

## **LABORATORY FUME HOOD CONTROL SYSTEMS GUIDE SPECIFICATION**

### **Part I - General**

- A. Provide a complete system for the variable air volume control of laboratory spaces and fume hoods.
- B. System shall include, but not be limited to, control panels, supply variable air volume boxes, general room exhaust valves, fume hood exhaust valves, sensing stations and fume hood sensors and alarm modules.
- C. Total system shall be installed and commissioned by, or under the direct supervision of, factory trained and authorized field engineers.

### **1.2 Related Work**

- A. Section :General Provisions
- B. Section :Variable Frequency Drives
- C. Section :Factory Assembled Air Handling Units
- D. Section :Factory Built-up Air Handling Units
- E. Section :Centrifugal Fans
- F. Section :Axial Fans
- G. Section :Power Ventilators
- H. Section :Ductwork
- I. Section :Ductwork Accessories
- J. Section :Air Distribution Devices
- K. Section :Air Flow Control Systems
- L. Section :Building Control Systems
- M. Section :Building Automation Systems
- N. Section :Control Sequences of Operation
- O. Section :Testing, Adjusting and Balancing

### **1.3 Job Conditions**

- A. Coordinate exact sizes and locations of components with the contractor installing the ductwork, temperature controls, and Division 16 work.

### **1.4 Submittals**

- A. Furnish shop drawings on all equipment provided under this Section, including but not limited to:
  - 1. Hardware and Devices
  - 2. Installation Control Drawings
  - 3. Sequence of Operation
  - 4. Operating and Maintenance Manuals

### **1.5 Quality Assurance**

- A. Supplier of this section's systems shall be regularly engaged in the production, assembly, and installation of laboratory fume hood control systems and have a proven track record of a minimum of 5 years.
- B. Supplier of this section's systems shall assume single source responsibility for the complete installation, calibration, and startup of the fume hood tracking systems. Systems shall be left in a completely automated, fully functioning mode of operation.

## **Part II - Products**

### **2.1 Acceptable Manufacturers**

- A. Base Bid: Laboratory Control Systems Inc. ENVIROTRAK System

### **2.2 General**

- A. Fume hood tracking system shall use closed loop control to continually monitor and adjust the supply, general room exhaust, and fume hood exhaust volumes. Open loop control systems that merely feed back an analog signal that measures a position of a mechanical device, or systems that can control by pressure only, are unacceptable and will not be considered. Open loop and closed loop as defined by 1991 ASHRAE Applications Manuals Chapter 41, page 41.1 .

### **2.3 System Design**

- A. In all cases, systems shall fail-safe to a mode which achieves the maximum safety to personnel in the spaces served by the systems.
- B. Room pressurization control will be accomplished by flow synchronization (airflow tracking) or by direct space pressure control, or by a combination of both. Unless specifically identified elsewhere, all systems on this project shall utilize flow synchronization as the mode of control. Air flows from the supply air, general room exhaust, and fume hood exhaust will be measured and controlled to maintain a safe, comfortable, and energy efficient environment.
- C. Fume hood face velocity control will be used to maintain a preset adjustable face velocity setpoint. Inputs to the controller shall include sash position or velocity sensor and fume hood exhaust air flow, from which the controller will calculate the hood face velocity. A pneumatic, normally open, damper motor will modulate an exhaust valve as required to maintain the face velocity setpoint.
- D. All actuators will be pneumatic to ensure quick response time and fail-safe operation.

### **2.4 Equipment**

- A. Laboratory Room Control Panels: Equal to LCS Inc. Envirotrak laboratory control panels and shall include all control components for the system logic, input signal conditioning, output signal conditions, power supplies and operator interface. Laboratory control panels shall be located to facilitate maintenance and troubleshooting. Panels shall be of standalone design with the ability to operate the entire laboratory space it serves upon loss of communications from the laboratory network. Each panel shall be fully field programmable.

- B. Central Processing Unit (CPU): Industrial quality with the following minimum performance parameters:
1. Scan Rate: The time used by the control system to read a sensor value, calculate a control response, and output a signal to the controlled element shall not exceed 50 milliseconds. If a communications link is used to pass control information, then the communications rate and protocol lag time must still allow the control loop to obtain the same response time.
  2. Input Accuracy: The input section of the electronics (A/D converter) shall be minimum 12 bits (0.024%) resolution.
- C. Control Modes: The control system shall incorporate proportional, integral and derivative modes of control. Each mode shall be indefinitely adjustable.
- D. Alarm Processing: The pressurization and fume hood control system shall provide fully field programmable alarm processing capabilities. The system shall have the capability of high and low alarms. These alarms shall be transmitted over this network to the supervisory system and/or annunciated locally as required.
- E. Gateway: Equal to LCS Inc. ENVIROTRAK Communications Gateway. Provides a network function for data retrieval and communication with Envirotrak controllers through the keyboard and line display or provide for communication exchange with the system supervisory workstation . Features shall include:
1. Optional OPTI-VIEW Alphanumeric Display
  2. Multiple Password Protected Operator Interface with Multiple Levels of Security
  3. Auto Restart Following Power Failure
  4. Rechargeable 72 Hour Memory Battery Backup
  5. Time of Day Scheduling Including Night Setback, Holidays and Weekends
  6. Alarm Actions and Messages
  7. Trend Log and Data Logging Capabilities
  8. Existing Menu Programs and User Defined Programs
  9. PC Interface for Program Uploading and Downloading (RS-232 Port, 9600 Baud)
  10. Two RS-485 Ports for Communication with Envirotrak Controllers (51.2K Baud)
  11. Optional Modem through Standard RS-232 Port (1200 Baud or Greater)
  12. Operating Environment: 30 - 122F, 0-90% RH (non-condensing)
  13. Power Requirements: 120VAC, 0.25a
- F. Provide an Envirotrak System Supervisory Workstation for central supervisory operations interface. Workstation shall be Pentium II Model computer with dual 3.5 inch diskette drives, 8 Gig Hard Drive, display adapter, 17 inch color display, keyboard and IBM PC DOS 3.3 or higher operating system of OS/2 system.
1. In addition to the above, the system shall include the following:
    - a. Alarm and Report Printer
  2. The functions of the System Supervisory Workstation shall include:

- a. Envirotrak System Access
- b. System Monitoring
- c. Database Management
- d. Management Reports
- e. System Programming. If the contractor provides only 0 - 10 volt analog signals, the system must be able to be reprogrammed and calibrated from the P.C. workstation. Simple monitoring of such output is not acceptable.
- f. User Program Development
- g. Facilities Management
- h. Dynamic Graphics Display Generator
- i. Data Collection and Recording
- j. Report Generation
- k. Maintenance Management

G. Controller: Equal to LCS Inc. Envirotrak microprocessor-based distributed control system. Able to control a variety of fume hood and face velocity control sequences through standard configurations of interface hardware and software. Analog inputs shall be capable of being software filtered to eliminate hysteresis effects and unwanted signals. Controller database stored in non-volatile EEPROM memory for complete standalone operation. Features include:

1. 2 Wire RS-485 Serial Communications, 51.2K Baud
2. Contact Inputs: 2 Total Used for Status Monitoring of Dry Contacts
3. Digital Outputs: 2 Total, 24VAC, 12VA (.05 amp max)
4. Analog Inputs: 5 Total Universal Inputs Individually Configurable for Any of the Following:
  - 1000 Ohm Platinum Temperature Sensor  
-40F to +240F at 0.1F Resolution
  - 1000 Ohm Balco Sensor  
-28.6F to +240F at 0.1F Resolution
  - 0-10VDC at 0.005V Resolution
  - 4-20mA at 0.01mA Resolution
5. Analog Outputs: 3 Total, Configurable for the Following:
  - 0-10VDC at .005 V Resolution
  - 4-20mA at .005mA Resolution
  - Accuracy: +/- % F.S.
6. Alarm Inhibiting: User programmable, S/S points up to 255 seconds; analog and loop points up to 255 minutes following start command.
7. Power Requirements: 24V, +/-2%, 50-60Hz, 101VA Maximum
8. User-defined programming - 100 lines of UDP CODE available. 10 User-defined programs maximum.
9. Local Interface Port - Supports IAM alarm/Interface module, ITS temperature sensor and/or hand-held operator interface tool.
10. Time-of-Day and Back-Up Schedule - Assignable to Any Schedulable Point. Two Schedules: 10 Days; 6 Events per Day.
11. Operating Environment: 32 to 122F (0-50C) 0-90%RH (non-condensing)
12. The control unit shall generate real time signals reflecting actual air flow measurement. Systems that provide only a 0-10 volt analog signal, must be programmable as mentioned in Section F.2.e, and must provide an actual air flow measurement to complete a closed loop system. Systems that merely sense a 15-20% reduction in air flow are not acceptable. As a minimum the following signals shall be available:
  - a. Hood Exhaust Flow (CFM)
  - b. Supply/Make-Up Air Flow (CFM)

- c. General Exhaust Flow (CFM)
- d. Total Lab Exhaust Flow (CFM)
- e. Total Lab Supply Flow (CFM)
- f. Room Offset (CFM)
- g. Sash Position or Face Velocity
- h. Room Temperature

H. Fume Hood/Room Alarm Module: Equal to LCS Inc. IAM. The local interface module shall incorporate the following functions and features as a minimum:

1. Microprocessor-Based with Programmable Function Section
2. Membrane Push-Button Function Keys
3. Red, Yellow, and Green L.E.D. Indicators
4. Communication Ports
5. Digital Liquid Crystal Display (LCD) Capable of Displaying the Following:

a. Environmental Control

1. Air Flow: CFM or L/S
2. Pressurization: Differential Flow - CFM or FL/S  
Differential Pressure - H20 or Pa
3. Time of Day: a.m. or p.m.  
Clock

b. Fume Hood Control: Face Velocity - FPM or M/S  
Air Flow - CFM or L/S  
Open Area - Qs ft or M2  
Sash Alarm

c. Additional Alpha Display Points:

- |                       |                 |
|-----------------------|-----------------|
| 1. Alarm HI           | 7. Service      |
| 2. Alarm Lo           | 8. Clock        |
| 3. Normal             | 9. On/Off/Auto  |
| 4. Caution            | 10. Fan - Lo/HI |
| 5. Emergency Override | 11. Day/Night   |
| 6. Setpoint           | 12. Deviation   |

6. Alarm module shall incorporate a hidden password push-button and feature a programmable "monitor only" mode to restrict tampering.
7. Mounting: The IAM shall be surface-mounted to the fume hood or the wall with mounting plate furnished.

I. Optional Auxiliary Emergency Override Switch: Each laboratory space connected to the fume hood system control shall include a hall mounted emergency override switch, located near the exit door from the space.

J. Room Temperature Sensor: Equal to LCS Inc. Model IS.

The IS Series Intelligent Sensors are programmable room temperature thermostats designed to operate as a standalone interface to the Envirotrak controller. Each sensor features a microprocessor, communications ports, membrane push-button keys and a digital liquid crystal display (LCD).

K. RTD Duct Temperature Sensor: Equal to LCS Inc. DTS RTD sensor for installation in air ducts. Two-wire interface with Envirotrak controller. Features include:

1. Type: Resistance temperature detector (RTD)
2. RTD material: Thin film silicon in stainless steel probe
3. Nominal resistance: 2000 ohms at 68F
4. Temperature range: -30F to +212F
5. Stability: Better than 0.25C per year
6. Accuracy: +/-5% at 86F
7. Insulation resistance: >50 megaohms, 50VDC at 25C
8. Recommended current: 1.0 mA
9. Maximum current: 3.0 mA
10. Vibration resistance: 5 G to 50 Hz

L. Low Differential Pressure Transmitter: Furnish for each air flow or differential pressure measurement point a low differential pressure transmitter incorporating the following functions and features:

Pressure Range: 0-0.1 through 0-5.0"W.C. - Selected according to required operating range.

Accuracy: 1% F.S.O.

Stability: +/-0.5% F.S.O.

Thermal Effects: +/-1% F.S.O.

Over pressure Rating: 15 PSI

Power Supply: 24VAC

Supply Current: 25mA (peak draw 70mA when auto zeroing)

Output Signal: 4-20mA

The transmitter shall be temperature compensated and feature an auto zero function to eliminate zero drift and the need for periodic calibration.

M. E/P Transducers: Furnish and install for each actuator an E/P transducer which converts a proportional electric output signal from the Envirotrak controller to a direct-acting proportional pneumatic signal to operate a pneumatic actuator. The transducer shall be powered by the control signal and require no extra power supply.

Specifications:

Ambient Operating Limit:

Temperature: 41F to 131F (5C to 55C)

Humidity: 5 to 95% RH

Storage: -22F to 158F (-30C to 70C)

Power Supply: None, powered by control signal

Power consumption: 16mA at 11.5VDC

Input Signal: 2 to 10VDC

Main Air Pressure: 18psi (125kPa)

Maximum Safe Air Pressure: 29psi (200kPa)  
Air Consumption: 0.025SCFM (11/17ml/s)  
Air Capacity: 0.45SCFM (211ml/s)  
Air Connections: Dual barb-fittings for: 1/4" (6mm) O.D. or 5/32" (4mm)  
O.D. polyethylene tubing  
Electrical Connections: Screw terminals for 14 to 22 gage wire  
Calibration: Factory calibrated Note: Must be mounted vertically within 5 degrees to  
maintain factory calibration.

- N. Air flow sensors shall be furnished as an integral part of the supply and exhaust boxes. Sensor shall measure velocity pressure and produce an output that is an amplified velocity pressure signal equal to 1.8 x actual velocity pressure. The sensor shall be averaging type employing no fewer than 12 total pressure and 3 static pressure measurement points in a symmetrically weighted arrangement.

Sensor material shall be aluminum, heresite-coated aluminum, or stainless steel to correspond with duct material. Sensors, or their associated terminal box assemblies, shall be installed with a minimum of three straight duct diameters upstream and a minimum of 2 diameters downstream when used as a duct mounted air flow measuring device. Air flow measurement accuracy shall be +/-0.5%. Flow curves shall be furnished with the air flow sensor.

- O. Sash Position Sensors: Sash Position Sensor shall consist of a precision optical encoder coupled to a spring return cable assembly. The sensor shall be 0.1% resolution and accuracy combined. The sensor shall be mounted in a concealed location and coordinated with the fume hood manufacturer.
- P. Face Velocity Sensors: Face Velocity Sensors shall consist of electronic velocity sensor mounted in a PVC shroud assembly. The sensor shall be hot-wire anemometer consisting of platinum elements in a glass encased assembly. The sensor shall be temperature compensated and produce a linear output voltage equivalent to 0-200FPM. The sensor shall be mounted in accordance with the manufacturer's recommendations and shall be coordinated with the fume hood manufacturer. The sensor shall provide an accuracy of not less than +/-2% and shall have the capability to be field-calibrated in the installed condition to provide for maximum installed accuracy and performance.
- Q. Duct Velocity Transmitter Specifications:

A DVT as manufactured by LCS Inc. Products Division shall sense a flow dependent pressure signal that has been averaged on an incremental basis over the full duct. This air flow sensor shall amplify the velocity pressure signal so that the transmitted pressure is a true linear function of velocity pressure, approximately 1.6 times the average velocity pressure in the standard configuration. Higher amplification factors may be achieved if furnished with a calibrated orifice so the measured signal is optimized for duct size and flow.

The DVT shall be built from heavy gauge coated sheet steel. Calibration charts showing signal pressure vs. capacity shall be provided. This transmitter shall be installed in the supply or extract ductwork.

Air flow sensing tubes shall have a minimum of 12 total pressure measuring points and 3 static pressure measuring points.

The DVT shall be furnished with an integral differential pressure transmitter suitable for output to a building automation system for control or monitoring purposes. The transmitter shall incorporate the following features and functions:

Pressure Range: 0-0.1" to 0-5.0"W.C.-Selected according to required operating range.

Accuracy: 1% F.S.O.

Stability: +/-0.5% F.S.O.

Thermal Effects: +/-1% F.S.O.

Over pressure Rating: 15PSI

Power Supply: 24VAC

Supply Current: 25mA (peak draw 70mA when auto zeroing)

Output Signal : 4-20mA

The transmitter shall be temperature compensated and feature an auto zero function to eliminate zero drift and the need for periodic calibration.

A schematic drawing shall be provided with each DVT indicating proper hookups for transmitter and controls.

It shall be the responsibility of the installing contractor to install the DVT as required by the DVT manufacturer.

- R. Room Static Pressure Sensor: Provide, where required, a shielded static pressure sensor suitable for flush mounting in either the wall or the ceiling. The sensor shall incorporate multiple sensing ports, pressure impulse suppression attenuator, airflow shielding and barbed or compression fitting. Casing shall be capable of measuring static pressure to within 1% of actual.

The Room Static Transmitter shall be furnished with a differential pressure transmitter suitable for output to a building automation system for control or monitoring purposes. The transmitter shall incorporate the following features and functions.

Pressure Range: 0.15"W.C. -selected according to required operating range.

Accuracy: 1% F.S.O.

Stability: +/-0.5% F.S.O.

Thermal Effects: +/-1% F.S.O.

Over pressure Rating: 15PSI

Power Supply: 24VAC

Supply Current: 25mA (peak draw 70mA when auto zeroing)

Output Signal: 4-20mA

The transmitter shall be temperature compensated and feature an auto zero function to eliminate zero drift and the need for periodic calibration.

- S. Supply Variable Air Volume (VAV) Boxes: Furnish VAV boxes as on the drawings and specified under Section , Air Distribution Devices. Controls for the VAV box shall be located in the laboratory control panel for ease of adjustment, calibration, and troubleshooting. This shall apply to all supply VAV boxes serving laboratory and support areas. Each device must be field calibrated to accurately reflect construction and last minute design changes.
- T. Supply Box Reheat Coils: Furnish reheat coils as shown on the drawings and specified under Section , Air Distribution Devices.
- U. General Room Exhaust Valves: Furnish general room exhaust valves as shown on the drawings and specified under Section , Air Distribution Devices. Controls for the exhaust valves shall be located in the laboratory control panel for ease of adjustment, calibration, and troubleshooting. This shall apply to all general exhaust boxes serving laboratory and support areas. Each device must be field calibrated to accurately reflect construction and last minute design changes.
- V. Fume Hood Exhaust Valves: Furnish fume hood exhaust valves as shown on the drawings and specified under Section , Air Distribution Devices. Controls for the exhaust valves shall be located in the laboratory control panel for ease of adjustment, calibration, and troubleshooting. Each device must be field calibrated to accurately reflect construction and last minute design changes.

## 2.5 Sequence of Operation

### A. Fume Hood Face Velocity Control:

- 1a. Sash Position Sensing: The control shall determine the face velocity by measuring the fume hood sash position and the fume hood exhaust flow. The fume hood exhaust damper shall then be adjusted to maintain the programmed adjustable face velocity setpoint.

Response time will be 3 seconds or less.

- 1b. Fume Hood Face Velocity Control with Side Wall Velocity Sensor: Face velocity will be controlled to maintain an adjustable face velocity setpoint. The linear velocity sensor shall continuously monitor the pressure (velocity) differential between the laboratory and the fume hood interior. Changes in sash position, laboratory room pressure, or duct static pressure causing the hood face velocity to change, shall be sensed by the sensor and transmitted to the control system, which shall position the exhaust valve damper, by a pneumatic actuator, to maintain the programmed setpoint.

2. Alarms: A visual and audible alarm signal will be initiated if the fume hood face velocity falls below, or rises above, the low or high alarm setpoints respectively. The audible alarm will continue until the alarm silence button is depressed on the fume hood interface module. The visual alarm will continue until the alarm condition ceases.

3. Emergency Override: When the emergency override button on the fume hood interface module is depressed, the exhaust damper shall go to its preprogrammed position (normally, this would be the full open position), and the visual and audible alarms will be

activated. Depressing the button a second time will return the system to normal operation. A remote override located in the hall outside the space shall function similarly.

4. Night Setback: If desired, the controller will go into the night setback mode at a preprogrammed and adjustable time, or when receiving a signal from an external source. At least two modes of night setback shall be available:

- a. Mode 1: Night setback reduces the face velocity to a preprogrammed value.
- b. Mode 2: Night setback reduces the fume hood exhaust flow to a preprogrammed value.

B. Air Flow Tracking - Laboratories With Fume Hoods:

1. The laboratory tracking system measures all supply and exhaust flows into and out of the laboratory space. Supply air flow is varied to maintain a fixed offset air volume differential between the supply and total exhaust in a closed loop tracking arrangement. A space temperature sensor and a duct mounted temperature sensor are inputs to an anticipatory temperature control proportional/integral/derivative (PID) loop.

2. The supply and total exhaust air volumes from the laboratory space shall be controlled (varied) in such a manner as to perform both air flow volume (mass) and air flow temperature (energy) calculations and adjustments.

3. Space supply air volume shall be controlled to maintain space comfort conditions, or to maintain the required air volume offset between the supply and exhaust air volumes.

4. When the supply air volume required for makeup exceeds the volume required for space comfort conditions, the control system shall modulate the general exhaust damper to its closed position.\* If additional makeup air is still required, the supply air volume will be increased as required to maintain the volume differential between the supply air and exhaust air. The temperature of the supply and exhaust air, along with their respective air volumes, will be measured and input into the controller. The controller will adjust the heating valve on the supply air reheat coil, based on those inputs as well as an input from a space temperature sensor, as required to perform an energy balance in the space. The controller program shall be adjusted and calibrated to each space it serves to perform the mass and energy calculations and adjustments without noticeable swings in space temperature

\* Or to maintain the minimum ventilation setpoint

5. As the required total exhaust from the space is reduced because of reduced fume hood usage, the supply air volume delivered to the space will be reduced to a level where the required air volume offset is being maintained. If the space thermostat requires a greater volume of supply air to condition the space than is being supplied to maintain the required supply/exhaust offset, the general exhaust volume shall be increased and the supply volume from the space will be increased as required to maintain the offset.

C. Air Flow Tracking - Laboratories and Collection Areas Without Fume Hoods

1. The laboratory tracking system measures all supply and exhaust flows into and out of the laboratory space. Supply is varied to maintain a fixed air volume differential between the supply and room exhaust in a closed loop tracking arrangement. A space temperature sensor and a duct mounted temperature sensor are inputs to a anticipatory temperature control proportional/integral/derivative (PID) loop.

2. The supply and room exhaust air volumes from the space shall be controlled (varied) in such a manner as to perform both volume (mass) and temperature (energy) calculations and adjustments.
3. Space supply air volume shall be controlled by either a space thermostat, to maintain space comfort conditions, or by the rooms exhaust volume from the space, to maintain the required air volume offset between the supply and exhaust air volumes.
4. Negative Pressure Spaces: The general exhaust damper shall be modulated to maintain either the minimum ventilation setpoint or to satisfy cooling demand, whichever is higher. The supply flow shall track the exhaust flow to maintain a fixed offset CFM between total exhaust and total supply to keep the space negative at all time. If the air quantity necessary to maintain the ventilation setpoint causes a drop in space temperature below the room setpoint, the reheat coil control valve shall be modulated to maintain setpoint.
5. Positive Pressure Spaces: The supply box shall be modulated to maintain either the minimum ventilation or cooling setpoint, whichever is higher. The general exhaust is modulated to maintain a fixed offset CFM between total supply and total exhaust to maintain the space positive at all times. If the air quantity, necessary to maintain the ventilation setpoint causes the space temperature to fall, then the reheat coil control valve shall be modulated to maintain space temperature setpoint.

### **Part III - Execution**

#### **3.1 Installation**

- A. The laboratory control manufacturer shall be responsible for ensuring that the control system is installed and operates properly as intended and designed. Installation of all components shall be installed by, or under the direct supervision of, factory authorized personnel.
- B. The Mechanical Contractor shall be responsible for the installation of the supply VAV boxes, fume hood exhaust valves, general exhaust valves, sensing stations and any other devices to be installed in the air streams.
- C. The laboratory control manufacturer shall provide detailed control schematics and prepare field installation drawings for the ATC Contractor to install control wiring and tubing. The temperature control contractor shall provide a source of clean, dry, control grade 20 psig air as required.
- D. The electrical contractor will provide a 120VAC power receptacle (as required).
- E. The laboratory control manufacturer shall send the fume hood interface modules and sensors to the successful fume hood supplier for mounting at the fume hood manufacturer's factory and provide detailed mounting schematics.

#### **3.2 System Start-Up**

- A. Point to point terminations check-out, setpoint adjustments and calibration, system start-up, and final calibration shall be performed by, or under the direct supervision of, factory trained and authorized field engineers. The installed system must be able to be field calibrated on site without removing the box or valve. This will ensure an accurately calibrated finished product that will reflect changes in the construction phase or last minute design requirements.

- B. Each fume hood system shall be calibrated and tuned to provide safe, efficient, fail-safe operation. Sash position sensors shall be field calibrated for sash area, flow transducers shall be field calibrated for zero and span, and control loops shall be tuned for each mode of proportional, integral and derivative control. All dampers, damper operators, flow sensors, etc., shall be checked for proper operation and field calibrated where required. Alarm systems and fail-safe modes shall be checked for each and every device.
- C. Each tracking system shall be calibrated and tuned to provide fail-safe, efficient operation. Flow transducers shall be calibrated for zero and span, the control loop shall be for each mode of proportional, integral and derivative control. All dampers, damper operators, flow sensors, etc., shall be checked for proper operation. The flow volume control system shall be run through its entire range and calibrated as required to linearize the output. Alarm systems and fail-safe modes shall be checked for each and every device.
- D. The laboratory control system supplier shall work closely with the balancing contractor to ensure proper air distribution in the HVAC system. The balancing contractor shall coordinate the work of the hood and tracking systems supplier with the hood certification testing and the HVAC balancing. It is imperative that the methods of testing air flow at the hoods are known and understood by all parties involved. Where there is a conflict as to proper methods to use for balancing, the Engineer shall have the final say.
- E. The Balancing Contractor shall be responsible for providing CFM versus signal data to the laboratory fume hood control system supplier, who will then generate CFM versus signal charts for each box. This data shall be provided to the Owner as a part of the Operation and Maintenance manuals.

### 3.4 Documentation and Training

- A. The laboratory control supplier shall provide all the documentation and training necessary so that the Owner can be capable of operating and maintaining the control system.
- B. Provide 4 hours of pre-construction systems overview for construction personnel.
- C. Provide 3 days of onsite training to personnel designated by the Owner. Training is to Include: Systems operation, troubleshooting, instrument calibration, alarm handling, and system reconfiguration.
- D. Follow-up Training (optional): Provide 5 working days of training for 3 people, of the Owner's choosing, at a factory training site. Transportation, room and board expenses will be the Owner's expense. The training presented shall be the same training that the factory field engineers receive.
- E. Documentation shall consist of dimensional data for control panels, supply boxes, exhaust valves, flow measuring sensors, etc., control schematics, equipment sizing, instrumentation data sheets and Sequences of Operation.