

SECTION 23 09 10 - LABORATORY AIRFLOW CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

- A. The Conditions of the Contract and applicable requirements of Division 1, "General Requirements", and this Section govern the work of this Division.

1.2 DESCRIPTION OF WORK:

- A. System Description: Provide a Laboratory Airflow Control System (LACS) to control the airflow into and out of laboratory rooms. The exhaust flow rate of a laboratory fume hood shall be precisely controlled to maintain a constant average face velocity into the fume hood. The laboratory control system shall vary the amount of makeup/supply air into the room to operate the rooms 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 laboratory airflow control system shall be capable of operating as a stand-alone system and as a system integrated with the existing UH Campus Building Control and Automation System (BCAS).
- B. Control Protocol: Each room in the suite shall be operated as a constant volume occupied/unoccupied mode system with room pressurization via supply/exhaust offset as shown on the drawings. Unoccupied mode shall reduce the room supply air volume by 50% while maintaining pressure control offsets. The unoccupied mode shall be implemented based on time program inputs through the UH Campus system. The system design shall allow for future conversion to VAV operation with a supply air minimum in the future without any hardware changes.
- C. Airflow Device Actuation: Airflow device actuation shall be DDC modulated electric actuation. Electrical power shall be supplied from the building 120 volt power supply.

1.3 QUALITY ASSURANCE:

- A. Manufacturer: Laboratory airflow control shall be manufactured and installed by Phoenix Lab System Controls and their local representative. Phoenix Lab Controls have systems installed in the SERC Building and have passed rigorous control and air leakage tests. No other manufacturer will be considered without including the costs of similar tests and certification/compliance with UH standards being included in their project scope.
- B. Certification: Provide manufacturer's and independent test lab certification of test results, signed by an authorized officer of the company.
- C. Preparation: Laboratory airflow control products to be clean and free of all foreign matter prior to shipping. Units and associated equipment such as controls, shall be packaged in a manner to prevent dust and other foreign matter from entering the unit, controls, and similar items during shipment. All external controls, operators, and sensors shall be covered by rigid metal shields during shipment and storage.
- D. Performance Verification: The laboratory airflow control system supplier shall demonstrate a typical laboratory space that includes multiple fume hoods, a general exhaust, and a supply airflow control device for the purpose of verifying the laboratory airflow control system's ability to meet the performance requirements indicated in this specification. All travel and lodging costs to witness the performance verification shall be the responsibility of the laboratory airflow control system supplier.
- E. Preventive Maintenance: The laboratory airflow control system supplier shall provide at no additional cost to the owner during and after the warranty period, five years of required preventive maintenance on all airflow sensors (e.g., pitot tube, flow cross, orifice ring, air bar, hot wire, vortex shedder, side wall sensors, etc.), and flow transducers provided under this section. Airflow sensors shall be

removed, inspected, and cleaned annually during the five year period to prevent inaccuracies due to long term buildup from corrosion, lab tissues, wet or sticky particles, or other materials that foul the sensor. If impractical to remove the airflow sensors, the laboratory airflow control system supplier shall include in the proposal the cost of supplying and installing duct access doors, one for each sensor. The transducer shall be checked and recalibrated annually to insure long-term accuracy. Note that auto-zero recalibration of transducers is not acceptable as a substitute for annual recalibration.

- F. Warranty Period: Warranty shall commence upon the date of shipment and extend for a period of thirty-six months whereupon any defects in materials or laboratory airflow control system performance shall be repaired by the supplier at no cost to the owner.

1.4 SUBMITTALS:

- A. Shop drawing submittals shall include, but not be limited to, the following:
1. The laboratory airflow control system supplier shall provide a detailed proposal describing all elements of the laboratory control system. A schematic layout shall be provided, showing relations of these elements and a description of how they interact.
 2. Technical specification data sheets shall be provided for all proposed system components and devices.
 3. Cut sheets on each all laboratory airflow controls, clearly marked to show sizes, configuration, construction, unique features, controls, clearances, accessories, performance data, sound data, operating sequence and other pertinent information.
 4. Air valve curves or charts which clearly show air valve performance, including air flow sensor calibration curves.
 5. Performance characteristics for each terminal unit.
 6. All proposed airflow control devices shall include discharge, exhaust, and radiated sound power level performance obtained from testing in accordance with ARI Standard 880.
 7. Wiring and control diagrams.
 8. Copies of factory-certified sound, leakage and performance test results from actual tests of units of the same model and construction to those which will be provided for the project.
 9. Written report of the test results including noise criteria (NC) in sound power as tested in reverberant room with terminal unit operating at the scheduled airflow. When reporting NC levels, no credits or reduction shall in any way be considered for room, plenum, ceiling, and similar item effects.
 10. Certified dimensioned drawings showing the locations of all openings, support points, connections, sizes for same, overall dimensions of all boxes and any other pertinent information that may affect the installation of the boxes.
 11. Submit the following certified performance data for each size and type of terminal unit to be used on the project:
 - a. Maximum and minimum cfm ratings at 0.35" discharge static pressure.
 - b. Pressure drop through each primary air damper at 25%, 50% and 100% of design cfm.
 - c. Pressure drop through terminal unit and heating coil at full plenum air mode for fan powered terminal units and full heating and full cooling modes as applicable for single and double duct terminal units.
 - d. Radiated and discharge sound power data for each size terminal unit at 0.5", 1.0", and 1.5" primary duct static pressure, 0%, 25%, 50%, 75% and 100% primary cold air and design discharge cfm (constant fan powered terminal units only) and static pressure.

- e. Temperature mixing data for each size dual duct terminal unit at maximum and minimum discharge cfm for the unit size with 25%, 50% and 75% primary air.

12. Product warranties and guarantees.

13. Additional information as required in Section 23 01 00.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING:

- A. Deliver laboratory airflow control systems in bulk containers or factory-fabricated water-resistant packaging.
- B. Handle laboratory airflow control systems carefully to avoid damage to components, enclosures, and finish.
- C. Store laboratory airflow control systems in a clean, dry space and protect from weather until delivery to the site or to the designated contractor..

PART 2 - PRODUCTS

2.1 AIRFLOW CONTROL SYSTEM DESCRIPTION:

- A. Each individual area shall have a dedicated laboratory airflow control system. Each dedicated laboratory airflow control system shall support a minimum of twenty (20) network controlled airflow devices.
- B. The laboratory airflow control system 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.
- 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 between 1.0 to 1.5 feet per second.
- D. The laboratory airflow control system shall maintain specific airflow ($\pm 5\%$ 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 0.6" to 3.0" wc)
- E. The laboratory airflow control system 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 or velocity measurement to control room pressurization are unacceptable.
- F. The laboratory airflow control system shall maintain specific airflow ($\pm 5\%$ of signal) with a minimum 16 to 1 turndown to insure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

2.2 AIRFLOW CONTROL SOUND SPECIFICATIONS:

- A. Unless otherwise specified, the airflow control device shall not exceed the sound power levels in Table 1, Table 2 and Table 3.
- B. If the airflow control device cannot meet the sound power level specification, a properly sized silencer or sound attenuator must be used. All silencers 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.

- C. All proposed airflow control devices shall include discharge, exhaust and radiated sound power level performance.

Table 1. Exhaust Airflow Control Device Sound Power Level

Octave Band Number	Exhaust Sound Power Level in dB (re: 10 ⁻¹² watts)					
	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 cfm Device						
800 cfm @ 0.6" wc	63	55	52	54	50	49
200 cfm @ 0.6" wc	46	42	38	37	32	25
800 cfm @ 3.0" wc	73	70	64	66	65	60
200 cfm @ 3.0" wc	51	52	51	50	52	51
1500-100 cfm Device						
1200 cfm @ 0.6" wc	65	58	53	56	52	52
400 cfm @ 0.6" wc	50	45	38	39	37	31
1200 cfm @ 3.0" wc	72	70	62	65	64	60
400 cfm @ 3.0" wc	55	57	55	53	56	55
3000-200 cfm Device						
2400 cfm @ 0.6" wc	63	56	55	58	54	55
800 cfm @ 0.6" wc	51	45	41	42	39	34
2400 cfm @ 3.0" wc	75	71	65	68	67	63
800 cfm @ 3.0" wc	58	58	56	56	59	58

Table 2. Supply Airflow Control Device Sound Power Level (Discharge)

Octave Band Number	Discharge Sound Power Level in dB (re: 10 ⁻¹² watts)					
	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 cfm Device						
800 cfm @ 0.6" wc	62	57	54	58	54	51
200 cfm @ 0.6" wc	45	46	42	44	40	34
800 cfm @ 3.0" wc	72	71	67	75	72	68
200 cfm @ 3.0" wc	53	56	54	58	56	54
1500-100 cfm Device						
1200 cfm @ 0.6" wc	63	59	55	60	54	53
400 cfm @ 0.6" wc	53	49	44	49	45	39
1200 cfm @ 3.0" wc	72	73	69	77	72	68
400 cfm @ 3.0" wc	58	63	61	63	60	57
3000-200 cfm Device						
2400 cfm @ 0.6" wc	64	60	58	63	56	56
800 cfm @ 0.6" wc	52	48	47	52	46	41
2400 cfm @ 3.0" wc	75	75	72	78	73	70
800 cfm @ 3.0" wc	59	62	62	66	62	60

Table 3. Supply Airflow Control Device Sound Power Level (Radiated)

Octave Band Number	Radiated Sound Power Level in dB (re: 10 ⁻¹² watts)					
	2	3	4	5	6	7
Center Frequency in Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
1000-50 cfm Device						
800 cfm @ 0.6" wc	44	41	45	41	36	34
200 cfm @ 0.6" wc	33	28	31	29	26	20
800 cfm @ 3.0" wc	53	53	56	57	55	53
200 cfm @ 3.0" wc	41	38	41	39	39	37
1500-100 cfm Device						
1200 cfm @ 0.6" wc	47	53	40	42	38	36
400 cfm @ 0.6" wc	35	39	31	34	33	26
1200 cfm @ 3.0" wc	52	60	54	60	59	53
400 cfm @ 3.0" wc	42	44	43	46	46	42
3000-200 cfm Device						
2400 cfm @ 0.6" wc	58	56	45	47	43	42
800 cfm @ 0.6" wc	45	43	36	39	37	29
2400 cfm @ 3.0" wc	69	68	60	65	63	57
800 cfm @ 3.0" wc	54	53	48	51	50	48

2.3 MATERIALS:

- A. General: Provide Laboratory airflow control systems using standard materials and components designed and constructed as recommended by the system manufacturer and as required for a complete installation in compliance with these Specifications.
- B. Control Calibration:
 1. Each airflow control device shall be factory calibrated to the job specific airflow as detailed on the plans and specifications. Each factory calibrated control/measuring device shall be electronically calibrated/characterized at the factory. Calibration shall be included in the product cost or related labor hours. No device shall be installed without verification or certification of accuracy or airflow measurement calibration.
 2. A final field verification of accuracy and control stability shall be made by the balancing contractor where so directed by the Owner. Accuracy and performance shall be guaranteed as specified irrespective of field conditions and device inlet conditions.
 3. Each airflow control valve shall be individually marked with valve specific factory calibration data by the equipment supplier. As a minimum, data shall include valve tag number, serial or unit number, model number, valve characterization information or field test results, and quality control inspection numbers.
 4. A final calibration list (electronic data format) of all settings and test results, in MS-Excel 97 format, shall be provided to the Owner.

2.4 AIRFLOW CONTROL DEVICES – GENERAL:

- A. The airflow control device shall be a venturi valve equal to the Phoenix Controls Low Pressure Accel II Valves installed using Phoenix Controls drawband clamps.

- B. The airflow control device shall be 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 or quantity of airflow controllers on a manifolded system.
- C. The airflow control device shall maintain accuracy within $\pm 5\%$ of signal over an airflow turndown range of no less than 16 to 1.
- D. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
- E. The airflow control device shall be constructed of one of the following three types:
 - 1. **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 shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal mounting link shall be made of aluminum. The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a Teflon, or polyester, or PPS (polyphenylene sulfide) composite.
 - a. 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.
 - 2. **Class B** - The airflow control device for corrosive airstreams such as fume hoods 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 mounting 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 a Teflon or PPS (polyphenylene sulfide) composite.
- F. For two-position or VAV operation, a pneumatic actuator shall be factory mounted to the valve. Loss of pneumatic main air or control power shall cause normally open valves to fail to maximum position, and normally closed valves to fail to minimum position. Electric actuators that fail in last position are not acceptable when used in fume hood and make-up air control applications. Constant volume valves do not require actuators.
- G. The controller for the airflow control devices shall be microprocessor based and operate using a peer-to-peer control architecture. The room-level airflow control devices shall function as a stand-alone network.
- H. The room-level control network shall utilize a LonTalk communications protocol.
- I. 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, Temperature control, Humidity control, and implement Occupancy and Emergency mode control schemes.
- J. The laboratory airflow control systems shall have the option of digital integration with the BMS.
- K. Certification:
 - 1. Each airflow control device shall be factory calibrated to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of at least $\pm 1\%$ of signal over the entire range of measurement. Electronic airflow control devices shall be further calibrated and their accuracy verified to $\pm 5\%$ of signal at a minimum of forty-eight different airflows across the full operating range of the device.
 - 2. All airflow control devices shall be individually marked with device specific, factory calibration data. At a minimum, it should include: tag number, serial number, model number, eight point

characterization information (for electronic devices), and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation.

- L. Airflow control devices that are not venturi valves, and airflow measuring devices (e.g., pitot tube, flow cross, air bar, orifice ring, vortex shedder, etc.) shall only be acceptable provided they meet all the performance and construction characteristics as stated throughout this specification and:
1. The airflow control device employs transducers manufactured by Rosemount, Bailey, Bristol, or Foxboro. Accuracy shall be no less than $\pm 0.15\%$ of span (to equal $\pm 5\%$ of signal with a 15 to 1 turndown) over the appropriate full scale range including the combined effects of nonlinearity, hysteresis, repeatability, drift over a one year period, and temperature effect. 316L stainless steel materials shall be provided for all exhaust applications. The use of 304 stainless steel materials shall be provided for all make-up air applications.
 2. Airflow sensors shall be of a multi-point averaging type, 304 stainless steel for all supply and general exhaust applications, 316L stainless steel for all fume hood, canopy, snorkel, and bio-safety cabinet applications. Single point sensors are not acceptable.
 3. Suppliers of airflow control devices or airflow measuring devices requiring minimum duct diameters shall provide revised duct layouts showing the required straight duct runs upstream and downstream of these devices. Coordination drawings reflecting these changes shall be submitted by the supplier of the laboratory airflow control system. In addition, suppliers shall include static pressure loss calculations as part of their submittals. All costs to modify the ductwork, increase fan sizes and horsepower, and all associated electrical changes shall be borne by the laboratory airflow control supplier.

2.5 FUME HOOD CONSTANT/VARIABLE VOLUME CONTROLLER

- A. Constant volume fume hood controllers shall be identical to the variable volume controller specified herein except that the controls are set to maintain a constant airflow with minimum flow equal to maximum air flow. Constant volume controllers may be changed to variable volume controllers using only the local controller or the central workstation.
- B. The laboratory control system manufacturer shall supply a fume hood control system to directly measure the area of the fume hood sash opening. The measured sash area shall proportionally control the hood's exhaust airflow in a variable volume mode to maintain a constant face velocity. Hood airflow shall be varied to maintain a constant face velocity over no less than a 5 to 1 change in the sash open area (change in sash position).
- C. Fume hood control system shall respond to and maintain the face velocity set point to insure fume hood containment. Response time shall be less than one second with no more than a 5% of set point overshoot and undershoot when the sash is raised or closed. Sash raise time for this test shall be one second with a 5 to 1 change in sash area.
- D. An approved horizontal and/or vertical sash sensor shall be provided by the lab system supplier as an integral part of the lab air volume control system (single source responsibility) to measure the height of each vertically and/or horizontally moving fume hood sash. The sash sensor shall be an approved method of sash position sensing that has a proven application history. **Through wall pressure sensors are not acceptable.**
- E. A fume hood monitor shall be provided to receive the sash opening signals from the vertical and/or horizontal sash sensors. The monitor shall compute the total open sash area and output an exhaust airflow control signal to the appropriate volume control device (valve) to maintain a constant face velocity.
- F. The fume hood monitor shall modulate the airflow in response to the sash opening signals from the vertical sash sensors between closed and 18" open or the stop set point. Above the stop set point, the exhaust valve shall maintain a constant airflow and allow the face velocity to reduce proportionately to the face opening.

- G. The face velocity and minimum and maximum exhaust flow level of the fume hood shall be set through the fume hood monitor or control. A hand held device shall be provided to the university for each 50 (or fraction thereof) hoods, or labs, if an independent tool is required to adjust settings. Adjustments of the face velocity shall be provided at the minimum and maximum sash positions. Sash sensors shall be provided with an unconditional five (5) year material, labor and calibration warranty.
- H. As an option the owner may select an air flow control system with an emergency exhaust switch mounted on the fume hood monitor, with an audible alarm, which shall override the sash sensor and command maximum exhaust airflow. A dedicated push to start, push to stop, push button switch shall force the hood exhaust volume control device to its full flow position and force the supply valve to it specified minimum position.
- I. Fume hood monitor shall contain a visual and audible alarm to indicate a low face velocity. Muting of the alarm shall only silence the audible portion, while the visual alarm shall be maintained until the low flow condition has returned to normal. Alarm shall be triggered by:
 - 1. A differential pressure sensor located across a hood exhaust valve or a calibrated airflow measuring station that reports the differential to the control system. The controls will initiate an alarm at an air flow or pressure reduction of approximately 20% (operator adjustable) below air flow set point or design pressure differential.
 - 2. A difference between the airflow command sent to the hood exhaust valve compared to the actual flow measurement feedback. This type of control will not replace the differential pressure sensor.
 - 3. The sash being raised above a specified height and or specified area for fume hoods not sized for 100% opening.
 - 4. The alarm wire being disconnected.
- J. A push button switch shall be provided to mute the audible alarms. The mute mode is automatically reset when the alarm condition ceases.
- K. In labs without fume hoods, a lab emergency push button (equipment and control option) may be installed at the exit to the lab. Switch shall activate all exhaust and supply valves causing the exhaust and supply system to flush the lab and sound an audible alarm to signal lab emergency condition.

2.6 INDIVIDUAL ROOM AIRFLOW CONTROL UNITS:

- A. Provide a room airflow control or control panel for **each room to control the airflow balance of that room**. The room Airflow Control Unit shall be panel mounted in the location shown on the drawings to provide ease of maintenance. Provide one room Airflow Control Unit per controlled room.
- B. The output from the room's temperature sensor, in response to the space temperature, will cause the dual duct dampers to modulate independent of the room volume control.
- C. The control signal for the make-up/supply air flow control valve shall be generated by the required offset and the difference between the supply air flow and the total general exhaust or auxiliary and hood exhaust valve air signals. The controls shall cause the supply to modulate with the exhaust total to maintain a **stable room pressurization differential (offset). The controls shall maintain a stable offset airflow to prevent the room from changing pressure relationships during variable airflow and during hood sash movement.**
- D. The individual room controls shall sense the room temperature and the mixing damper position. Air flow shall be increased only when the mixing dampers are at their limit with all flow through the hot deck or the cold deck.
- E. The room Airflow Control Unit shall increase flow at the general exhaust valve or auxiliary exhaust valve under conditions where additional exhaust is required to maintain the room's airflow balance and temperature. The general exhaust valve command shall equal the difference between the supply volume requirement for temperature control and the hood's make-up air volume. Control of the

general exhaust valve directly by the thermostat, with the supply volume equal to the sum of the general and hood exhaust volumes less offset **is not allowed**.

- F. The Airflow Control Unit shall sum the hood exhaust and general exhaust volume signals and output a linear scaled control signal representing the total exhaust volume.
- G. The Airflow Control Unit shall be electronic or a DDC microprocessor-based digital controller. The controller shall control and communicate digitally via a high speed Peer to Peer digital network. A polling sub-LAN network requiring a primary controller to provide communication and distribution of information between the secondary lab controllers is not acceptable. The inputs shall accept signals proportional to general, auxiliary, fume hood, exhaust, and space supply flows. The output signals shall control supply valves, general exhaust/return air valves, with signals proportional to the desired supply or exhaust volumes.
- H. Integral field adjustable controls shall be provided for all required calibration and scaling adjustments. Where direct airflow measurement is used for this control, each sensor utilized must have the capacity of being field validated with individual zero and span calibrations. Autozero routines that use or modulate the damper position are not acceptable. Autozero routines shall limit controls for less than one second and shall be prohibited during sash movement.
- I. The Airflow Control Unit shall maintain a variable negative or positive offset as scheduled on the lab airflow schedule between the sum of the room's total exhaust and the make-up/supply air volumes. This offset represents the volume of air that will enter or exit the room from the corridor or adjacent rooms.
- J. The Airflow Control Unit shall generate signals to represent all airflow sources, sash sensors, and flow alarms. The alarm signals shall be transmitted to the central monitoring system and programmed as a point in the facilities Direct Digital Control/Energy Management System schematic. As a minimum, the following signals (points) shall be monitored at the network interface and scheduled as a data point in the facilities Direct Digital Control/Energy Management System schematic. This installer shall enter these points on a system schematic before each room is turned over to the owner.
 - 1. Fume Hood Exhaust Flow (CFM)
 - 2. Fume Hood Exhaust Low Flow Alarm.
 - 3. Fume Hood Sash Position.
 - 4. General Exhaust Flow (CFM)
 - 5. Exhaust Flow Alarm
 - 6. Supply/Make-up Airflow (CFM)
 - 7. Supply/Make-up Airflow Alarm
 - 8. Room Temperature
 - 9. Room Offset (CFM)
 - 10. Room Temperature Setpoint
 - 11. Room Offset Setpoint (CFM)
 - 12. Total Room Exhaust Flow (CFM)
 - 13. Total Room Supply Flow (CFM)
- K. A power supply for the control panel mounted unit, shall be included to power the laboratory airflow control system from one dedicated 120 VAC line connection per interface panel.

2.7 EXHAUST AND SUPPLY AIRFLOW DEVICE CONTROLLER:

- A. 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.

- B. 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.
- C. Room-level control functions shall be embedded in and carried out by the airflow device controller using a distributed control architecture. Critical control functions shall be implemented locally, no room-level controller shall be required.
- D. The airflow control device shall use industry standard 24 Vac power.
- E. The airflow control device shall have provisions to connect a notebook PC commissioning tool and every node on the network shall be accessible from any point in the system.
- F. The airflow control device shall have built-integral Input/Output connections 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:
 - 1. Three (3) Universal Inputs, capable of accepting 0 to 10Vdc, 4 to 20mA, 0 to 65k ohms, or Type 2 or Type 3 10k ohm @ 25 degree C thermistor temperature sensors.
 - 2. One (1) Digital Input capable of accepting a dry contact or logic level signal input.
 - 3. Two (2) Analog Outputs capable of developing either a 0 to 10Vdc, or 4 to 20mA linear control signal.
 - 4. One (1) Form C (SPDT) relay output capable of driving up to 1A @ 24Vac/Vdc.
- G. The airflow control device shall meet FCC Part 15 Subpart J Class A, and be UL916 listed.

2.8 SUPPLY AND EXHAUST TERMINAL UNITS/AIRFLOW DEVICES GENERAL:

- A. General Performance: Devices using mechanical CFM limiters will not be accepted, nor shall it be necessary to change control components to make airflow rate changes or change from constant volume operation to variable volume operation. Where used, electric actuator motors, electronic controllers, and electronic or DDC controls shall be furnished, mounted and adjusted by the laboratory airflow controls manufacturer to assure their proper placement within the units. The manufacturer shall be responsible for the construction of the terminal unit, the installation of internal control components, all workmanship and materials of the entire assembly of unit and controls and shall be responsible for the performance of the controls.
- B. Control Performance:
 - 1. Project lab air controls shall be designed to operate initially as a constant volume occupied/unoccupied room with the ability to change to variable volume room operation at a future date.
 - 2. Supply unit assemblies shall modulate cold and hot air to maintain space temperature. An independent volume controller downstream of the dual duct assembly shall provide volume control as specified hereinafter.
 - 3. General exhaust valves shall respond to the hood exhaust valve flow to maintain the room airflow offset when the hood sash is moved or repositioned. The auxiliary valve or room exhaust valve shall also modulate (in a VAV mode) to maintain the air flow as low as possible within the temperature and air change or air flow limits set for "occupied" and "unoccupied" conditions.
 - 4. The supply air volume controller shall modulate to provide a stable, constant, room offset (exhaust less supply CFM).
- C. Electric Control Operators, Sensors and Related Materials:
 - 1. Field pneumatic control air connections by the Contractor shall consist of air connections to the riser and all distribution within and to the room, if required, for electric operators, sensors and related components. All control logic shall be electronic. The dual duct box manufacturer shall install all airflow monitoring tubing between the heating and cooling sides of the assembly

required for operation. A calibration chart and piping diagram shall be submitted for approval. A copy of the approved wiring diagram shall be attached to the side of the unit near the cold duct valve.

2. To provide for a safe airflow in the event of power failure, the units are to be arranged so that supply airflow control dampers fail closed (normal position).
3. All electrical work and products shall meet Division 26 requirements..

2.9 TWO-POSITION EXHAUST AIRFLOW CONTROL DEVICES:

- A. The airflow control device shall maintain a factory calibrated fixed maximum and minimum flow setpoint based on a switched electronic signal. Two-position devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow. All Two-Position devices shall either be networks, or hard-wired into the room-level network so as to be considered under pressurization control.

2.10 CONSTANT VOLUME AIRFLOW CONTROL DEVICES:

- A. The airflow control device shall maintain a constant airflow setpoint. It shall be factory calibrated and set for the desired airflow. It shall also be capable of field adjustment for future changes in desired airflow.
- B. Laboratory airflow control systems suppliers not employing constant volume venturi airflow control valves shall provide electrical wiring as required for their devices.

2.11 CONSTANT AND VARIABLE VOLUME EXHAUST TERMINAL UNITS/AIRFLOW CONTROL VALVES:

- A. Constant volume exhaust controllers shall be identical to the variable volume controller specified herein except that the controls are set to maintain a constant airflow with minimum flow equal to maximum airflow. Constant volume controllers may be changed to variable volume controllers using only the local controller or the central workstation.
- B. All airflow control valves shall provide smooth accurate fast response to the control signals. Valve shall be constructed such that the control valve and damper insure a minimum static pressure loss. Valve shall provide accurate control at low flow values.
- C. Valve shall be pressure independent over a 0.3" to 4.0" WC drop across the valve. Integral pressure independent assembly shall respond and maintain specific airflow within two seconds of a change in duct static pressure.
- D. Valve airflow measurement shall use the flow measurement and control valve described in the dual duct device above with the following criteria or:
 1. General exhaust air valves shall use the multi port flow measurement device described above for the dual duct device or the orifice plate described below. The multi port flow measurement device shall maintain accuracy over a minimum turn down ratio of 5:1 when designed for a maximum flow pressure drop of 0.3" WG.
 2. The general exhaust air valve shall be suitable for use as a Hood exhaust air valve or as an general/auxiliary exhaust valve with a design flow of 75% of it's initial selection air flow and a 5:1 turndown from the reduced air volume.
 3. Hood exhaust valve bodies and assemblies shall use a calibrated orifice plate flow station designed for the airflow velocities scheduled or recommended for each application when selected for a design flow pressure drop of 0.3" WG. The orifice shall maintain accuracy over a minimum turn down ratio of 5:1.
- E. Airflow accuracy shall be a maximum of $\pm 5\%$ of reading (not full scale) regardless of inlet or exit duct configuration over an airflow turndown range of not less than 5 to 1 with an initial design pressure

differential of 0.30" static pressure drop across the measure/control device. No entrance or exit duct diameters (other than size transitions) shall be required to ensure speed of response, accuracy, or pressure independence. Where straight duct or a size transition is required, the manufacturer shall provide integral to the equipment supplied, straightening vanes and duct sections to accommodate the entrance/exit requirements and ensure performance.

- F. Valve shall be constructed of one of the following two types:
 1. General exhaust air valve bodies shall be constructed of 16 gauge aluminum or 18 gauge galvanized steel. All bearing surfaces shall be long life teflon or teflon infused. The valve's shaft, pivot arm, shaft support brackets, and internal mounting hardware shall be made of 316L Stainless Steel. Supply air valve may be integral to the dual duct assembly.
 2. Hood cabinet exhaust valve bodies and assemblies shall have two baked-on coats of corrosion resistant phenolic coating (Heresite P403) or shall be constructed entirely of 316L Stainless Steel. The valve components located in the air stream shall be 316L Stainless Steel. The pivot arm, shaft support brackets, and internal mounting hardware shall be made of 316L Stainless Steel. General 300 Series Stainless Steel materials are unacceptable.
- G. A pneumatic actuator shall be factory mounted to the valve body to vary the position of the valve cone/damper from its minimum to maximum flows. Loss of control power or pneumatic supply air shall cause hood exhaust valves to fail open, general exhaust valves to fail open, auxiliary valves to fail closed and supply valves to fail closed (verify with each lab).

2.12 DUAL DUCT/AIR VALVE SUPPLY TERMINAL UNITS:

- A. Casing Construction:
 1. The units shall be constructed of a minimum of 22 gauge galvanized steel, double walled, insulated with a minimum of R-10 insulation. Provide hanger tabs to prevent hanging from the bottom of the housing. The insulation shall be sealed between the two walls with all edges and seams sealed or "captured", encapsulating all fibers of the insulation. The interior wall shall be neatly installed with no rough edges to interrupt the smooth flow of air through the box. The casing shall be insulated throughout its interior. On manufactured units with separate volume control valves, provide 1 ½" thick foil faced fiberglass duct wrap installed per manufacturer's recommendations on the volume control valve.
 2. All interior features of the boxes (such as mixing baffles (if required), damper housings, etc.) shall be secured within the casing to avoid excessive movement or rattling with air movement or externally generated vibration. All external features of the terminal units shall be designed not to extend beyond the edges or sides of the unit. (For example, the actuator mounting brackets, etc. shall not extend beyond the plane of the inlet "bulkhead.") The only exception shall be flow sensors installed in the inlet duct connections. Note that if a separate flow station is installed within a frame within the casing, then it shall be so installed not to allow airflow to bypass the flow measurement station.
 3. The terminal units shall be constructed with round inlet and discharge ductwork connections. The inlet ductwork connections shall extend a minimum of 4 inches from the unit casing including an allowance for the installation of airflow station(s) or probe(s). The round connections shall include 1" extension with flanged or metal, lever action, draw band, quick connectors for use by the contractor to secure the discharge ductwork or appurtenances to the unit and shall be reinforced to provide a rigid assembly.
- B. Casing Leakage: Assembled units shall be so constructed and sealed to limit air leakage to the following listed quantities at 4" static pressure Leakage curves or tables will be required as part of the submittal data. The following is the maximum allowable CFM (unless otherwise scheduled) and casing leakage including all components:

<u>Diameter</u>	<u>Maximum Allowed CFM (Area x 2000 fpm)</u>	<u>Maximum Allowable CFM Casing Leakage</u>
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4"-5"-6"	393	8.0
7"-8"	698	14.0
9"-10"	1091	22.0
11"-12"	1571	30.0

- C. Access Doors: On double duct boxes, provide an access door (12" x 12") immediately downstream of the dampers for inspection, service and cleaning of the interior. If the damper assembly is easily removed from the rear of the box, the access size can be reduced to 8" round or 8" x 8" for inspection and cleaning only. Provide access door as manufactured by Ventlock, Flexmaster Inspector, Ward or equal.
- D. Mixing Damper Construction: The damper blades shall be a minimum of 22 gauge galvanized steel or equal aluminum and shall be securely riveted or bolted through the damper shafts to assure no slippage of the blades. The damper shafts shall operate in rust-proof, self-lubricating bearings. Damper shafts penetrating the unit casings shall be sealed against leakage, and bearings shall be installed for protection against wear in the casing penetration. Damper shafts shall be formed of, or cut from solid stock; no hollow shafts will be allowed. The dampers shall seat against gasketed stops or the dampers shall have gasketed edges. Gaskets shall be mechanically fastened to the blades. If the fastening method is not full contact clamping type, then the addition of adhesive to the gasket shall be required. The dampers shall be so constructed to prevent "oil canning" of the damper blade. The units shall be tested for leakage in both inlets with 6" static pressure imposed on one inlet at a time. The maximum percent leakage from all tests shall be reported. Leakage curves as a function of pressure shall be supplied as part of the submittal data. The damper actuator linkage, if used, shall be constructed of material of sufficient strength to avoid buckling under extreme loads. Also, linkages shall not allow play greater than 5 degrees of damper movement. The controls for the dampers shall cause the dampers to fail to the closed position unless specifically noted otherwise on the design documents.
- E. Unit Pressure Drop: For all units the static pressure across the assembly at design flow shall not exceed 0.45 inches water gauge, with the total flow through either inlet.
- F. Certification: The Unit Manufacturer shall certify (individual device testing is not required) that each unit used on this project will perform as specified. Each unit shall bear a tag or decal listing the following specified information:
 - a. Rated Pressure
 - b. Leakage CFM (casing)
 - c. Date of Mfg.
 - e) Unit Tag Number
 - f) Unit size - 6", 8", etc
 - g) Calibrated CFM, ie 800 CFM Max
- G. Mixing: Dual duct terminal units serving multiple spaces shall provide mixing within the units, and not rely upon the discharge ductwork to provide for the total mixing process. The horizontal average temperature of the air as it leaves the terminal unit shall not vary more than 5°F for each 20°F of temperature difference between the two inlet air supplies. (For example, if the cold supply air is 59°F and the hot supply air is 79°F., the difference is 20 degrees. The allowable temperature variation of the discharge air is, thus, 5°F.) The temperature of the discharge air shall be measured on randomly selected field units by the owner's TAB consultant using three evenly spaced vertical and horizontal rows.
- H. Constant Volume Terminal Units: Constant volume supply terminal units shall be identical to the variable volume terminal units except that the controls are set to maintain a constant airflow with minimum flow equal to maximum airflow. Constant volume controllers shall be capable of 2 position occupied/unoccupied operation and shall be field convertible to variable volume controllers using only the local controller interface or the central workstation.
- I. Flow Measurement and Control:

1. Airflow measurement and pressure independent control shall be accomplished by the use of one or more factory calibrated, pressure independent venturi air valves with electronically modulated pneumatic operators.
2. The control logic shall use the factory calibrated NIST traceable calibration to measure the airflow.
3. The airflow control and measuring device shall be designed to prevent signal degradation due to dirt or dust in the air stream.
4. On all systems, sensors shall be mounted as required by the laboratory airflow controls supplier.
5. Sensors shall be designed and manufactured such that inlet conditions do not reduce the accuracy or repeatability of the sensor and related control. Where straight duct is required, the manufacturer shall provide integral to the equipment supplied, straightening vanes and duct sections to accommodate the entrance requirements.
6. Control system shall be such that overshoot will be limited to three percent of the desired control volume under any condition.
7. Control system shall be such that control hunting will be limited to hunting of between 1% and 5% of set point CFM for a maximum of three seconds after the sash movement stops or a flow reset is established under any condition.
8. Control system shall be such that control hunting of the lab offset will be limited to prevent any lab from becoming positive due to sash movement or heat load changes in the lab.
9. Lab controls and individual devices shall be capable of a minimum of 5/1 turndowns as described herein.

2.13 CONTROL FUNCTIONS

- A. General: The airflow control devices shall utilize a peer-to-peer, distributed control architecture to perform room-level control functions. Master/Slave control schemes shall not be acceptable. Control functions shall at a minimum include, pressurization, temperature, humidity control and respond to occupancy and emergency control commands.
- B. Pressurization Control:
 1. The laboratory control system shall control supply and auxiliary exhaust airflow devices in order to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure. 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.
 2. 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.
 3. The pressurization control algorithm shall consider both networked devices, as well as:
 - a. Up to three (3) non-networked devices providing a linear analog flow signal.
 - b. 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.
 4. 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.
 5. The Pressurization 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. 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 (5) temperature inputs and calculating a straight-line average to be used for control purposes. Separate cooling and heating set points shall be writable from the BMS, with the option of a local offset adjustment.
 2. Temperature control shall be implemented through the use of independent primary cooling and heating control functions, as well as an auxiliary temperature control function, which may be used for either supplemental cooling or heating. Cooling shall be provided as a function of thermal override of conditioned air with both supply and exhaust airflow devices responding simultaneously so as to maintain the desired offset. Heating shall be provided through modulating control of a properly sized reheat coil.
 3. The laboratory control system shall also provide the built-in capability for being configured for Hot Deck/Cold Deck temperature control.
 4. The auxiliary temperature control function shall offer the option of either heating or cooling mode and to operate as either a stand-alone temperature control loop, or staged to supplement the corresponding primary temperature control loop.
- D. Humidity Control: The Laboratory control system shall have an embedded humidity control function, which allows the monitoring and control of the relative humidity level in the pressurized zone. Using peer-to-peer control, the airflow devices shall have the ability to monitor the relative humidity level of the space and, based on a BMS writable set point, develop a control signal to drive one or the other humidification or dehumidification control circuits. The humidity control loop(s) shall share a common set point, with a configurable deadband adjustment to prevent the humidification and dehumidification control functions to operate at the same time.
- E. 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 for 1 to 1,440 minutes. The local occupancy sensor/switch, or bypass button shall be given priority over a BMS command.
- 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. 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. 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.
 4. Provide alarm signals to the Fume Hood Monitor in the event the airflow device is unable to achieve the proper flow rate, or there is a loss of static pressure indicating improper fan operation, or that there is a loss of power to the airflow control device, in order to provide a local alarm indication.

- H. The fume hood airflow control device shall respond to changes in sash position and user presence within 1 second, 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 individual sub nets to isolate network communications to insure room-level control functions and BMS communications may be carried out reliably. Each laboratory space, or pressurization zone shall be it's own sub net. Commercially available routers shall be used to provide this isolation.
- J. The laboratory airflow control system shall support at least 20-networked devices in each pressurized zone.
- K. All points shall be available through the interface to the building management system (BMS) for trending, archiving, graphics, alarm notification, and status reports. Laboratory airflow control system performance (speed, stability, and accuracy) shall be unaffected by the quantity of points being monitored, processed, or controlled.
- L. Refer to the BMS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.14 INTERFACE TO BUILDING AUTOMATION AND CONTROL SYSTEMS

- A. The laboratory airflow control system network shall digitally interfacing with the MSB Johnson Controls MetaSys system (BCAS) using a Phoenix Controls Accel-Way interface. The required software interface drivers shall be developed and housed in a Gateway, a dedicated interface device furnished by the laboratory airflow control system supplier.
- B. Any or all room-level points shall be available to the BMS for monitoring or trending. The Gateway 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 building-level network shall be a high-speed LonTalk (1.25 mbps) communications protocol. The building-level network shall support up to one hundred (100) sub nets, or pressurization zones, or six thousand (6,000) data points.
- D. A commercially available interface card shall be provided with the Accel-Way in order to connect to the building-level network.
- E. A commercially available network interface card shall be provided with the Accel-Way to interface with the BMS.

3.1 TEMPERATURE AND HUMIDITY SENSORS:

- A. General: Phoenix Controls standard room temperature sensors (with LCD readout) and humidity sensors shall be provided to provide control inputs to the laboratory control system.

3.2 ROOM DIFFERENTIAL PRESSURE ALARM PANELS:

- A. General: Phoenix Controls IRM series room monitors shall be provided as shown on the drawings to provide individual room pressure differential monitoring and alarms. Room alarm panels shall also be connected to alarm when a system failure condition which affects the room is detected by the laboratory control system.

3.3 CONTROL WIRING:

- A. General: All wiring required for a complete and operational laboratory control system shall be provided by under this Section.
- B. All line voltage control wiring and all low voltage control wiring and the main data communications loop shall be installed in conduit.
- C. Minimum requirements for control wiring shall be as follows:

1. Control wiring for digital functions shall be No. 18 AWG copper minimum, with 600 volt insulation. Multi-conductor wire shall have an outer jacket of polyvinyl chloride (PVC) or UL listed plenum rated jacket.
 2. Control wiring for analog functions shall be No. 18 AWG copper minimum, with 600 volt insulation, twisted and shielded, 2-, 3- or 4-wire to match analog function hardware. Multi-conductor wire shall have an outer jacket of PVC or UL listed plenum rated jacket.
 3. Sensor wiring shall be No. 18 AWG copper minimum, twisted and shielded, 2-, 3- or 4-wire to match analog function hardware. Multiconductor wire shall have an outer jacket of PVC or UL listed plenum rated jacket.
 4. Class 2 low energy conductor sizes specified for digital and analog functions shall take precedence over any requirements for Class2 low energy remote control and signal circuit conductors specified elsewhere, unless a larger conductor size is required by the NEC.
- D. Line and low voltage control wiring shall not be installed in the same conduit and control wiring shall not be installed in the same conduit with power wiring.
- E. All conduit in shall be run in a neat manner and shall be perpendicular and parallel to building lines. Coordinate conduit routing with field conditions so as not to interfere with code clearances, maintenance access and walkways.
- F. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.
- G. Label or code each field wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
- H. Refer to applicable Division 16 Sections for additional requirements for conduit and wiring materials and installation. All conduit and wiring shall be installed in accordance with all requirements of applicable codes.

PART 3 – EXECUTION

3.4 INSTALLATION

- A. The laboratory controls contractor (LCC) shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood. 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. Sash interface boxes with interface cards shall be mounted in an accessible location.
- B. The LCC shall install all Routers and Repeaters in an accessible location in or around the designated laboratory room.
- C. The LCC 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 LCC contractor. The LCC contractor shall terminate and connect all cables as required.
- 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 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.

- I. The LCC shall provide point monitoring and make available in the BACnet standard protocol.
 1. Makeup/Supply Air Flow
 2. Makeup/Low Flow Air Alarm
 3. General Exhaust Air Flow
 4. General Exhaust Air Alarm
 5. Fume Hood Flow
 6. Fume Hood Flow Alarm
 7. Fume Hood Sash % Open
 8. Fume Hood Emergency Override
 9. Room Offset
 10. Room Offset Setpoint
 11. Room Temperature
 12. Room Humidity
 13. Room Temperature Setpoint
 14. Reheat Valve Command

3.5 INSTALLATION PRACTICES:

- A. Manufacturer's Instructions: Install system and materials in accordance with manufacturer's instructions, roughing-in drawings and details on the Drawings. All components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown or specified. All necessary interconnections, services and adjustments required to prepare the system for interface to the Division 23 Building Controls and Automation System shall be furnished. All electrical work shall be in accordance with NEC and current UH standards. Instrumentation grounding as necessary to preclude ground loops and noise from adversely affecting equipment operations shall be installed. Specially trained personnel in the direct employ of the lab airflow controls supplier shall perform final adjustment.
- B. Terminal Unit Locations: Locate each unit accurately in the position indicated in relation to other work. Position unit with sufficient clearance for normal service and maintenance, including clearance for cabinet removal.
- C. Terminal Unit Supports: Minimum support requirements for terminal units shall be as follows. Terminal units weighing less than 150 pounds shall be supported by four 16 gauge, one inch (1") wide sheet metal straps with ends turned under bottom of unit at corners and secured by two maximum 3/4" long by 1/4" diameter sheet metal screw per strap. The other strap end shall be attached to the structure by 1/4" diameter threaded bolt into the concrete insert or into drilled-hole threaded concrete expansion anchor. Boxes over 150 pounds in weight shall be supported the same as described above except 1/4" diameter sheet metal screws shall be located with one screw on the side of the unit and one screw on the bottom of the unit. Seal all screw penetrations into the terminal unit air stream.
- D. Terminal Unit Leveling: Level terminal units to the tolerances recommended by the manufacturer.
- E. Electrical Wiring: Power (120 V, 60 Hz) will be provided at the control panel locations shown on the drawings. Electrical distribution from those locations shall be the responsibility of this equipment supplier/installer.
- F. Raceways: All line and low voltage power and control wiring shall be installed in a raceway or conduit.
- G. Mechanical Work: The installation contractor for the overall lab air distribution systems will receive and install the air flow control equipment (general exhaust air valves, dual duct terminal units and hood exhaust valves). All control installation, calibration, equipment installation review and related electrical system installation shall be by this equipment supplier/installer.

- H. Installation: All automation materials shall be applied and installed per the manufacturers' recommendations.
- I. Pressure Sensors/Transducers: Pressure sensors/transducers (all types) installed in this system shall be installed by this equipment contractor. All pressure sensors shall have taps for calibration. Pressure sensors/transducers shall be verified by calibration. This equipment contractor shall calibrate differential pressure sensors/ transducers. All devices shall be as submitted for and approved during final tests by EAB.
- J. Hood Sash Position Sensors: Sensor type and mounting by this equipment supplier, on existing hoods, shall be properly suited for those existing hood applications to provide reliable operation.
- K. Electrical Wiring: Refer to the applicable Section of Division 16 for electrical wiring incidental to the pneumatic temperature control system regardless of where shown on the Drawings.
1. All conduit, wiring, accessories and wiring connections required for the installation of the Laboratory Control System (LCS), as herein specified, shall be provided by the Laboratory Control System Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 and all local and national electric codes, unless specified otherwise in this section.
 2. All LCS wiring materials and installation methods shall comply with BCAS manufacturer recommendations.
 3. The sizing type and provision of cable, conduit and trunking shall be the design responsibility of the LCS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, trunking and/or conduit by the LCS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.
 4. Class 2 Wiring:
 - a. All Class 2 (24 VAC or less) wiring shall be installed in conduit.
 - b. Class 2 signal wiring and 24 VAC power can be run in the same conduit. Power wiring 120 VAC and greater cannot share the same conduit with Class 2 signal wiring.
 5. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
 - a. All circuits are continuous and free from short circuits and grounds.
 - b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
 - c. All circuits are free from induced voltages.
 6. Provide complete testing for all cables used under this Contract. Provide all equipment, tools, and personnel as necessary to conduct these tests.
 7. Provide for complete grounding of all signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops
- L. LCS Raceways:
1. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 3/4".
 2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Engineer.
 3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

4. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

M. Penetrations:

1. Provide firestopping for all penetrations used by dedicated LCS conduits and raceways. All other project firestopping to be by other trade.
2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.
3. All wiring passing through penetrations, including walls, shall be in conduit or enclosed raceway.
4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.
5. No penetrations in structural elements shall be made before receipt of written approval from the Engineer.

N. LCS Identification Standards:

1. Refer to Section 23 03 00 for additional painting, nameplates and labeling requirements.
2. Node Identification. All nodes shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the node location.
3. Cable Identification: Cable shall be labeled at a minimum of every 18" with the LCS System manufacturer's name and the type of signal carried within the cable, i.e. Analog Input, Analog Output, Binary Input, Binary Output, 24 VAC.
4. Color Coding: Each of the cable types shall be of a different color coding for easy identification and troubleshooting. Color coding to match existing LCS color coding in the MSB.
5. Raceway Identification. All the covers to junction and pull boxes of the LCS raceways shall be painted with the appropriate color.
6. Wire Identification. All low and line voltage LCS wiring shall be identified by a number, as referenced to the associated shop drawing and as-built drawing, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed.

3.6 SYSTEM START-UP AND COMMISSIONING:

- A. General: System start-up shall be provided by a factory-authorized representative of the laboratory airflow control system 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. Adjustment: After completion of the installation, adjust control valves and similar equipment provided as work of this Section. Final adjustment shall be performed by specially trained personnel in the direct employ of the manufacturer of the primary temperature control system.
- C. Fully commission all aspects of the Laboratory Control System work.
- D. The TAB Consultant shall be responsible for final verification and reporting of all airflows.
- E. Acceptance Check Sheet:
 1. Prepare a check sheet that includes all points for all functions of the Laboratory Airflow Control System (LACS).
 2. Submit the check sheet to the Engineer for approval one month prior to testing.

3. Complete the check sheet for all items and functions of the LACS and initial each entry with time/date as record of having fully calibrated and tested the LACS. Submit to Engineer.
 4. The TAB Consultant will use the check sheet as the basis for acceptance testing with the LACS Contractor.
- F. Provide all necessary specialist labor, materials and tools to demonstrate to the Engineer/ TAB Consultant that the LACS has been commissioned and is operating in compliance with the contract. Prepare a list of noted deficiencies signed by both the Engineer/ TAB Consultant and the LACS Contractor.
- G. Promptly rectify all listed deficiencies and submit to the Engineer/ TAB Consultant that this has been done.
- H. The Engineer/ TAB Consultant will retest the deficiencies in conjunction with the LACS Contractor.
- I. Documentation: Provide all test and calibration data in a complete manual to the Owner for use during final commissioning of the project and whenever lab remodeling is required in the future.

3.7 ANTICIPATED TESTING BY TAB CONSULTANT:

- A. General: As a minimum, TAB Consultant will test a sample room system (supply, hood exhaust and general exhaust) under the following conditions to verify the noted requirements.
1. Casing leakage rates per the specified maximum leakage per device.
 2. Inlet damper leakage rates per the specified maximum leakage per device.
 3. Unit pressure drop at design flow rates not to exceed the specified limits.
 4. Auto zero function where applicable.
 5. Flow measurement accuracy must be within 5%.
 6. Operation with fittings at the equipment connection.
 7. Overshoot after transient operation shall be limited to 5% of control volume.
 8. Control hunting limited to 5% of set point for a maximum of three seconds.
 9. Verification that the controls do not allow the lab to become negative at any time during or following transient operation.
 10. Verification of stable operation at a 5:1 turndown ratio.
 11. Minimum controllable airflow rates for the devices tested.
 12. Control stability over the test duration.
 13. Full flow tracking during transient airflow and changing cooling and heating loads.

3.8 SYSTEM TRAINING:

- A. The laboratory airflow control system 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.
- B. Refer to Section 15002 for additional training requirements.
- C. Operation and Maintenance manuals, including as-built wiring diagrams and component lists shall be provided for each training attendee. Refer to Section 23 01 00 for additional requirements.

END OF SECTION 23 09 10