SECTION 15960

LABORATORY AIRFLOW CONTROL SYSTEM (LACS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this section.

1.2 SUMMARY

A. This Section includes the following:
   1. The Laboratory Airflow Control System (LACS) is designed to maintain laboratory airflow, room pressurization, temperature control, and maintain sufficient hood face velocity to capture process fumes across the face of the hood.
   2. Room pressurization control shall utilize airflow balance by tracking supply and exhaust airflow quantities in order to limit migration of contaminants generated at the laboratory hood. The volume of supply air into the room and general exhaust air from the room are modulated to maintain both minimum ventilation and airflow balances. The control system shall also maintain laboratory space temperature, monitor space relative humidity and differential pressure in relation to the adjacent areas.
   3. The exhaust airflow volume of the fume hood shall be controlled by a “stand-alone” system that is, seamlessly, incorporates all pertinent information into the building DDC control system.
   4. Room temperature, pressure controllers, fume hood controllers, supply and exhaust air flow control dampers, transducers, reheat coil temperature control valves, associated low voltage wiring, and all necessary accessories to implement an integrated system as specified herein.

B. Related Sections include the following:
   1. Division 15, Section 15950, “Direct Digital Control Systems.”
   2. Division 16, Section 16484, "Variable Frequency Drives."
   3. Division 16, Section 16730, “Fire Alarm Specification, Local Building Devices.”
   4. Division 16, Section 16735, “Site Fire Detection and Alarm System.”

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. ASTM A366/A366M (1997) Standard Specification for Commercial Steel (CS) Sheet, Carbon.
   2. ASTM A653/A653M (1999) Standard Specification for Steel Sheet, Zinc coated (Galvanized) by Hot-dip process.

B. Air Movement and Control Association International, Inc. (AMCA)

C. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE).

D. Air-conditioning and Refrigeration Institute (ARI):
   1. ARI 880 (1989) Air Terminals.

E. National Fire Protection Association (NFPA):
   1. NFPA 90A (1996) Standards for the Installation of Air Conditioning and Ventilation Systems.

F. Sheet Metal & Air Conditioning Contractors' National Association, Inc. (SMACNA):
   1. SMACNA DCS (1995; Addendum 1997)HVAC Duct Construction Standards Metal and Flexible.

G. Underwriters Laboratories, Inc. (UL)
   1. UL 913 (1997) UL Standards for Safety, Intrinsically Safe Apparatus and Associated Apparatus for use in Class I, II, and III, Division I, Hazardous.
   2. UL916 (1998) UL Standard for Safety Energy Management Equipment Systems.

1.4 SUBMITTALS

A. Submit five (5) complete sets of documentation prior to start of installation. The submittal shall include:
   1. Manufacturer's product data including all equipment components such as fume hood monitors, controller, terminal devices, etc.
   2. Shop drawings shall include system wiring diagrams with sequences of operation, schedule of air terminal devices, and a system configuration diagram showing all controller types and locations.

1.5 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of LACS systems and shall be the manufacturer's latest standard design that complies with these specification requirements.

B. Warranty shall start on the date of Substantial Completion and extend for a period of 1 year. The manufacturer, at no cost to the owner, shall correct any materials or system performance problems.

C. Supplier shall have an in-place support facility within 150 miles of the site with: technical staff, spare parts inventory, and all necessary test and diagnostic equipment.

D. Installation as well as startup, checkout, and commissioning of the LACS shall be by fulltime employees of the control system manufacturer and shall be fully trained by the system's manufacturer.

PART 2 - PRODUCTS

2.1 LABORATORY SUPPLY AND EXHAUST AIR TERMINALS

A. Laboratory terminal units shall provide turndown ratios of 5 to 1 for fume hood exhaust terminals and adequate turndown for room supply and general exhaust terminals. Adequate turndown to assure that the airflows specified can be maintained. All terminals shall be controlled to be pressure independent and include actual airflow measurement feedback as an integral part of their control process. Minimum airflow measurement accuracy shall be +/- 5% of actual reading over the entire rated airflow range of each device. Airflow measurement device accuracy shall be AMCA certified. Proof of AMCA accuracy certification shall be substantiated by an independent third party test report. Minimum to maximum terminal airflow (or visa versa) shall be attained in less than 1 second. Carbon-Steel Sheets: ASTM A366/A366M, cold-rolled sheets, commercial quality, with oiled, exposed matte finish.

B. Exhaust airflow measurement shall be provided by airflow sensing techniques that are not likely to obstruct the exhaust duct or become inoperative due to the accumulation of chemical deposits. For example: “pitot-tube” arrays are not acceptable for exhaust airflow measurement since they may collect tissues and other debris and their minute pressure sensing holes become plugged with deposits. .

C. All supply air terminals shall comply with NFPA 90A standards and shall be constructed of 20 gauge ASTM A653/A653M galvanized steel. Damper shafts shall be solid stainless steel with Teflon or Teflon infused aluminum bearings. Supply terminals must be capable of 100% shut-off to accommodate smoke control requirements. Supply terminal air leakage shall not exceed 2% of design airflow at 4 inches WG. positive static pressure.

D. All general exhaust terminals shall comply with NFPA 90A standards and shall be constructed of 316-L stainless steel or 20 gauge ASTM A653/A653M galvanized steel coated with corrosion resistant Teflon. Damper shafts shall be solid stainless steel with Teflon bearings.

E. All Fume Hood Exhaust Terminals (FHET) shall be constructed of 316L stainless steel or coated with corrosion resistant Teflon. Damper shafts shall be solid stainless steel with Teflon bearings.

F. All terminals at the maximum rated airflow shall have a maximum pressure drop of 0.3” WG.

G. A loss, increase and/or decrease of airflow shall be transmitted to the fume hood or room controller as appropriate.

H. Noise criteria compliance for laboratory application or radiated sound power level data for all installed terminals shall be available and provided at the Contracting officer’s request. The data shall be in accordance with the test procedure in ARI 880-89 Standards for Air Terminals and all data shall be obtained in a qualified, accredited and ARI approved testing laboratory.

I. Factory calibrated terminals shall also carry the calibrated instrument certificate as evidence of compliance used for the job specific airflow’s requirement adjustments as indicated on the drawings. Factory calibration shall be conducted on certified and traceable testing facility and tests shall be conducted for eight airflows including a test of pressure independence at three static pressures.

J. Each terminal device shall be individually marked with its specific factory calibration data. As a minimum, include tag number, serial number, model number, eight point characterization information, and quality control inspection numbers. All information shall be available for inclusion on as- built drawings.

1. Room and fume hood airflow accuracy and performance shall be guaranteed as specified irrespective of field conditions.
2. In order to guarantee safety and compliance, control systems that do not measure “actual” airflow must provide airflow measuring stations. Independent airflow measuring stations shall be provided at each supply air valve, general exhaust air valve and fume hood exhaust air valve for each laboratory or pressurized space. The signals from these measurement stations shall be directly linked to the central DDC. Airflow measurement stations shall consist of an averaging airflow sensor, which shall provide an average duct velocity pressure to an airflow transmitter. Airflow transmitters shall provide an output of 4-20 mA proportional to velocity pressure. Airflow transmitters shall have an accuracy of at least +/- 0.5% of the transmitter range.

2.2 LABORATORY ROOM CONTROLLER

A. Each supply and associated exhaust terminal shall be controlled to maintain an actual CFM airflow differential between total room exhaust and supply air that is equal to 10% for the maximum laboratory room design airflow or 200 CFM, which ever is greater, to meet space pressurization requirements. For negatively pressurized rooms, supply airflow shall be controlled to equal the total room exhaust airflow less the required airflow differential. For positively pressurized rooms, total exhaust airflow shall track supply airflow less the required airflow differential. Room airflow tracking shall be accomplished via actual measurement of terminal unit airflow. Controllers which track within a range of airflow's versus actual airflow set points shall not be acceptable.

B. Each laboratory room controller shall be specifically designed for control of laboratory temperature, (humidity and differential pressure monitoring where applicable) and room ventilation. Each controller shall be a microprocessor-based, multi-tasking, real-time digital control processor. Control sequences shall be included as part of the factory supplied software. These sequences shall be field customized by adjusting parameters such as control loop algorithm gains, temperature set-point, alarm limits, airflow different set-point, and pressurization mode. Closed loop Proportional Integral Derivative (PID) control algorithms shall be used to maintain temperature and airflow offset set points.

C. Controllers using a differential pressure switch to monitor differential pressure across control devices such as an air valve shall include provisions for manual and automatic zeroing in order to maintain stable control and ensure against drift over time.

D. Controller shall include al inputs and outputs necessary to perform all the specified control sequences.

E. Each controller shall operate stand alone, performing its specified control responsibilities independently.

F. All databases and programs shall be stored in non-volatile EEPROM< EPROM and PROM memory, or a minimum of 72-hour battery backup shall be provided. All controllers shall return to full normal operation without any need for manual intervention after a power failure of unlimited duration.

G. Should a power failure or operational failure occur within occur within the controller, the terminal unit damper shall automatically be positioned to the fully open or fully closed (failsafe) position as defined by the owner.

2.3 VARIABLE AIR VOLUME (VAV) FUME HOOD CONTROLLER

A. Provide a UL 916 listed individual VAV fume hood controller for each fume hood which shall maintain the face velocity set-point (adjustable) in response to sash position

B. In operation, the VAV fume hood control process consists of calculating the fume hood exhaust flow necessary to provide the required average face velocity at any sash position based upon actual sash position and total fume hood open area. The controller shall then position the fume hood exhaust terminal damper to attain the required exhaust airflow in conjunction with constant feedback from an integral exhaust airflow sensor. The controller shall perform this exhaust airflow calculation ten times per second to ensure maximum speed of response to changes in sash position. Even when no change has occurred in sash position since the previous calculation, the controller shall continue to position the exhaust terminal damper in response to its airflow measurement feedback to ensure that the required fume hood exhaust is always maintained independently of variations in exhaust system static pressure or room conditions that could otherwise affect fume hood exhaust airflow.

1. The VAV fume hood controller shall initiate corrective action immediately upon sash movement and be completed when sash movement stops so as to restore the required average face velocity within 1 second after completion of sash movement. Control scenarios that are not based upon sash sensing such as those utilizing side wall airflow sensing must substantiate that fume hood face velocity will be restored within 1 second after completion of sash movement. ASHRAE 110 VAV fume hood response time test data substantiating this performance requirement shall be submitted. All such ASHRAE 100 testing shall be conducted by a qualified, accredited and independent testing source.
2. Air velocity sensors utilized for sidewall sensing shall be UL 913 listed. Documentation of UL listing shall be submitted with the technical proposal and included with the submittals.
3. A “Sash Alert” feature shall provide periodic beeps at the Operator Display Panel when the sash remains open above the recommended safe working height (adjustable) for an adjustable period of time. This feature shall enhance fume hood safety operation and energy efficiency. This feature shall include a beep interval and be capable of being implemented on individual fume hoods as desired by authorized owner personnel.

C. The face velocity set-point shall be adjustable by authorized owner personnel

D. Controllers shall include the ability to accept and incorporate into the control sequence a dry contact closure from auxiliary sensors. Example: Occupancy override, Emergency button, etc.

E. Controllers shall provide a general alarm output for use with auxiliary devices.

F. Momentary or extended losses of power shall not change or affect any of the control system’s set points, calibration settings or emergency status. After power returns the system shall continue operation exactly as before without need for any manual intervention.

2.4 FUME HOOD OPERATOR DISPLAY

A. An operator display panel shall be provided for each fume hood to comply with laboratory safety standards. The operator display panel shall provide the following functionality.

1. Indicator lights that verify normal operation (green), marginal operation (yellow), and alarm condition (red). An alarm condition shall automatically be initiated for both high and low face velocity conditions.
2. An audible alarm device shall also be initiated in response to an alarm condition. The audible alarm device shall be capable of being silenced by a user silence button, however the alarm device shall automatically resound upon another alarm occurrence.
3. A user initiated emergency purge function shall initiates both visual and audible alarms and increase the fume hood exhaust to the maximum airflow. When the emergency purge button is depressed, a second time, the emergency sequence shall be terminated and fume hood control shall return to normal operation.

2.5 SASH SENSOR

A. Provide, sash position sensors for each fume hood to indicate the actual position of each sash. The sash sensor shall be a precision, linear device with repeatable location accuracy within on a half inch.

B. Sash sensors material shall be corrosion resistant.

C. Sash sensors shall allow complete and easy removal of the sashes for cleaning and maintenance.

D. Operational life of each sash shall be a minimum of 100,000 full cycles.

E. Sash sensor failure shall be indicated as an alarm at the fume hood operator display panel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The laboratory ventilation system contractor shall install sash sensors, control equipment, and operator display panels on fume hoods. This same contractor shall install and terminate all low voltage control wiring between each controller and all control and sensing devices, and provide 24 VAC positioners where required by the controller and control devices. This contractor shall install pneumatic control tubing from the nearest building's air main for all laboratory control devices that are pneumatically operated.

B. The electrical contractor shall provide 120-Volt power circuit in the laboratory ceiling space for connection to the laboratory control equipment.

C. Supply terminals with reheat coils, the mechanical contractor shall install exhaust terminals and temperature control valves.

3.2 SYSTEM STARTUP

A. System startup shall be provided by factory certified and trained employees of the laboratory ventilation control system manufacturer. Start up shall include the following:
   1. Determine when the HVAC equipment and physical space is ready for operational testing.
   2. Set up fume hood: face velocity controls, verify face velocity, and air flow measurement accuracy.
   3. Verify VAV room supply system performance.
   4. Verify VAV room exhaust system performance.
   5. Verify room airflow tracking performance.

B. All steps of system startup shall be formally recorded when performed and provided to the Construction Manager as part of as-built documentation.

3.3 TRAINING

A. The contractor shall provide competent instructors to give complete and specific on site instruction to designated personnel in the adjustment, operation and maintenance of the installed system, in lieu of a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter and the installed system. All training shall be held on weekdays during the normal work hours of 8:00am to 4:30pm.

B. Training shall consist of not less than 16 hours for Construction Manager designated operating personnel. Training shall include:
   1. Explanation of as built drawings, overall system operation, and user required maintenance.
   2. A thorough walk-through of the job to locate control components.
   3. Laboratory and fume hood controller specific operation and functions.

4. Explanations of adjustment, calibration, and replacement procedures.

C. Since the Construction Manager may desire that specific personnel have more comprehensive understanding of the system and its components, additional training shall be available from the Contractor at a future agreeable date that is to be stated in the Contract.

3.4 MAINTENANCE

A. Due to the life safety concern associated with use of this equipment, systems that do not measure airflow (at each air terminal) as well as those that require individually factory calibrated terminals (air valves), shall provide two (2) years of preventative maintenance after the initial warranty period, at no additional cost to the owner (as part of this bid). As part of this additional maintenance program, the Contractor shall also include, at contractor expense, a visual inspection of all internal linkages (points). All linkages must be cleaned to avoid fouling and to insure proper operation annually.

B. Systems that measure actual airflow's and incorporate the use of a closed-loop control, shall offer a preventative maintenance program options to the Construction Manager.

3.5 BUILDING DIRECT DIGITAL CONTROL (DDC) SYSTEM INTERFACE

A. Each Local Control Panel (LCP) shall interface with the building DDC system such that all measured space pressure and temperature data and set points can be monitored or adjusted through either the LCP or the building DDC. The following laboratory information shall be provided:
1. Room supply airflow (CFM).
2. Fume hood exhaust airflow (CFM).
3. Room general exhaust airflow (CFM).
4. Room Total exhaust airflow (CFM).
5. Room differential pressure (inches of WG, or PSI).
6. Room temperature (degree Fahrenheit).
7. Supply air to room "in-duct" volume damper position.
8. Exhaust air from room "in-duct" volume damper position.
9. Supply air heating coil temperature control valve position.

B. Information may be transmitted electronically through protocol translators, seamless LAN connection, or through a direct connection (hard wire). If the direct connection approach is used, the Contractor shall be responsible for all wiring and any additional building automation and local control panel requirements. If the electronic approach is used, the Contractor shall be responsible for all network wiring and any protocol translators required by the building's DDC or local control systems.

PART 4 - SEQUENCE OF OPERATIONS

4.1 LABORATORY ROOM PRESSURIZATION

A. Space negative pressurization: through the Local Control Panel (LCP) room supply air and exhaust air quantities are continuously compared and if required, modulated in order to maintain pre-set "negative" air flow ratio and consequently its pressurization in the laboratory. Air flow measuring stations in the room exhaust, hood exhaust, total exhaust air stream, and room supply air stream are to provide input to the local control panel. Space pressurization requirement between the laboratory and adjacent corridor is –0.02 inches of W.G. The tracking process shall be based upon subtracting the airflow tracking differential CFM set point (adjustable) from the total room exhaust CFM. The room pressurization controller shall then modulate the supply air terminal unit to achieve the necessary room supply airflow CFM to ensure that the airflow tracking differential is always maintained.

B. The room pressurization controller in the local control panel shall continuously receive the fume hood exhaust CFM set point values from each fume hood controller in the room and shall measure the actual room general exhaust airflow CFM. The controller shall continuously calculate total room's exhaust CFM by adding the room general exhaust CFM and all fume hood exhaust airflow's together. The controller shall then modulate the room general exhaust as necessary to ensure that the minimum total room exhaust necessary to meet the required room's ventilation rate is continuously maintained.

4.2 LABORATORY ROOM PRESSURIZATION (Flow tracking with room pressure reset)

A. The room pressurization controller shall maintain "negative" laboratory pressure by continuously calculating the required room supply airflow CFM necessary to maintain the predetermined airflow tracking differential. This process shall be based upon subtracting the airflow tracking differential CFM set point (adjustable) from the total room exhaust CFM. The room's pressurization controller shall then modulate the supply air terminal unit to achieve the necessary room supply airflow CFM to ensure that the airflow-tracking differential is always maintained.

B. The room pressurization controller shall continuously receive the fume hood exhaust CFM set point values from each fume hood controller in the room and shall measure the actual room's general exhaust CFM. The controller shall continuously calculate total room exhaust CFM by adding the room general exhaust CFM and all fume hood exhaust airflows together. The controller shall then modulate the room's general exhaust as necessary to ensure that the minimum total room exhaust necessary to meet the required room ventilation rate is continuously maintained.

C. The room pressurization controller shall utilize a differential pressure sensor in the wall between the room and an adjacent non-lab area to continuously measure the actual differential pressure between the laboratory room and adjacent area. The controller shall utilize the differential pressure measurement to establish the airflow-tracking differential required to maintain the room differential pressure set point.

D. The room pressurization control sequence shall include a selectable maximum airflow tracking differential set point and selectable minimum flow tracking differential set point. The minimum and maximum flow tracking differential set points shall serve as control limits for the room's pressurization control scenario.

1. The maximum flow tracking differential set point shall prevent the room's pressurization control scenario from decreasing the room supply airflow to an undesirable, low level. Whenever a condition (such as an open door allowing excessive airflow into the room from the adjacent area) would otherwise result in an undesirable, low level of room supply airflow, the maximum flow tracking differential set point shall limit this decrease.
2. The minimum flow tracking differential set point shall prevent the room's pressurization control scenario from increasing the room supply airflow to an undesirable, high level. Whenever a condition (such as a failure of the room differential pressure sensor) might cause the room supply airflow to approach or exceed the total room exhaust, the minimum flow tracking differential set point shall limit this increase.
3. The room's pressurization control shall also include selectable high and low room static pressure alarm limits and an adjustable alarm delay period. Whenever the room's static pressure exceeds a high or low static pressure alarm limit for a period of time in excess of the alarm delay period, annunciation of the high or low alarm condition shall occur at the designated central workstation.

4.3 VAV FUME HOOD CONTROL

A. The fume hood controller shall continuously calculate the total fume hood open area based upon the fume hood's fixed openings, bypass opening, and sash position as indicated by the sash sensor(s). The fume hood controller shall also continuously calculate the fume hood's exhaust CFM required to maintain the average face velocity set point based upon the total open area of the fume hood and the average face velocity (adjustable) set point. The fume hood controller shall utilize actual fume hood exhaust CFM and modulate the fume hood exhaust to control and maintain the required fume hood's average face velocity.

B. The fume hood controller shall always maintain the fume hood's exhaust CFM at the desired minimum (and maximum set point value (adjustable)) when the total fume hood open area would otherwise result in less than the desired minimum (maximum) fume hood exhaust CFM. This minimum fume hood exhaust set point shall be set to the value recommended by the fume hood manufacturer in order to maintain adequate fume containment and dilution.

4.4 ROOM TEMPERATURE CONTROL (Single Supply Duct Terminal Reheat)

A. The room controller shall continuously measure the temperature in the room by means of the room temperature sensor and shall maintain the room temperature at the set point by modulating the normally open (N.O.) heating valve.

B. If the room supply air is at its minimum temperature and the room requires an increased amount of supply air (beyond the amount of room supply airflow necessary to maintain required room pressurization), the room controller shall increase the room's general exhaust air and track its change with the room supply air to maintain the room temperature set point. This will assure that room pressurization is maintained. Systems that increase the room's supply airflow first will not be acceptable.

END OF SECTION 15960