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The Description of the Project
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SPECIFICATION DIVISION 23

NUMBER SECTION DESCRIPTION

DIVISION 23
SECTION 230920 - LABORATORY AIRFLOW CONTROLS- ANALOG ELECTRONIC

END OF CONTENTS TABLE

DIVISION 23 HEATING, VENTILATING AND AIR CONDITIONING (HVAC)
SECTION 230920 - LABORATORY AIRFLOW CONTROLS-PNEUMATIC AND ANALOG ELECTRONIC

DECEMBER 2013: REVISED PART 1 TO MASTER SPEC TEMPLATE FORMAT. MOVED ITEMS IN PART 1 THAT BELONG IN PART 2. REVISED FUME HOOD MONITOR TO INCLUDE SASH ALARM, THE SAME AS REQUIRED FOR DDC LAB CONTROLS. REVISED 3.2 TO MATCH DDC LAB AIR FLOW CONTROLS SPEC. D. KARLE FOR HVAC MTT.

JUNE 2015: ADDED REQUIREMENT FOR VALVE CALIBRATION CERTIFICATE UNDER SUBMITTALS, ADDED POST SUBMITTALS ARTICLE. IMPROVED DESCRIPTION OF VALVE OPERATION UNDER 2.3.A TO REQUIRE THAT CHARACTERIZED VALVE POSITION BE THE PRIMARY MEANS OF ACHIEVING AIR VOLUME SETPOINT, ADDED THAT ADDITIONAL OR FEWER AIR VALVES ARE THE RESPONSIBILITY OF THE CONTRACTOR TO PROVIDE IF A MANUFACTURER OTHER THAN THE DESIGN BASIS IS SUPPLIED SINCE FLOW RANGE V. VALVE DIAMETER VARIES BETWEEN MFR.S, REQUIRED THAT +/- 5% VALVE ACCURACY BE OVER THE ENTIRE CATALOGED VOLUMETRIC OPERATING RANGE OF THE LTAU. STRENGTHENED REQUIREMENT THAT LTAU INDICATED AIR VOLUME NOT TO BE ADJUSTED BASED UPON FIELD MEASUREMENTS (ART. 3.2). D. KARLE PER HVAC MTT.

CAUTION: *ANALOG STYLE LTAUS TYPICALLY NOT AVAILABLE OR USED FOR CURRENT PROJECTS SO THIS SPECIFICATION SHOULD NOT NORMALLY BE USED, INSTEAD USE DDC VERSION (230910). IN THE UNUSUAL CONDITION THAT THIS SPEC IS USED, EDIT CAREFULLY TO MAKE PROJECT SPECIFIC.*

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

INCLUDE PARAGRAPH 1.1.A AND B IN EVERY SPECIFICATION SECTION. EDIT RELATED SECTIONS 1.1.B TO MAKE IT PROJECT SPECIFIC.

A. Drawings and general provisions of the Contract, Standard General and Supplementary General Conditions, Division 01 Specification Sections, and other applicable Specification Sections, in particular the Related Sections listed below, apply to this Section.

CAREFULLY VERIFY, EDIT AND COORDINATE RELATED SECTIONS.

B. Related Sections:

1. Section 115313: Laboratory Chemical Fume Hoods
2. Section 233300: Air Duct Accessories and RGDs
3. Section 230900: Mechanical Systems Controls
4. Section 230593: Testing, Adjusting, and Balancing (TAB)
5. Division 26: Electrical

1.2 SUMMARY

A. Section Includes:

1. Laboratory Airflow Control (LAC) system, including controls for Laboratory Terminal Airflow Units (LTAUs), fume hoods, and other devices to control laboratory (or other specialized spaces) pressurization, temperature, and other functions as indicated.
2. Laboratory terminal airflow units.
3. Sound attenuators for LTAUs.

B. The Laboratory Controls Contractor shall be a direct Subcontractor to the Contractor.

1.3 REFERENCES

A. Abbreviations, Acronyms, Definitions (partial list)

1. Owner: The University of Michigan.
2. Laboratory: For the purposes of this specification, a broad designation for any space served by laboratory airflow controls.

1.4 DIVISION OF WORK

A. As it relates to the extent of responsibility for work within this specification section, "provide" shall mean the identified party both furnishes and installs such item(s). "Furnish" shall mean the identified party furnishes the item to the project site for installation by others.

***IMPORTANT**: DESIGNER SHALL CLEARLY DELINEATE ON THE PROJECT DRAWINGS WHICH SPACES ARE TO BE SERVED BY 230920 "LABORATORY AIRFLOW CONTROLS-DDC" (I.E. THIS SPECIFICATION) VERSUS 230900 "MECHANICAL SYSTEMS CONTROLS". MAKE A CLEAR DELINEATION ON THE CONTROL DRAWINGS. NORMALLY ANY SPACE UTILIZING LTAUS IS CONSIDERED LABORATORY CONTROL, BUT IN SOME CASES A SPACE MAY BE SERVED BY BOTH TYPES OF CONTROL (ANIMAL ROOMS ARE AN EXAMPLE WHERE THIS FREQUENTLY OCCURS). SUCH SPACES REQUIRE SPECIAL CARE TO INDICATE THE BOUNDARIES OF THE SPLIT.*

B. The Laboratory Controls Contractor (LCC) shall provide a complete LAC system as described in this specification.

1. Any space designated as a laboratory, served by LTAUs, or where indicated, shall be provided with a LAC system.
2. All items specified shall be provided by the LCC, including items specified in Related Sections, except where explicitly indicated otherwise.
3. The LCC shall be an installer authorized by the laboratory controls manufacturer.
4. Provide supervision and instruction to insure proper installation of all furnished laboratory control components.
5. Furnish and install all control wiring and pneumatic tubing related to laboratory controls, including interconnection tubing and wiring to thermostats, switches, etc. Temperature Control Contractor (TCC) shall provide and install the control air main tubing to the lab area to be used by the LCC. TCC shall also provide and install all room level control components, including thermostats, control valves (on LTAU reheats, fin tube, chilled beams, etc.), switches, etc.

6. Furnish and install differential pressure gauges at locations indicated on the drawings to indicate (visually) the room pressurization.

C. The LCC shall furnish LTAUs and LTAU sound attenuators to the mechanical contractor. The mechanical contractor shall install in the duct work.

D. The mechanical contractor shall provide reheat coils, duct transitions to connect to LTAUs/LTAU reheat coils, and all other components not specified in this specification section.

1.5 COORDINATION

A. Provide supervision and instruction to insure proper installation of all laboratory airflow components installed by others.

B. Coordinate work with Temperature Controls Contractor (TCC).

C. Coordinate work with Air Balancing Contractor.

D. Coordinate with Architectural Trades regarding location and exact dimensions of recessed components.

E. Provide controls and control wiring compatible with equipment provided by others and with existing equipment and controls.

F. Coordinate the installation of controls with the installation of other project equipment.

G. Ensure all control components are located and installed correctly so that the specified and intended performance and the sequence of operation is achieved, including components supplied and/or installed by others.

H. Coordinate with laboratory equipment suppliers (fume hoods, etc.) regarding cut-out dimensions for alarm monitors and to assure proper accommodation is made for the installation of sash sensors and other devices related to laboratory airflow controls.

1.6 ITEMIZED QUOTATION

A. The Laboratory Controls Contractor shall submit with bid, an itemized cost breakdown listing all major components, labor cost (including subcontractor labor and material cost), and engineering costs, for base bid and for each alternate, for the entire work scope of the Laboratory Controls. When requested, provide the itemized breakdown to the Owner post bid, for review and approval.

1.7 SUBMITTALS

A. Submit the following for approval:

1. A separate schematic drawing and wiring diagram for each laboratory room or zone, with sequence of operation. Indicate all set points and alarm settings.
2. Equipment schedule for each room or zone, with the following information:

a. Equipment tag, room served, occupied/unoccupied min., max., and offset CFM.
b. Model number of each LTAU and control component.
c. Function of each LTAU and control component.

3. Equipment data sheets indicating performance, wiring and tubing diagram, dimensions, weights, required clearances, component locations, and location and size of each field connection.
   a. Data sheets shall be organized behind sheet tabs. Each sheet tab shall indicate the category or component name (i.e. LTAUs, controllers, sensors, etc.)
4. Accuracy certificate, certified by an officer of the company, indicating that LTAU control error will not exceed +/- 5% of flow set point, over the manufacturer's cataloged volumetric operating range of the LTAU.
5. Ductwork connection types and sizes.
6. Wiring diagrams and locations of power supplies.
7. Conduit and wire/cable data sheets.
8. Octave band and A-weighted sound power data for each LTAU, with and without sound attenuators.
9. Installation, operation, and maintenance instructions for each component. Include calibration method, calibration tolerance, inspection period, and cleaning method.

1.8 CLOSE-OUT SUBMITTALS

A. Submit the following as a condition of final payment:

1. As-built schematic drawings and wiring diagrams. Indicate set points, settings and adjustments of all components.
2. Calibration certificate, signed by an officer of the company, indicating that each LTAU was factory calibrated at a minimum of 48 points and that the factory determined calibration data was loaded into the LTAU's respective controller. Indicate if calibration data was loaded into the LTAU controller at the factory or in the field.DELIVERY, STORAGE AND HANDLING

1.9 DELIVERY, STORAGE AND HANDLING

A. Mark each LTAU before factory shipment with a unique identifier corresponding to the LTAU drawing schedule.

B. Shipping and storage protection shall be provided by manufacturer to insure that the interior and exterior of components are completely protected from damage, dirt or weather. Components shall be continuously covered with plastic or other durable means, until just prior to installation. Maintain protection after installation to protect against on-going construction activities.

1.10 QUALITY ASSURANCE

A. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2.

B. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the specified quality assurance standards; latest editions unless noted otherwise.

1. AMCA 610 Laboratory Method of Testing Airflow Measurement Stations for Performance Ratings.
2. AHRI 880 Performance Rating of Air Terminals.
3. NFPA 70 National Electric Code.
4. NFPA 90A Installation of Air-Conditioning and Ventilating Systems.
5. ASTM C916 Standard Specification for Adhesives for Duct Thermal Insulation.
6. ASTM E84 Standard Test Method for Surface Burning Characteristics of Building Materials
7. UL 916 Energy Management Equipment
8. Components shall be Underwriters Laboratories (UL) or Intertek (ETL) listed.

1.11 WARRANTY

A. Provide a complete parts and labor warranty for a minimum of 3 years from the date of Substantial Completion.

B. Provide 24 hour per day service during the warranty period, with a maximum response time from when service is requested of 4 hours.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Laboratory Controls Manufacturers:

1. Phoenix Controls

2.2 GENERAL

A. All control components except for pneumatic actuators shall be strictly analog electronic in nature.

B. All laboratory airflow controls and laboratory terminal airflow unit system components shall be products of a single manufacturer.

2.3 FUME HOOD MONITORS AND CONTROLS

A. Monitors

1. Monitor shall include emergency exhaust control switch and LED (VAV hoods only), audible alarm, visual alarm, and alarm silence switch.
   a. VAV system - Phoenix FHM430 Controller
   b. CAV system - Phoenix FHM530 Controller
2. Normal operation and alarm conditions
   a. The fume hood monitor shall provide an alarm indication for the following conditions.
      1) Insufficient differential static pressure as detected by the exhaust airflow LTAU pressure switch.
      2) Signal loss between the exhaust airflow LTAU and the fume hood monitor(VAV hoods only).
      3) Sash raised above sash stop position.

b. When an alarm condition is detected, audible and visual alarm indicators shall activate. Pushing the alarm silence button shall mute the alarm for an adjustable time delay, initially set at 10 minutes. Alarm shall re-sound after the time delay, until alarm condition clears. Visual alarm shall remain lit until alarm conditions clears.
   1) Sash position shall be sensed by using a vertical sash position sensor. Vertical sash position sensor shall be as specified under the article "VAV Fume Hood Controls".

B. VAV Fume Hood Controls

1. The fume hood controller shall use a sash position sensor to measure sash opening to proportionally control the hood's exhaust airflow. Controller shall maintain an "average" constant face velocity to +/- 5% tolerance at all sash positions.
2. Signal
   a. The fume hood monitor shall receive the sash opening signals from the sash sensors. The monitor shall compute the total open sash area and then output an exhaust airflow control command signal to the appropriate exhaust airflow control device.
   b. Vertical Sash Sensor
      1) A vertical sash sensor shall be employed to measure the height of each vertically moving fume hood sash. The vertical sash sensor shall consist of a precision 10-turn potentiometer mechanically coupled to a constant tension spring reel. A stainless steel, vinyl coated cable shall be attached to the spring reel. Expected lifetime based on manufacturer's component data and tests shall be over 200,000 full height sash movements. Sash sensor shall be installed in an easily accessible location on the fume hood for service.
         a) Phoenix VSS
   c. Horizontal Sash Sensor
      1) A horizontal sash sensor shall be provided for each pair of horizontal or overlapping sashes that are located on horizontal, combination or walk-in sash fume hoods. The horizontal sash sensor shall consist of two long flat bars for each pair of overlapping sashes. The first bar shall contain a magnetic element to send magnetic flux to the second bar. The second bar shall contain a multitude of magnetic sensors spaced every .75" or less. The bars shall be mounted at the top of each sash, one per sash. As the two sashes slide past each other, the bars shall overlap to determine the total amount of sash opening.
         a) Phoenix HSS
   d. Combination Horizontal & Vertical Sash Sensor
      1) Provide the required combination of vertical and horizontal sash sensors as required by the types of fume hoods to be controlled.
         a) Phoenix CSS
3. Emergency Exhaust

a. An emergency exhaust capability shall be provided to override the sash sensor and command maximum exhaust airflow. A push-to-start, push-to-stop, push button switch shall initiate this mode.

4. The fume hood control system shall respond to a step change in sash position by reaching 90% of the final position CFM value within 3 seconds with no more than a 5% overshoot or undershoot and with no noticeable oscillation.

C. Mounting of Monitor

a. Fume hood monitor shall be suitable for surface or fully recessed mounting on the front of the fume hood.

2.4 LABORATORY TERMINAL AIRFLOW UNITS (LTAU)

A. Description

1. The laboratory terminal airflow unit (LTAU) shall be of venturi control type utilizing a cone shaped element. The position of the valve cone assembly shall be factory characterized to determine a position versus air flow volume relationship. Air flow control shall be achieved by moving the valve cone assembly to the factory characterized position that provides the required air volume. Air flow control shall not be achieved by air flow measurement. Control shall be pressure independent, accomplished by the cone/spring element continuously adjusting position relative to the venturi orifice to compensate for duct pressure fluctuations. All LTAUs shall have an equal percentage flow characteristic to provide stable control at low flow values. Butterfly, opposed blade, or parallel blade style damper or VAV boxes are not acceptable.

B. Accuracy

1. Total LTAU control error (including the combined effects of nonlinearity, hysteresis, repeatability, temperature and drift over a one year period) shall not exceed +/- 5% of flow set point. Example: If the LTAU's current flow set point is 1000 CFM, the volume of air delivered by the LTAU shall be within +/- 50 CFM of that set point. This error shall not be exceeded regardless of duct inlet or exit configurations, over the entire manufacturer’s cataloged volumetric operating range of the LTAU, and at any pressure drop across the LTAU from 0.3" WG to 3.0" WG static pressure..

C. Calibration

1. Every LTAU shall be factory calibrated across the manufacturer’s cataloged volumetric flow range using NIST traceable air flow stations and instrumentation with a combined accuracy of +/- 1 percent of signal over the entire range of measurement. Air flow shall be verified to be within an accuracy of +/- 5 percent of signal at a minimum of 48 different air flows. Provide factory calibration certificate for each valve, certified by an officer of the manufacturer.

D. Construction

EDITOR: IF VALVES OTHER THAN FUME HOOD VALVES (FOR EXAMPLE SNORKELS (THOUGH COATING IS NOT ALWAYS REQUIRED FOR SNORKELS)) NEED TO BE COATED VALVES, BE SURE TO INDICATE SO ON THE DRAWINGS.

1. LTAUs shall be constructed of heavy gauge aluminum. All bearing surfaces related to the control of airflow shall be made of Teflon or Teflon coated aluminum.
2. Supply air LTAUs shall come factory insulated with minimum 3/8" thick flexible closed cell polyethylene insulation with a flame/smoke rating not to exceed 25/50, K value not to exceed 0.270 btu-in/hr-ft²-°F @ 75°F mean temperature, and a permeability maximum of 0.08 Dry Cup. Perm-In. Rubatex Therma-Cel, AP/Armaflex, or equivalent. Insulation shall be installed per mfg. recommendations using mfg. recommended adhesives and joint vapor barrier sealants.
3. LTAUs on fume hoods or as indicated on drawings shall be coated with at least two baked coats of Heresite P403 coating material. The shaft and other exposed metal parts shall be made of 316 stainless steel. Stainless steel shaft stall be Teflon coated.
4. LTAUs used on cage or rack washer equipment shall be coated with two coats on all surfaces, including body, cone, shaft and hardware. Coating shall be suitable to eliminate corrosion for each installation application.

E. Electronically Controlled LTAUs:

1. Description
   a. Valves shall be pressure independent and use closed loop control to regulate air volume linearly proportional to a 0-10 volt DC analog electronic control signal. Valves shall also generate a 0-10 volt DC feedback signal linearly proportional to valve airflow for internal volume control, monitoring, or airflow tracking control. Signal shall be factory calibrated using NIST traceable instrumentation.
2. Actuator
   a. A pneumatic actuator shall be factory mounted to the LTAU body to vary the position of the internal cone from its minimum to maximum flows. Provide electronic "stops" to set maximum and minimum controllable airflows. Loss of control signal or power shall cause the units to fail to the position indicated on drawings. Fail-in-last-position actuators are not acceptable.
3. Flow Measuring Devices
   a. No electronic (hot wire, thermistor, etc.) flow measuring devices may be used.
4. Power Supply to LTAU
   a. Unless power supply is integral to a wall mounted control panel, provide a unit mounted power supply and disconnect switch on same side of LTAU as controller for each LTAU.
5. Static Pressure Switch:
   a. Fume hood exhaust LTAUs shall include a unit-mounted static pressure switch to sense and alarm on a reduction in airflow below set point. The switch shall operate by measuring the pressure drop across the unit's orifice.

F. Pneumatically Controlled LTAUs:

1. Description

a. LTAUs shall be pressure independent and shall have two factory calibrated min/max flow set points in the form of mechanical stops. Valves shall reposition between min/max flow set points based on a switched 0 to 20 psi pneumatic signal. Where required, LTAU shall generate a 0 to 10 volt feedback signal linearly proportional to LTAU airflow. Signal shall be factory calibrated to a stated CFM per volt scale factor using NIST traceable instrumentation.

2. Actuator
   a. A pneumatic actuator shall be factory mounted to the unit body to vary the position of the internal cone from its minimum to maximum flows. Loss of pneumatic supply air shall cause the units to fail to the position indicated on the drawings. Fail-in-last-position actuators are not acceptable.
3. Flow Measuring Device
   a. No electronic (hot wire, thermistor, etc.) flow measuring devices may be used.

G. Constant Volume Airflow Control Valves:

1. Valve Description:
   a. Valve shall be pressure independent and shall maintain a constant volume set point. Valves shall be factory calibrated, NIST traceable and set for the desired airflow rate. Valves shall also be field adjustable to allow for future changes of airflow rate.

2.5 VAV FUME HOOD ROOM CONTROLLER

A. Make-up/supply air and exhaust air controller shall control the airflow balance of the laboratory. The controller shall be unit mounted or wall mounted, as indicated on drawings. If no indication is given on drawings, provide wall-mounted controller.

B. Controller shall maintain a constant offset (adjustable) between the sum of the room's total exhaust and the make-up/supply air volumes. This offset shall represent the volume of air that will transfer to or from the corridor or other adjacent rooms.

C. The controller shall generate signals linearly proportional to the airflow of each exhaust LTAU as indicated by the calibrated input signals. Similar outputs signals shall also be provided for the supply, other general exhaust (where appropriate), and total exhaust airflow volume signals.

D. An integral power supply for each wall-mounted controller shall power the complete laboratory airflow control system from one (1) 120 volt AC line connection. Provide a labeled disconnect switch at each 120 volt AC connection. Locate switch above ceiling.

2.6 ENHANCED TRACKING CONTROL SYSTEM

EDITOR: ENHANCED TRACKING CONTROL REQUIRES MORE EXPENSIVE VALVES FOR PHOENIX SYSTEMS (AND FOR PHOENIX IS TYPICALLY CHARACTERIZED BY "MAV" AND "EXV" VALVE COMBINATIONS) AND IS TYPICALLY USED ONLY IN VAV FUME HOOD APPLICATIONS OR WHERE THERE IS A HIGH

PROBABILITY VAV FUME HOODS WILL BE USED IN THE FUTURE. SINCE IT REQUIRES MORE EXPENSIVE PHOENIX VALVES IT SHOULD NOT BE INDISCRIMINATELY SPECIFIED BY THE DESIGNER OR ACCEPTED FROM PHOENIX.

A. Tracking controller shall control the operation of electronically controlled supply, exhaust, or return air LTAUs to provide proper room pressurization and airflow balance. Provide this system only when specifically indicated on the design drawings, and where VAV type fume hoods are indicated.

B. The tracking controller shall be unit mounted and shall accept one input signal (multiple sources summed as one input) and produce one output signal.

C. Tracking controller shall maintain a constant offset between the room's exhaust (return) and make-up/supply volumes. This offset shall be electronically adjustable.

D. It shall be possible to electronically scale and calibrate the input and output signals. Both the minimum and maximum value of the tracking airflow shall be separately adjustable.

2.7 STANDARD TRACKING CONTROL SYSTEM

EDITOR: STANDARD TRACKING CONTROL CAN BE USED FOR MOST APPLICATIONS AND FOR PHOENIX IS TYPICALLY CHARACTERIZED BY "BSV" AND "EXV" VALVE COMBINATIONS.

A. Tracking controller shall control the operation of supply, exhaust, or return air LTAUs to provide proper room pressurization and airflow balance. Provide this system unless specifically noted otherwise on the drawings. One LTAU within the system shall be electronically controlled; the other shall be pneumatically controlled with a feedback potentiometer.

B. The tracking controller shall be unit mounted and shall accept one input signal (multiple sources summed as one input) and produce one output signal.

C. Tracking controller shall maintain a constant offset between the room's exhaust (return) and make-up/supply volumes.

D. Both the minimum and maximum value of the tracking airflow shall be separately adjustable.

2.8 LABORATORY TERMINAL AIRFLOW UNIT SOUND ATTENUATOR

EDITOR: DESIGNER SHALL PROVIDE PERFORMANCE DATA FOR THE SOUND ATTENUATORS ON THE DRAWINGS. DESIGNER MUST SPECIFICALLY INDICATE WHERE ATTENUATORS ARE REQUIRED. DESIGNER SHALL REVISE SPEC SECTION REFERENCE BELOW, IF REQUIRED.

A. Sound attenuator shall be furnished by the LTAU manufacturer. Attenuator shall be properly matched to each individual LTAU to meet sound performance as scheduled. Provide packless type stainless steel attenuators for all fume hood and "wet" exhaust applications. Provide attenuators only where specifically indicated.

B. Refer to other Division 23 sections for additional attenuator specifications.

2.9 FUME HOOD CALIBRATION BLAST GATE

A. Refer to other Division 23 sections for specifications for the blast gate used for low flow alarm calibration.

2.10 HOOD OCCUPANCY SENSOR

A. Provide manufacturer' standard occupancy sensors when specifically indicated on the drawings.

2.11 DIFFERENTIAL PRESSURE GAUGE

A. Provide where indicated. Dwyer Series 2000 Dual Scale (-0.25" to 0.25" W.G.)

2.12 ELECTRICAL

A. Provide all necessary power supplies/control transformers, power distribution wiring, etc. for a complete operating system. This includes but is not limited to power supplies for lab airflow controls, sensors/transmitters, etc.

BELOW PARAGRAPH INDICATES THAT POWER SUPPLIES SHOULD BE INSTALLED ABOVE DOORS TO LABS. DESIGNATE THE LOCATION OF THIS EQUIPMENT ON THE DRAWINGS. WORK WITH ELECTRICAL ENGINEER TO DESIGNATE THE RECEPTACLE PANEL CIRCUITS TO FEED LAB CONTROL POWER SUPPLIES. DEPENDING ON LOAD, MULTIPLE POWER SUPPLIES MAY BE FED FROM A SINGLE 120 VAC CIRCUIT.

B. Install power supplies secured to a wall and mounted above the doors to labs, unless indicated otherwise. Utilize receptacle panel circuits designated for powering lab control power supplies.

C. Provide power supplies for lab airflow controls in NEMA 1, metal, adequately ventilated to prevent overheating of the equipment, with exterior labeled "Laboratory Airflow Controls Power Supply", and listing the room numbers served. Maximum cabinet projection from wall shall be 8 inches. Label each secondary circuit inside the cabinet with the room number(s) served.

1. Control transformers shall be rated NEC Class 2 and shall meet all the requirements and recommendations of the laboratory airflow controls manufacturer.
2. No more than five pressurization zones shall be served from a single control transformer. No control transformer shall exceed 500 VA.
3. Each pressurization zone shall be powered by a dedicated (isolated) secondary circuit. Each secondary circuit shall include a disconnect switch, "power on" indicator, and be current limited with a slow blow fuse or circuit breaker.
4. Provide a disconnect switch, with shielded terminations, for line side power (one per control transformer). Locate inside the power supply enclosure.

D. Conduit fittings and junction box covers shall be painted bright orange.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components in strict compliance with component manufacturers' recommendations.

B. Install fume hood monitors surface mounted on the front of the fume hood. Furnish exact cut-out dimensions to the fume hood factory to allow for concealed wiring to the monitor..

C. Install the sash position sensors and sash travel limit brackets in a neat and workmanlike manner. Install cables and wires in a manner which avoids contact by the user during normal fume hood use, and which allows both the horizontal and vertical sashes to be opened and closed in any combination without binding, twisting or tangling.

D. Terminate wiring at all devices.

E. No material shall be exposed if it is possible to conceal it. Exposed materials shall be installed only with consent of the Owner. Installation shall also comply with Related Sections Mechanical Systems Controls and Division 26.

F. Install components so that they are easily accessible for service and in conformance with NEC clearance requirements.

DESIGNER: NOTE THE PARAGRAPH BELOW AND INCLUDE U-M STANDARD DETAIL "SUPPLY AIR LTAU CLEARANCE" ON THE DESIGN DRAWINGS.

G. Install LTAUs with proper NEC clearances at LTAU mounted controls.

3.2 SYSTEM START-UP

A. Program, start-up, calibrate, and test all laboratory airflow controls.

B. Adjust LTAU air volume to provide hood face velocity to within +/- 5% of required setpoint. Operate the lab airflow controls to assist the TAB Contractor in verifying that correct airflow rates and alarm settings are within +/- 5% tolerance.

1. All adjustments to the LTAUs shall be done by the LCC, not the TAB contractor.
2. TAB contractor shall take flow readings to verify that the air flow volumetric flow rate indicated by the LTAU matches the measured air flow volume, and to assist in setting alarms. Assist the TAB contractor in verifying measured LTAU air flow against that reported by the LTAU controller, at design minimum and maximum CFM.
3. LTAU air flow shall not be adjusted based on field air flow measurements. If LTAU air flow verification indicates calibration is not within +/- 5% tolerance, do not field adjust. Notify Owner and return to factory for recalibration.

C. Unless indicated otherwise, set controls to maintain hood face velocities as follows:

1. VAV Hoods
    a. To maintain 100 fpm (standard hoods) and 70 FPM (Reduced Face Velocity Hoods) for the entire sash travel, for all vertical and horizontal sash positions. Note: The LTAU's capacity may be insufficient to maintain the required air flow velocity through the entire travel of the sash as it is raised above the sash stop. Do not "clamp" hood LTAU air flow, allow the LTAU to open as far as it can in an attempt to maintain face velocity, except limit travel to the extent necessary so that the room cannot become more negative than indicated; clamp valve if necessary to prevent room from going more negative.
        1) Hoods with Horizontal Sashes: Set controls to maintain the required face velocity with the sashes in the position that creates the maximum free area opening. Example:, If the sash has 4 horizontal sashes, the face velocity must be achieved with 2 sashes in the full open position (with the sash vertical position closed)
2. CAV Hoods
    a. To maintain 100 fpm (standard hoods) and 70 FPM (Reduced Face Velocity Hoods) at sash stop position.

D. Set fume hood monitor alarms as follows:

1. Insufficient differential static pressure/air volume:
    a. Face velocity 80 FPM (standard hoods) or 60 FPM (Reduced Face Velocity Hoods.
    b. LTAU valve cone at maximum travel (VAV hoods).
2. Sash above the sash stop position.
    a. Time delay to re-alarm after silence button pushed: 10 minutes.
    b. Alarm shall clear when sash returned to sash stop position or lower.
    c. Floor mounted hoods: Alarm shall activate when any sash is above its sash stop position; time delay and alarm clear shall be same as above.

E. Set other control parameters/alarms to comply with the laboratory airflow control drawings.

3.3 COMMISSIONING

A. Perform the commissioning activities as outlined in the Division 01 Section Commissioning and other requirements of the Contract Documents..

B. Demonstrate that the laboratory controls perform per the sequence of operation and the design intent..

C. Demonstrate every fume hood monitor alarm set point.

D. Perform other demonstrations as may be required by the CxA.

3.4 CLOSEOUT ACTIVITIES

A. Submit as-built documentation per article "Submittals". Obtain approval of as-built documentation prior to Owner training.

B. Provide on-site training to Owner's maintenance personnel. Familiarize personnel with location of LTAUs, controllers, system components, power supplies, and network devices. Review the control concept for each lab and room type.

END OF SECTION 230920