acceptable.
16. The LACS shall have the option of digital integration with the BMS or BAS. If digital integration device, room controller, laboratory space controller or similar is lost or offline or fails then the valve controllers shall have distributed controllability and will keep the basic room functions of zone balance, temperature, humidity control, offset control, etc. operating to maintain a safe and comfortable zone.

17. NVLAP Accreditation (Lab Code 200992-0)
   a. Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.
   b. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined accuracy of no more than ±1% of signal (5,000 to 250cfm), ±2% of signal (249 to 100cfm) and ±3% of signal (199 to 35cfm). Electronic airflow control devices shall be further characterized and their accuracy verified to ±5% of signal at a minimum of 48 different airflows across the full operating range of the device.
   c. Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.

C. EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER
   1. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
   2. During normal operation the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:
      a. 1 second or less with high speed actuation.
      b. 60 seconds for standard speed actuation (90 seconds from shutoff to max flow and vice versa).
   3. The airflow control device shall store its control algorithms in non-volatile, re-writable memory. The device shall be able to stand-alone or to be networked with other room-level digital airflow control devices using an industry standard protocol.
   4. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no separate room-level controller shall be required.
   5. The airflow control device shall use industry standard 24 VAC power.
   6. The airflow control device shall have provisions to connect a Phoenix Controls Workbench (WKB100) commissioning tool and every node on the network shall be accessible from any point in the system.
   7. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:
      a. Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25 degree C thermistor temperature sensors.
      b. One digital input capable of accepting a dry contact or logic level signal input.
      c. Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
      d. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.
   8. The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
   9. The airflow control device shall be ROHS compliant.

D. CONSTANT VOLUME AIRFLOW CONTROL DEVICE
   1. The airflow control device shall maintain a constant airflow set point. It shall be factory characterized and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.
2. Constant volume valves must be 100% mechanically pressure independent, and require no actuation to maintain set point.
3. Constant volume valves shall have no required electronics to maintain set point.
4. LACS suppliers not employing constant volume venturi airflow control valves shall provide pneumatic tubing or electrical wiring as required for their devices.

E. FUME HOOD DISPLAY
1. The display screen shall be a Phoenix Controls Sentry 3.2” (diagonal) color LCD resistive touch screen (240 x 320 RGB).
2. The touch screen shall support input configurations for fume hood operational parameters done at the touch panel at a minimum including:
   a. Sash Dimensions
   b. Hood ID
   c. Hood Certification Reminder
   d. Hood Occupancy Status
   e. Stopwatch/Timer
   f. Message Display

3. Hood configuration for the following properties shall be viewable and editable from the touch display:
   a. Sash Dimensions
   b. Hood ID
   c. Hood Certification Reminder
   d. Hood Occupancy Status
   e. Stopwatch/Timer
   f. Message Display

4. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down with non-solvent cleaning agents.
5. The unit’s exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), perchloric acid, sodium hypochloride/hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
6. Two mechanical membrane buttons shall be provided at the front panel of the display to enable users to quickly activate emergency exhaust mode and mute without having to remove protective gloves.
7. Flush mount or recess mount shall be installation options.
8. A USB port shall be provided to support firmware and software upgrades and shall be covered to protect against moisture or corrosion.
9. A timer feature shall be provided to enable users to set specific durations for experiments and provide visual and audible alarms when the set time is expired.
10. The fume hood display shall have an available I/O at its associated valve controller which may be used to receive a 0 – 10 volt signal from a Through-The-Wall (TTW) sensor. The TTW shall not control the valve but provide a drift alert to indicate when the TTW sensor reading is out of range relative to the sash position face velocity value.

11. POWER
   The device shall be powered by 24 VAC ± 15% at 10VA, 50/60 Hz.

12. CONFIGURATION
    a. Configuration shall be performed from the touch display and/or manufacturer’s software tools.
    b. The device shall be capable of being added to an existing LON communication network.
    c. The device shall display fume hood performance data based on control logics embedded inside the valve controller.

13. COMMUNICATION
a. The fume hood display unit shall connect to LON communication and link directly to a specific valve controller associated with the hood it is mounted on.
b. The device shall display fume hood performance data based on sash movements and valve controller performance over LON.

14. INFORMATION DISPLAY
a. The device shall have the ability to indicate when the fume hood face velocity is within the normal operating range as well as energy saving, hood certification, hood ID, timer, and hood occupancy status.
b. The device shall be configurable to display one of the following measurement units: cubic feet per minute (CFM), meters cubed per hour (m³/h), liters per second (L/s), feet per minute (fpm), or meters per second (m/s).
c. The device shall have the ability to display system errors caused by the airflow valve or sash travel.
d. The device shall have the ability to indicate to users when the hood is due for recertification by stating on the LCD display “Hood Cert. due MM/DD/YYYY”.

15. EMERGENCY (PURGE) EXHAUST
a. The display shall have a mechanical membrane button on the lower portion that when pressed will initiate an emergency (purge) exhaust mode in the attached fume hood valve(s).
   1) Button shall be mechanical so that users with rubber, nitrile, vinyl, latex, or other gloves can operate the emergency exhaust button.
b. The emergency (purge) exhaust mode, when initiated, will send the attached fume hood exhaust valve(s) to either the maximum flow of the valve or another predefined flow (as configured in the fume hood valve).

16. ALARMS
a. The device shall have the ability to show alarms on the main screen using visual and audible alerts.
b. The main screen background color shall change to flashing red with text stating the type of alarm.
c. In alarm state, the visual indication shall remain active until the event that triggered the alarm is removed or fixed.
d. The audible alarm tone shall be cleared only when the event that triggered the alarm is removed or fixed.
e. The device shall have an Alarm Muting option, which silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm shall override the mute delay and the alarm shall sound again.
f. The device shall have the ability to customize audible alarms levels and customize mute duration.
g. Users shall have the ability to change the volume of the alarm tone to low, medium, or high.
h. The device shall have the ability to show Diversity alarm.
   1) Diversity alarm shall be generated by the valve or from the BMS system.
   2) No audible tone for diversity alarm shall be generated at the fume hood display.

17. ENERGY CONSERVATION
a. The device shall have the ability to enable fume hood hibernation mode.
   1) When activated, with the sash fully closed and no chemicals present in the hood, the exhaust flow through the fume hood goes to the minimum allowed by the exhaust valve (or shut-off where available).
   2) The mode shall be initiated by a sequence including entering the menu and a password on the touch display, an external momentary switch input to the fume hood controller, or a network command via BMS or BAS.
   3) When activated, the LCD display shall show “Hood in Hibernation,” and the exhaust valve shall move to its minimum position or shutoff position.
4) Safety shall be built into the hibernation mode, whereby opening the fume hood sash shall automatically return the fume hood exhaust to an in-use operating volume as determined by the sash sensor. Fume hood hibernation shall be a point that can be integrated to the BMS or BAS system.

b. The device shall provide night time energy waste alarming to generate a visual and audible alarm to indicate that the fume hood sash is open beyond its minimum flow position and the lights in the room are off.
   1) When activated, the LCD display shall show “Energy Waste Close Sash” and the audible alarm shall sound until the sash is closed.
   2) The light levels at which the alarm is both initiated and cancelled shall be configurable.

c. The device shall provide sash energy waste alarming, which generates a visual and audible alert to notify when the fume hood sash is open beyond a configurable set position and no one is in front of the fume hood.
   1) When activated, the LCD display shall show “Energy Waste Close Sash” and remain until the sash is closed.

18. SECURITY
End users shall have the ability to enable a PIN pass code to prevent unauthorized changes to sash heights, airflow settings and other editable parameters.

19. COMPLIANCE
   a. The unit shall be certified as meeting regulatory compliance with CE, CUL, and RoHS.
   b. The unit shall be suitable for use with non-solvent wipe down and is designed to meet IP44 test standards.
   c. The device shall comply with part 15 of the FCC Rules. Operation is subject to the following two conditions:
      1) This device shall not cause harmful interference.
      2) This device shall accept any interference received, including interference that may cause undesired operation.

20. ENVIRONMENT
The operating temperature range shall be between 32 – 122°F (0 – 50°C).

2.03 ACCEPTABLE MANUFACTURERS
   A. Manufacturer List
      The plans and specifications for the LACS are based on systems and equipment manufactured by Phoenix Controls no substitutes.

2.04 PERFORMANCE/DESIGN CRITERIA
   A. Each laboratory shall have a dedicated LACS. Each dedicated LACS shall support a minimum of 20 network controlled airflow devices.
   B. The LACS shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood’s exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1. Use of Sidewall Sensors or Through The Wall (TTW) sensors to control the face velocity are unacceptable.
   C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from one to one and one-half feet per second.
   D. The hood exhaust airflow control device shall be switched automatically between in-use and standby levels based on the operator’s presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5% overshoot or undershoot.
E. The LACS shall maintain specific airflow (±5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 0.3" to 3.0" wc).

F. The LACS shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement, vortex shedding measurement, or velocity measurement to control room pressurization are unacceptable.

G. The LACS shall maintain specific airflow (±5% of signal) with a minimum turndown as specified in 2.2.B.4 to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

H. Airflow Control Sound Specification
   1. The LACS manufacturer shall provide comprehensive sound power level data for each size airflow control device. All data shall be obtained from testing in accordance with ASHRAE/ANSI Standard 130, Methods of Testing Air Terminal Units.
   2. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.
   3. If the airflow control device cannot meet the sound power levels required to achieve the sound criteria appropriate for the space, as determined by the engineer, a properly sized sound attenuator must be used. All sound attenuators must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device’s maximum rated flow rate not to exceed 0.20 inches of water.

2.05 OPERATION SEQUENCES
A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to hood flow demands, occupancy, and emergency control commands.

B. Volumetric Offset Pressurization Control
   The laboratory control system shall control supply and auxiliary exhaust airflow devices to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure (within specified range for medium or low pressure valves). This offset shall be field adjustable and represents the volume of air, which will enter (or exit) the room from the corridor or adjacent spaces.

   The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new set points to maintain the desired offset. The offset shall be adjustable as a configurable parameter in the LACS as set by startup technician or BMS/BAS.

   The pressurization control algorithm shall consider both networked devices, as well as:
      I. Up to three non-networked devices providing a linear analog flow signal.
      II. Any number of constant volume devices where the total of supply devices and the total of exhaust devices may be factored into the pressurization control algorithm.

   Volumetric offset shall be the only acceptable means of controlling room pressurization. Systems that rely on differential pressure as a means of control shall provide documentation to demonstrate that space pressurization can be maintained if fume hood sashes are changed at the same time a door to the space is opened.

   The volumetric offset control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices in order to optimize air distribution in the space.

C. Temperature Control
   1. Standard Primary Temperature Control
The laboratory control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The laboratory control system shall support up to four separate temperature zones for each pressurization zone. Each zone shall have provisions for monitoring up to five temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writeable from the BMS, with the option of a local offset adjustment. Temperature control shall be implemented through independent primary cooling and heating control functions. Primary heating shall be provided through the use of a modulating control of a properly sized reheat coil. Primary cooling shall be provided as a function of volumetric override or through auxiliary modulating control of a chilled water valve. Volumetric override will command both supply and general exhaust valves to maintain desired offset as a high select zone control. Volumetric cooling override may be staged before or after chilled water control valve.

D. Occupancy Control
The laboratory control system shall have the ability to change the minimum ventilation and/or temperature control set points, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the BMS as a scheduled event or through the use of a local occupancy sensor or switch. The laboratory control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over a BMS command.

E. Emergency Mode Control
The laboratory control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow set point. The system shall support up to four emergency control modes (zone or valve level). The emergency control modes may be initiated either by a local contact input or BMS command. Valve level emergency modes can be individually programmed on each valve as one of four emergency control modes. Zone level emergency modes will drive supply and exhaust valves to maintain or ignore zone offset (excludes control of hood valves). Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

F. Local Alarm Control
The laboratory control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output, as well as to the BMS. The alarm mask may be configured differently for each room-level system.

G. Diversity Alarm
The laboratory control system shall have the ability of monitoring the airflow values for the pressurized space and generating an alarm signal in the event the total exhaust flow exceeds a predetermined threshold. The diversity alarm is intended to allow the user to take diversity in the design and generate an alarm condition in the event the diversity threshold is compromised. This function must be available in either an integrated or standalone system.

H. Fume Hood Control
Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:
1. Accept command inputs to regulate the flow accordingly and make this command value available to the BMS.
2. Accept a sash position signal and make this value available to the BMS.
3. Accept a Zone Presence Sensor (ZPS) Usage Based Control signal to indicate user presence and make this signal available to the BMS. Wide range motion sensors or Doppler radar motions sensors are not acceptable.
4. Provide a flow feedback signal to the fume hood monitor, which may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the BMS.
5. Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device, in order to provide a local alarm indication. The fume hood airflow control device shall respond to changes in sash position and user presence within one second without hunting, in order to provide a constant 100-feet-per-minute face velocity when the fume hood is in use.

I. The laboratory control system shall be segregated into subnets to isolate network communications to ensure room-level control functions and BMS communications are carried out reliably. Each laboratory space or pressurization zone shall be on a single subnet. Phoenix Controls supplied Room Controllers or Room Integrators shall be used to isolate the subnets in a facility where BMS or BAS system is used, providing a maximum of 20 valve devices and 10 fume hood monitor per subnet.

J. The LACS shall support at least 20 networked valve devices and 10 fume hood displays in each pressurized zone.

K. All points shall be available through the interface to the BMS for trending, archiving, graphics, alarm notification and status reports. LACS performance (speed, stability and accuracy) shall be unaffected by the quantity of points being monitored, processed or controlled.

L. Refer to the BMS or BAS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.06 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. The LACS network shall have the capability of digitally interfacing with the BMS. The required software interface drivers shall be developed and housed in one or more dedicated interface devices furnished by the LACS supplier.

B. All room-level points shall be available to the BMS for monitoring or trending as shown in the following section F, Table 1. Integration Points. The LACS Integrator and/or Room Manager shall maintain a cache of all points to be monitored by the BMS. The room-level airflow control devices shall update this cache continually.

C. The Room-level network shall be LonTalk FTT-10A communications protocol.

D. Room Level Integration

1. The Room Level Integration device shall be a Phoenix Controls Integrator (PCI8000) or equivalent. Room Level Integration device shall be a standalone piece of hardware with embedded Niagara 3.8.213 or Niagara and will be used for commissioning and configuration of venturi valves and ancillary components such as Fume Hood Displays, and Input Output (I/O) modules when connected to a Phoenix Controls Workbench, Room Manager, or Supervisor.

After the Room Level Interface is commissioned it shall provide a web based user interface for device, network, and platform diagnostics as well as a Test and Balance web application for zone balance and airflow validation. Room Level interface will also provide a means of integrating on an open BACnet network via IP, Ethernet, or MS/TP to be field selectable at time of commissioning.

Room Level Integration device shall operate with the following platform and Operating System:

a. Platform

- ARM Cortex A8 or greater processor
- 1GB DDR SDRAM & 4 GB or greater Flash Memory
- Data Recovery Services with SDRAM
- Real-time clock

b. Operating System

- Niagara 4.4 or later for N4 implementation
- Niagara AX 3.8.213 or later for AX implementation

Room Level Integration device shall support a combination of the following network connection ports and communication protocols as standard or orderable options:

a. 2 Ethernet Ports (RJ-45 Connectors) – 10/100 Mbps
2 RS-485 on board port (3 Screw Connector on base board)
Up to 2 Dual port RS-485 expansion modules
Up to 4 LON modules 78 Kbps FTT 10
BAS protocol: BACnet over Ethernet, or BACnet over IP, or BACnet over MS/TP
BAS Implementation: Conformance Class 3 BIBBS-BBC (BACnet Building Controller)
BAS data transfer rates (points per second): Read requests – 50 sustained, 100 peak; Write
commands – 30 maximum
Room network: ANSI 709.1 LonTalk protocol
Room-level integration device shall support 200 devices maximum, of which up to 120 LON per table
below and the rest BACnet.
Each LON FTT-10A adapter on the Room Level interface shall support up to 20 nodes (LVC + LRC
+ PCM2) within a 30 device maximum per channel as defined in the LON chart below.
A total 5,000 points can be reported per room level integration device.
A PCI8000 to support pluggable local Input/Output (I/O) modules with the following options:

a. 16-Point Module
   - 8 Universal Inputs (Type 3 (10 k) Thermistors, 0 - 100,000 ohms, 0 - 10 volts, 4 - 20 mA with external resistor), Binary (pulse or dry contact) Input
   - 4 Relay Outputs (Form A contacts, 24 VAC or 24VDC @ 0.5 amp rated)
   - 4 Analog Outputs (0 - 10 VDC @ 4mA max (2500 ohms or greater))

34-Point Module
   - 16 Universal Inputs (Type 3 (10 k) Thermistors, 0 - 100,000 ohms, 0 - 10 volts, 4 - 20 mA with external resistor), Binary (pulse or dry contact) Input
   - 10 Relay Outputs (Form A contacts, 24 VAC or 24 VDC @ 0.5 amp rated)
   - 8 Analog Outputs (0 - 10 VDC @ 4mA max (2500 ohms or greater))

If the room level integration device drops off the network or loses power, it shall not cause the zone balance, temperature control, or fume hood devices to lose control. The room level valve devices should operate independently of the room level integration device. Laboratory space controller, room controller with hardwired control of hood, general exhaust and supply valves, or PLC with hardwired control of fume hood, general exhaust or supply valves for zone balance, temperature control, room offset, etc. will not be acceptable.

Room Level Integrator shall be able to integrate to BAS shall be through BACnet/IP, BACnet/Ethernet, BACnet MS/TP, or LON through on board communication adapters and shall be field configurable/upgradable.

E. Room Manager.

1. For buildings that require a single IP address to interface to the Building Management system (BMS) or Building Automation system (BAS) or where a local access point for all the Phoenix Controls Integrators (PCI8000’s), Valves and Ancillary components is necessary, a Phoenix

<table>
<thead>
<tr>
<th>LON Products</th>
<th>Counts as LON Node</th>
<th>Counts as LON Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI8000: Integrator</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>LVC: LON Valve Controller - Celeris</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>LVC: LON Valve Controller - Theris</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>LVC: LON Valve Controller - Traccel</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>LRC: LON Room Controller</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>PCM2: Programmable Control Module</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>LRC2: Local Display Unit</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>PTC: Phoenix Temperature Controller</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>FHD: Sentry Fume Hood Display</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Spyder: LON version</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>
Controls Room Manager (RMM100) shall be used. The Room Manager shall house the database wherein all the PCI8000 stations will reside, will provide a single BACnet IP port to be used to connect to the BMS or BAS system, will provide a means to access all the Phoenix Controls valve and Fume Hood Display configuration data, input/output module programming, diagnostic views, Lab Verification tools, as well as a central location to back up all the configuration data, valve characterization data, and balancing reports as generated from the Phoenix Controls Lab Verification Tool.

2. The Room Manager software shall operate on a physical Personal Computer or on a Virtual machine with the following platform and operating system(s):
   Niagara AX 3.8.213 or greater
   Processor:
   Intel Xeon CPU E5-2640 x64 or better
   Operating System:
   • Microsoft® Windows® 10
   • Microsoft® Windows® 8.1 Enterprise 64-bit
   Hard Drive:
   • 4 GB minimum
   e. Memory:
   • 1 GB minimum
   • 4 GB or more recommended for large systems
   f. Communications:
   Full-time high-speed ISP connection recommended for remote site access (i.e. T1, ADSL, cable modem)
   g. Network Support:
   • Two Ethernet adapters (10/100 Mb with RJ-45 connector)
   • Ethernet driver support for BACnet I/P

G. LACS critical environment integration shall support distributed network architecture from room level BACnet MS/TP segment or LON FTT-10 bus to a dedicated BACnet MS/TP segment, building BACnet/Ethernet, or BACnet/IP building backbone using single or multiple IP addresses. Backbone communication protocol must be field selectable/upgradable.

H. Communication between devices in a room or zone will operate independent of building level communications maintaining integrity of the airflow. LACS Building level communication, or loss of, will not disrupt the communication between devices in a room or zone.

I. LACS critical environment integration shall provide an easy means to access room level device health status at a room-by-room or building wide level via web page. The system health pages shall provide information to assist in diagnostics for:
   1. Online/Offline status for the room level integration appliance.
   2. Runtime information such as heap memory usage and CPU usage.
   3. Communication channel online/offline and configuration data.
   4. Device level online/offline information.
   5. Device level alarm information.
   6. Device level Configuration errors.

J. LACS critical environment integration shall provide an easy means to access a Test and Balance function tool at a room-by-room basis. Test and balance functions should include:
   1. Setting the devices in the room to various conditions in order to read airflow.
   2. Manually override the outputs for testing purposes.
   3. Adjust airflow to meet field acceptance tests.

K. LACS critical environment integration must be able to support SQL database for long term data storage.

L. LACS critical environment integration shall provide optional software to manage local backup and restore, entire site device management, building wide test and balance functions, building wide diagnostic tools, and building wide configuration tools. Software shall be field upgradable to support graphical dashboard displays.
2.07 CONTROL FUNCTIONS
A. The airflow control devices shall utilize peer-to-peer, distributed control architecture to perform room-level control functions. Master-slave control schemes shall not be acceptable. Control functions shall include, at a minimum, pressurization, temperature, and humidity control, as well as respond to occupancy and emergency control commands. Laboratory space controllers, PLC’s, or room controllers utilizing analog control of general exhaust, hood, and supply valves are not acceptable.

PART 3 - EXECUTION

3.01 INSTALLATION
A. The building management system (BMS) or building automation system (BAS) contractor shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the LACS supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels or use of fixed sash sensors with take up reels is also permitted. Sash interface boxes with interface cards shall be mounted in an accessible location. Sidewall sensors are not acceptable for use to control the fume hood valves. If sidewall sensors are installed for monitoring purposes or drift alarm, follow manufacturer installation instructions and reference Phoenix Controls control wiring details for connection to Phoenix valve controllers.
B. The BMS contractor shall install all Room Controllers and Room Integrators in an accessible location in or around the designated laboratory room.
C. The BMS shall install an appropriately sized and fused 24 VAC transformer suitable for NEC Class II wiring.
D. All cable shall be furnished and installed by the BMS contractor. The BMS contractor shall terminate and connect all cables as required. The BMS shall utilize cables specifically recommended by the laboratory airflow controls supplier.
E. The mechanical contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.
F. The mechanical contractor shall provide and install all reheat coils, Neutralizers, Silencers, and transitions.
G. The mechanical contractor shall provide and install insulation as required.
H. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.02 SYSTEM START UP
A. System start-up shall be provided by a factory-authorized representative of the LACS manufacturer. Start-up shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Start-up shall also provide electronic verification of airflow (fume hood exhaust, supply, make-up, general exhaust or return), system programming and integration to BMS (when applicable).
B. The balancing contractor shall be responsible for final verification and reporting of all airflows. For all field flow measurement devices the balancer shall produce a flow report that documents field flows vs device flow and associated error. This to be tabulated for each device location at several flows including min and max. Cost and responsibility to meet the specified performance to be carried by the LACS.

3.03 CLOSEOUT ACTIVITIES
A. Training
1. The LACS supplier shall furnish a minimum of eight hours of owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves and general troubleshooting procedures.
2. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

Table 1. Integration Points List

| HVAC EQUIPMENT | 23 0200-53 |
### M. FAN COIL UNIT

#### PART 1 GENERAL

1.1 SUMMARY
   A. This section includes fan coil units and accessories.

1.2 SYSTEM DESCRIPTION
   B. Unit shall be 4-Pipe Hydronic Heat/ Hydronic Cool

1.3 QUALITY ASSURANCE
   A. Coils shall be tested in accordance with AHRI Standard 440-2008. Each coil shall be factory tested for leakage at 300 psig air pressure with coil submerged in water.
   B. Base or standard units shall be ETL listed.

1.4 DELIVERY, STORAGE AND HANDLING

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<table>
<thead>
<tr>
<th>Point Description</th>
<th>Read/Write</th>
<th>Point Description</th>
<th>Read/Write</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve-Level (per Valve)</td>
<td>Read Only</td>
<td>Temperature Control (per Zone)</td>
<td>Read Only</td>
</tr>
<tr>
<td>Flow Set Point</td>
<td>Read Only</td>
<td>Space Temperature</td>
<td>Read Only</td>
</tr>
<tr>
<td>Flow Feedback</td>
<td>Read Only</td>
<td>Avg Space Temperature</td>
<td>Read Only</td>
</tr>
<tr>
<td>Jam Alarm</td>
<td>Read Only</td>
<td>Discharge Air Temperature</td>
<td>Read Only</td>
</tr>
<tr>
<td>Flow Alarm</td>
<td>Read Only</td>
<td>Duct Temperature</td>
<td>Read Only</td>
</tr>
<tr>
<td>User Definable Inputs/Outputs</td>
<td>Read/Write</td>
<td>Temperature Set Points (9)</td>
<td>Read/Write</td>
</tr>
<tr>
<td>Zone Balance Control (per Zone)</td>
<td>Read Only</td>
<td>Effective Temperature Set Point</td>
<td>Read Only</td>
</tr>
<tr>
<td>Occupied Min Ventilation Rate</td>
<td>Read/Write</td>
<td>Offset Lever Percent of Range</td>
<td>Read/Write</td>
</tr>
<tr>
<td>Unoccupied Min Ventilation Rate</td>
<td>Read/Write</td>
<td>Cooling Demand</td>
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<tr>
<td>Offset</td>
<td>Read Only</td>
<td>Heating Demand</td>
<td>Read Only</td>
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<tr>
<td>Offset Set Point</td>
<td>Read/Write</td>
<td>Heat Delivered (BTU)</td>
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<td>MAV Command &amp; Feedback</td>
<td>Read Only</td>
<td>Auxiliary Temp Control Demand</td>
<td>Read Only</td>
</tr>
<tr>
<td>GEX Command &amp; Feedback</td>
<td>Read Only</td>
<td>Humidity Control (per Zone)</td>
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<td>Total Zone Supply Flow</td>
<td>Read Only</td>
<td>Humidity Set Point</td>
<td>Read/Write</td>
</tr>
<tr>
<td>Total Zone Exhaust Flow</td>
<td>Read Only</td>
<td>Humidity Demand</td>
<td>Read Only</td>
</tr>
<tr>
<td>Total Hood Flow Feedback</td>
<td>Read Only</td>
<td>Active Pressure Control (per Zone)*</td>
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<tr>
<td>Diversity Alarm</td>
<td>Read Only</td>
<td>Zone Pressure</td>
<td>Read Only</td>
</tr>
<tr>
<td>Fume Hood Control (per Hood Valve)</td>
<td>Read Only</td>
<td>Effective Pressure Set Point</td>
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</tr>
<tr>
<td>Face Velocity</td>
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<td>Pressure Warming Set Point</td>
<td>Read/Write</td>
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<td>Face Velocity Set Point</td>
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<td>Pressure Alarm Set Point</td>
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<td>Sash Opening Percentage</td>
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<td>Sensor Failure Alarm</td>
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<td>Hood Override Alarm</td>
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<td>Freeze Mode Time Set Point</td>
<td>Read/Write</td>
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<td>Sash Height Alarm</td>
<td>Read Only</td>
<td>Freeze Mode Time Remaining</td>
<td>Read Only</td>
</tr>
<tr>
<td>Broken Sash Cable Alarm</td>
<td>Read Only</td>
<td>Freeze Mode Offset Set Point</td>
<td>Read/Write</td>
</tr>
<tr>
<td>Sash Switch Status</td>
<td>Read Only</td>
<td>Effective Pressure Control State</td>
<td>Read Only</td>
</tr>
<tr>
<td>Emergency Mode (per Zone)</td>
<td>Read/Write</td>
<td>*Points are only available on systems using Active Pressure Control (see Article 2.7)</td>
<td></td>
</tr>
<tr>
<td>Emergency Mode Override</td>
<td>Read/Write</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Mode State</td>
<td>Read Only</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### HVAC EQUIPMENT

23 0200-54
A. Unit shall be handled and stored in accordance with the manufacturer's instructions.

PART 2 PRODUCTS

2.1 MANUFACTURER
   A. International Environment Corporation, Trane, York, Diakin

2.2 CONFIGURATION
   B. Cabinet shall be made of heavy gauge galvanized steel.
   C. Unit shall be lined with 1/2" Standard Fiberglass insulation.
   E. Units shall have a galvanized drain pan extending the entire width of the coil. Drain pan shall comply with ASHRAE 62.1-2010.
   F. CBY Horizontal Telescoping Hideaway
   G. Unit shall be equipped with a 1" disposable glassfiber filter

2.3 CERTIFICATION
   A. Safety:
      Units shall be listed by ETL indicating the units comply with the minimum requirements of the U.S. and Canadian national product safety standard, ANSI/UL Standard 1995, and with CAN/CSA C22.2 No. 236.
   B. Capacities:
      Coil capacities are tested in accordance with AHRI Standard 440-2008.

2.4 MATERIALS
   A. Coils: All coils shall have 1/2" copper tubes, manual air vent(s), and aluminum fins, 10 fins per inch spacing. Coil fins shall be mechanically bonded to copper tubes. Copper tubes must comply with ASTM B-75. Fin thickness shall be 0.0045" and tube thickness shall be 0.016". All coils shall be leak tested with air at 300 psig under water.
   B. Valves:
      1. For installation in a 2-pipe system, unit shall be equipped with:
         A. 2 manual isolation valves for service
         B. 1 motorized control valve, 300 psig service, 150 psid close-off ball-type with quick-release actuator
      2. For installation in a 4-pipe system, unit shall be equipped with:
         A. 4 manual ball valves for service
         B. 2 motorized control valve, 300 psig service, 150 psid ball-type with quick-release actuator
   C. Fans:
      1. Fans shall be direct-drive, double-width fan wheels with forward-curved blades.
      2. Blower wheels shall be statically and dynamically balanced.
      3. Scrolls and fan wheels shall be constructed of galvanized steel.
      4. Shall be easily removable.
   D. Motors:
      1. Motors shall be proportional, constant-torque ECM type, permanently lubricated, with ball bearings.
      2. Motors shall be suitable for 115 volts, single phase
      3. Motors shall be connected with quick connect electrical plugs.
      1. Motors shall be proportional, constant-torque ECM type, permanently lubricated, with ball bearings.
      2. Motors shall be suitable for 115 volts, single phase
      4. Motors shall have internal thermal overload protection with automatic reset.
   E. Controls and Safeties:
      1. Controls: Reference Fan Coil Unit Controls section.
2. Units shall be equipped with 24V controls and high level condensate switch
3. Service switch with lock-out & tag-out features shall be factory installed.
4. Safeties: Unit fan motor shall be equipped with integral motor protection.

F. Operating Characteristics:
   1. A 4-pipe system shall be capable of providing heating and cooling on demand.

G. Electrical Requirements

H. Electric Heat
   1. Units not equipped with electric heat

I. Options and Accessories:
   1. No Grille

N. AHU REFURBISHMENT
   1. The following scope is limited to AHU-3/4
   2. AQUIS CPR-SL System Specification – (Self-Leveling System)
   3. Installation surfaces shall be cleaned and prepared for installation including the removal of loose rust/corrosion, patching of holes, reinforcement of structurally compromised areas and removal of any identified non-compliant coatings or foam:
      4. AQUIS CPR-SL Epoxy (self leveling) shall be installed throughout chamber floor and 6” up walls to seal surface and halt corrosion.
      5. AQUIS Fire Barrier shall be installed over all epoxy to ensure compliance with NFPA 90A.
      6. AQUIS Antimicrobial Top Coat shall be installed over all fire barrier to ensure watertight surface and provide an active antimicrobial surface in compliance with EPA requirements for HVAC applications.
   7. Additional Specifications:
   8. Thickness of Finished Application: 1/4” or greater for structural integrity
   9. Surface Burning Characteristics (ASTM E84 per NFPA 90A):
      10. Per NFPA 90A requirement, tested at application thickness of 1/4”
      11. Flame Spread Index: 25 without continued progressive combustion
      12. Smoke Developed Index: 30
   13. Surface Adhesion:
      14. Pull Off Strength (ASTM D4541): 855 PSI
      15. Crosshatch Test (ASTM D3359): 5b (No Failure)
      16. Volatile Emissions: Negligible volatile organic compounds (VOCS)
      17. Odors: Very low odor
      18. Cure Time: 4 hours or less until unit may be restarted
      19. Active Antimicrobial: EPA approved for HVAC use
      20. Color: White or Gray

O. SOUND ATTENUATORS
   1. Silencers shall be of the size, configuration, capacity and acoustic performance as scheduled on the drawings. All silencers shall be factory fabricated and supplied by the same manufacturer.
   2. Silencer inlet and outlet connection dimensions must be equal to the duct sizes shown on the drawings. Duct transitions at silencers are not permitted unless shown on the contract drawings.
   3. Silencer manufacturer shall operate its own duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with ASTM E-477-99. The facility shall maintain NVLAP accreditation for the E477-99 test standard.
   4. Acceptable manufacturers: Vibro-Acoustics, Industrial Acoustics Company and Kinetics Noise Control Alternate manufacturers shall request approval no less than 10 days prior to bid.
   5. MATERIALS
(6) Elbow Silencers: All elbow silencers shall be constructed with an 18-gauge galvanized steel outer casing and 22 gauge galvanized perforated steel unless otherwise noted on schedule. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48” shall have at least two half splitters and one full splitter.

(7) Acoustic Media: Media shall be incombustible, acoustical quality, shot-free fiberglass insulation with long, resilient fibers bonded with a thermosetting resin. Fiberglass shall be packed with 15% compression during panel assembly. Media shall be bacteria and fungus resistant and conform to irregular surfaces. Media shall not cause or accelerate corrosion of aluminum or steel. Mineral wool will not be permitted as a substitute for fiberglass.

(8) All silencers installed in the lab exhaust air stream shall be constructed of stainless steel.

(9) Combustion Ratings:

(10) Film Lined silencers: Silencer materials, including acoustic media, Tedlar film and acoustical spacer shall have maximum combustion ratings as noted below when tested in accordance with ASTM E84, NFPA 255 or UL 723.

a. Flamespread Classification: 20
b. Smoke Development Rating: 45

(11) HTL Casings: Where indicated on the silencer schedule, silencers shall have high transmission loss (HTL) walls externally applied and completely sealed to the silencer casing by the silencer manufacturer to assure quality controlled transmission loss. The HTL walls shall consist of media, airspace, mass and outer protective metal skin, as required, to obtain the specified room noise criteria. Standard acoustical panels will not be accepted as HTL walls. If requested by the Engineer, breakout noise calculations for each air handling and fan system shall be provided with the silencer submittal to ensure compliance with the room noise criteria. Breakout noise calculations shall be based on the sound power levels of the specified equipment.

(12) CONSTRUCTION

(13) Silencers shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges noted in “Section B Materials”, are minimums. Material gauges shall be increased as required for the system pressure and velocity classification. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.

(14) Casings shall be lockformed and sealed, except as noted in Section B Materials, to provide leakage-resistant construction. Airtight construction shall be achieved by use of a duct-sealing compound supplied and installed by the contractor at the jobsite.

(15) All perforated steel shall be adequately stiffened to insure flatness and form. All spot welds shall be painted.

(16) ACOUSTIC PERFORMANCE

(17) Silencer dynamic insertion loss shall not be less than that listed in the silencer schedule.

(18) Silencer generated noise shall not be greater than that listed in the silencer schedule.
(19) Acoustic performance shall include dynamic insertion loss and generated noise for forward flow (air and noise in same direction) or reverse flow (air and noise in opposite direction) in accordance with the project’s air distribution system requirements.

(20) All silencer ratings shall be determined in a duct-to-reverberant room test facility which provides for airflow in both directions through the test silencer in accordance with the ASTM E-477-99 test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.

(21) AERODYNAMIC PERFORMANCE

(22) Silencer pressure drops shall not exceed those listed in the silencer schedule. Silencer pressure drop measurements shall be made in accordance with the ASTM E-477-99 test standard. Tests shall be conducted and reported on the identical units for which acoustical data is presented.

(23) SUBMITTALS

(24) Provide acoustical system calculations for all duct systems with silencers to demonstrate that the resultant ductborne sound levels of the equipment as measured in the occupied spaces meet the specified criteria. In the absence of specified background sound level criteria, the guidelines as expressed in Table 34 of Chapter 47, “Sound and Vibration Control” of the 2003 ASHRAE Handbook - HVAC Applications, shall be used. Provide calculations to the third air device in each system.

(25) The manufacturer shall supply certified test data for each scheduled silencer. The data shall include dynamic insertion loss, generated noise and pressure drop for forward or reverse flow, matching the project’s air distribution system requirement. All ratings shall be conducted in the same facility and shall utilize the same silencer.

(26) Test facilities and test reports shall be open to inspection upon request from the Engineer. Silencer performance must have been substantiated by laboratory testing according to ASTM E-477-99 and so certified when submitted for approval. The aero-acoustic laboratory must be NVLAP accredited for the ASTM E-477-99 test standard. A copy of the accreditation certificate must be included with the submittals. Data from non-NVLAP accredited test facilities will not be accepted.

P. VENTILATING FANS

(1) Ventilating fans shall be of the type, capacity, size, etc. here-in-after scheduled. Catalog numbers are listed as design criteria only. Alternate selections will be accepted provided quality, function, etc. are equivalent. All fans shall be UL listed, complete with all required disconnects and starters and shall be AMCA rated and certified. Model numbers listed are Greenheck, acceptable alternates are Penn, Carnes, Acme, Shipman, Jenn-Aire and Loren-Cook. The Architect shall select the color for all exposed fans.

(2) Selection

a. Refer to the schedule on the plans.

(3) COMMISSIONING: This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

(4) QUALITY CONTROL/STARTUP: Major equipment and system startup and operational tests shall
be scheduled and documented in accordance with Section 01 9100 Commissioning.

(5) FUNCTIONAL PERFORMANCE TESTS: System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

(6) DEMOLITION AND TRAINING: Training of the owner’s operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

Q. HYDRONIC SPECIALTIES

(1) Manufacturers
   a. Subject to compliance with the specified and scheduled requirements the following manufacturers will be considered, but not limited to:
      1) Hoffman
      2) Amtrol/Thrush
      3) Armstrong/Aurora
      4) Bell & Gossett
      5) Patterson
      6) Taco
      7) Wheatley
   b. Air Release Tank
      1) The air release tank shall be of the in-the-pipe-line type with flanged tangential openings for inlet and outlet connections. The inside shall be specifically designed to create a low velocity vortex for the separation of free air from the water stream. The tank shell shall be rated at 125 PSI working pressure and shall be constructed with the ASME code for unfired pressure vessels and shall be so certified and stamped. The tank shall be equipped with a bottom drain connection and expansion tank/vent connection. Tank shall be line sized. Tank shall not have a strainer.
   c. Expansion Tank
      1) The tank shall be constructed in accordance with the ASME Code for unfired pressure vessels and shall be suitable for 125 PSI water working pressure and 340°F maximum water temperature. The tank shall be a pre-charged, heavy duty butyl rubber diaphragm-type pressure vessel complete with standard tire charging valve. Refer to the plans for mounting orientation. Capacities shall be as scheduled on the drawings.
   d. Suction Diffusers
      1) Provide at the inlet of each base mounted pump, a suction diffuser as manufactured by Bell and Gossett, Victaulic, Thrush, or approved equivalent. Each suction diffuser shall be equipped with a disposable fine mesh start-up strainer and an adjustable support foot to carry weight of inlet piping. W731G, Bell and Gossett Suction Diffuser, or equal.
   e. Triple Duty Valves
      1) Provide at the discharge of each base mounted pump and where shown on the plans, a triple duty valve as manufactured by Bell & Gossett, Thrush or Engineer approved equivalent. Each valve shall perform check, shut-off and throttling functions and shall be line sized.
   f. Flexible Connections
      1) Provide at the inlet and discharge side of each base mounted pump, at each connection to major equipment requiring vibration isolation and where shown on plans, a flexible connector, Metraflex Metrasphere or Engineer approved equal. Flexible connectors shall be of the flexible neoprene and nylon or EPDM and suitable for 225 PSI working pressure and 230°F temperature. Couplings shall be installed per the manufacturer's recommendations, in close proximity to the source of the vibration.
g. **Pressure Reducing Valve**
   1) Provide at the point of connection of the domestic water line to the hydronic system and where shown on the plans, a pressure reducing valve by Thrush, Bell and Gossett, or Engineer approved equivalent. Such pressure reducing shall be provided with an inlet strainer and shall be set to maintain a pressure of 4 PSI in excess of that at the highest point in the hydronic system. Each pressure reducing valves shall be line sized.

h. **Vacuum Breaker**
   1) Provide, where shown on the plans, a vacuum breaker as manufactured by Huffman, Jackson or Engineer approved equivalent.

i. **Manual Air Vents**
   1) Provide, where shown on the plans, at each rise in piping and where required a manual air vent.

j. **Automatic Air Vents**
   1) Provide, where shown on the plans, automatic air vents.

k. **Expansion Loops**
   1) Expansion loops shall be Metaflex Metra loops or Engineer approved equivalent. Install with pipe guides and anchors as recommended by the manufacturer in all piping runs 75 feet long or greater and also where indicated on the plans.

2. **FACTORY START-UP REPORTS**

   A. Provide factory start-up on site by a factory representative (not a third party contractor) for all HVAC equipment, including pumps, VFD’s, boilers, chillers, cooling towers, heat pumps, rooftop units, etc. Submit factory start-up reports to the Engineer. The Mechanical Contractor and the Controls Contractor shall have a representative on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action taken shall be submitted to Engineer.

   B. At a minimum, the report submitted to the Engineer shall include the following data:

   (1) **Base-Mounted Pumps**
      a. With power off, note the following:
         1) pump properly secured, level, and grouted
         2) pipe installed so as not to transmit stress to pump
         3) coupler between pump and water shaft aligned
         4) pump and motor lubricated
      b. With power on, note the following:
         1) impeller rotation
         2) Actual amps/volts vs. nameplate amps/volts.
         3) Inlet and outlet pressure

   (2) **Air Handling Units**
      a. Verify economizer operation
      b. Verify operating per sequence of control
      c. Discharge air temperature sensor calibration
      d. Discharge static pressure
      e. Dirty filter differential pressure switch function
      f. Outside air temperature sensors calibration
      g. Return air temperature sensor calibration
      h. Airflow monitoring station calibration
      i. VFD response to pressure sensors or other DDC input
      j. Smoke detection shut down
      k. Freeze protection sequence
      l. Fan bearings lubrication
      m. Fan not vibrating
      n. Fan motor volts / amps
      o. Check drive belt tension
      p. Check sheave alignment
      q. Coils clean
r. Dampers operating properly
s. Filters clean
t. Fan rotation direction

(3) Blower Coil and Fan Coil Units
a. Fan bearings lubrication
b. Fan not vibrating
c. Fan motor volts / amps
d. Fan belt tension, if applicable
e. Sheave alignment, if applicable
f. Coils clean
g. Filters clean
h. Fan rotation direction

3. WATER TREATMENT

A. SCOPE
(1) Provide a one-year water treatment program for the HCS and HPS water loop systems. The one-year period shall start from the date of substantial completion. The program shall minimize corrosion, scaling, and prevent biological fouling of the piping system.

B. QUALIFICATIONS
(1) Chemicals, service, and equipment shall be supplied by a single water treatment company for undivided responsibility. The water treatment chemical and service supplier shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years, whose major business is in the field of industrial water treatment. The water treatment company shall have regional water analysis laboratories, service department, and full time representatives located within the trading area of the job site or facility.

(2) Water treatment company shall be Bluegrass Kesco, Nalco, American Water Treatment, or approved equal.

C. SERVICE
(1) Provide quarterly field service and Owner consultation. System water or fluid shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition. Provide any laboratory and technical assistance required to achieve a successful program.

D. CHEMICALS
(1) Provide one year’s supply of the recommended chemical for scale and corrosion protection of the closed loop recirculating system. If needed, provide separate chemical to control microbiological growth in the system. Formulations shall not contain any ingredients which are harmful to system materials of construction.

E. PHASED PROJECTS
(1) Provide multiple trips, testing, treatment, chemicals, etc. as required to accommodate phased projects. Systems that will be constructed and brought on-line in phases shall be treated at the completion of each phase. Under no circumstance shall any portion of the system operate with untreated heat transfer fluid.

F. EQUIPMENT
(1) Bypass Feeder
   a. Provide one 5 gallon bypass chemical feeder for each system. Neptune DBF-5HP or approved equivalent.

(2) Packaged Hydronic System Feeder (Heat Transfer Fluid Reservoir and Pump Assembly)
   a. The contractor shall supply and install, as indicated on the plans and in the specifications, a prefabricated automatic and autonomous fluid make-up package for the heat recovery chilled water condenser loop.
   b. The package shall be designed to occupy a minimum amount of floorspace (no more than 30 inches in diameter), to operate on a standard 120 Volt, 60 Hz electrical circuit, and to maintain a fill pressure in the system. The pumping assembly shall be mounted in a sturdy steel frame with legs to keep it off the floor.
c. It shall include a 1.7 GPM at 70 psi pump, a ½ horsepower motor, a magnetic starter, a pressure tank with pressure control, a priming valve, a pressure reducing valve, a shut-off valve, and a pressure gauge. It shall be connected to the system with a ½” NTP connection. It shall feature a cut-off and alarm arrangement, which will stop the pump in case of excessive pressure, or a low fluid level in the reservoir, and activate an audible (which can be silenced) and a visual alarm. A 120 Volt dry contact shall also be available for a remote alarm or connection to a building management system.

d. A translucent polyethylene (50) gallon reservoir, complete with lid, shall be mounted on the pumping assembly and shall include a strainer and shut-off valve. A one inch heat transfer fluid recovery line shall be piped in from the system relief valve outlet to the solution container, through the lid in such a way that the lid can be removed for filling and mixing.

e. The make-up package shall be (Wessels GMP Glycol/Water Make-up System, Pulsafeeder DGF, or pre-approved equal.

f. The Contractor is responsible for filling, flushing, and all glycol required to fill the system. Once filled, the loop water shall be tested to verify that is at the percentage glycol/water mixture specified.

(3) HPS Loop Filter LF-1

a. Harmsco HIF or WB series fluid filter. Refer to schedule on the drawings for selection. Provide with a total of three sets of filter cartridges.

G. REPORTS

(1) A summary of water or fluid quality and treatment shall be provided in writing to the Owner and Engineer after each quarterly site visit. Results of quarterly biological activity tests shall also be provided to the Owner and Engineer.

4. HEATING/COOLING SYSTEM CLEANING

A. GENERAL

(1) The heating/cooling system for this contract is a hydronic heat pump system and there are several precautions which must be observed during its installation. The Contractor is advised to read all of the manufacturer's instructions prior to commencing the installation.

B. SYSTEM START-UP

(1) The Contractor shall include as a part of his work a factory system fill and start-up by an authorized Factory Representative of the unit manufacturer.

C. CLEANING AND FLUSHING HYDRONIC PIPING SYSTEMS

(1) During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.

(2) After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil and any and all other material foreign to the water.

(3) For all water, steam, and condensate systems provide flushing and drain connections for complete flushing and drainage of the entire system.

(4) Remove strainers, open all valves and continuously flush the system with clean domestic water until all foreign matter is removed.

(5) Fill and vent the system, adding one pound trisodium phosphate for each fifty gallons of water. Circulate this solution for four hours, then drain and flush the system with clean domestic water.

(6) Replace the strainers and fill the system with clean water, circulate for one hour and test for alkalinity. If the system pH is below 7, add trisodium phosphate until the pH reads 7-8.
(7) Fill the system using water or steam from the permanent system once approved by the University and Engineer.

END OF SECTION 23 0200