LABORATORY FUME HOOD CONTROL SYSTEMS

Part I - General

A. Provide a complete system for the variable air volume or constant air volume control of Laboratories 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, air flow sensing stations, 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 and 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 isolation room 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 IV System

2.2 General

A. Laboratory Control system shall use closed loop control to continually monitor and adjust the supply and 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 are as defined by 1991 ASHRAE Application 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 and exhaust air 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 or high speed electronic, normally open, damper motor will modulate an exhaust valve as required to maintain the face velocity setpoint.

D. All actuators will be pneumatic or high speed electronic to ensure quick response time and fail-safe operation.

E. The laboratory controllers shall be integrated into the Building Automation System (BAS) (campus wide) :____

2.4 Equipment

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

The Envirotrak® IV (Model No.: ENV IV) is a high speed (25 msec scan rate) native BACnet microprocessor based controller, designed for fume hood, laboratory air flow, isolation and containment room control applications. Powerful high-speed processor with 1 MB Flash memory and 1 MB RAM provides plenty of room for demanding and complex applications. On-board battery-backed real-time clock is standard, enabling full stand-alone scheduling capabilities as well as historical trend data storage and alarm event time stamping. The ENV IV can be easily customized using a graphic programming language to meet whatever sequence of operation needs are desired, with no limits imposed on the application nor on the number of graphic programs that can be downloaded into it (memory permitting).

Besides its programming flexibility, another key feature of this controller is that it has built-in hardware and software support for the 4 leading protocols in use among BAS companies today: BACnet (ARC 156, MS/TP, and PTP), Modbus (RTU & ASCII), N2 Bus, and LonWorks (optional plug-on card used for LonWorks). It will also support BACnet/IP communications through an optional Ethernet plug-on card (this Ethernet card will also be capable of serving up Web pages to a standard Internet Browser package). The point “mapping” to all of these protocols can be pre-setup at the factory, so that the protocol & baud rates desired can be easily field-selected or switched without the need for any additional downloads or technician assistance.

The ENV IV is flexible in its input/output capacity. The base controller has 6 Digital Outputs, 12 Universal Inputs, and 6 Universal Outputs (configurable as digital or analog). However, this controller supports communication to one point expander board should you find the need for additional I/O capacity.

B. Controller:

Input/Output (I/O) Configuration:

1. **Digital Outputs:**
   a. 6 relay outputs SPDT (contact ratings: 5A @ 25OVAC)
   b. Removable Screw terminals
   c. Individual LED Indication of output status (color - “red’)

2. **Universal Inputs:**
   a. 12 total
   b. Input Signals Supported (jumper selectable):
      - Thermistor/Dry Contact.
      - 0-10 VDC (scalable in software for other ranges)
      - 0-20 mA (scalable in software for other ranges)
      - 1K Platinum RTD
   c. Removable screw terminals
   d. 12-Bit A/D
   e. Selectable +5V or +24V voltage source (240 mA max)
3. **Universal Outputs:**
   a. 6 total
   b. Analog Output Signals Supported:
      - 0-10 V DC on all 6 outputs (scalable in software for other ranges)
      - 0-10 VDC or 0-20 mA on 2 of the outputs
   c. Digital Output Signals - Each of the 6 outputs can be individually configured as digital outputs. They have the signal capacity to drive an external voltage relay device.
   d. Removable screw terminals
   e. Individual LED Indication (red - vary in intensity based on output signal status)

Power Requirements:

1. External Power Source - 24 VAC ± 15 *%*, 50-60 Hz, 20 VA.
2. Removable screw terminal (2-position) for power connection
3. LED Indication: Power (green), Run (green), and Error (red) LEDs

Communication Ports:

1. 4Ports
   1) **Open Protocol Port #1 –** BACnet (ARCNET; ARC 156)
   2) **Open Protocol Port #2a –** Configurable for EIA-232 or EIA-485 (2 wire or 4 wire). Network protocol selectable for BACnet (MS/TP or PTP), MODBUS, N2, LONWorks SLTA, or modem.
      Open Protocol Port#2b – Configurable for Lon Works plug-in or Ethernet (BACnet/IP capable of serving up custom web pages).
   3) **Rnet Port -** for connection to keypad/displays and/or intelligent sensors. This port also acts as the local laptop access port.
   4) **I/O Expansion Port** (CAN-bus)
2. Removable Screw terminals
3. Transmit & Receive LEDs for each port
4. Rotary Address Switches
5. Protocol & Baud Rate selector DIP switch

Size and Environmental Requirements:

1. Board Size (including metal cover): *11-3/4"* wide x *5"* high x 2" deep
2. Expander Board Size: 10-5/8" wide x 3" high x 2" deep (note: the expander boards can be mounted on top of the ENV IV controller to conserve panel space or they can be remotely mounted up to 500 feet away from the controller.)
3. Protection: Brushed aluminum, gull-wing metal
4. Temperature Range: -40 to 150 deg. F, 10-95% RH non-condensing
5. Agency Listings: UL, cUL, CE. FCC

C. Room Alarm Module:

Equal to Laboratory Control Systems Inc. RPM-MZ-5. The local interface module shall incorporate the following functions and features as a minimum:

1. Alarm Silence and/or override function keys
2. Red and Green L.E.D. Indicators for status display
3. 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 L/S
         Differential Pressure - H20 or Pa

4. Mounting: The RPM-MZ-5 shall be mount to a double gang electrical box in the wall.

D. Fume Hood Alarm Module:
Equal to Laboratory Control Systems Inc. HMI-AL. The local interface module shall incorporate the following functions and features as a minimum:

1. Alarm Silence and/or override function keys
2. Red and Green L.E.D. Indicators for status display
3. Digital Liquid Crystal Display (LCD) Capable of Displaying the Following:

    a. Face velocity: FPM or M/S

4. Mounting: The HMI-AL shall be mount to a single gang electrical box on the fume hood.

E: 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.

F: 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

G: Room Temperature Sensor:
Equal to Laboratory Control Systems Inc. Model RS.

The RS Series Intelligent Sensors are room temperature sensors designed for use with the Envirotrak IV controller. Each sensor features a precision 10K ohm thermistor and communications port. The RS-Pro also features the addition of LCS display and function buttons.

Specifications:

Sensing Element: 10K ohm precision thermistor. Standard accuracy +/-0.35°F. Less than +/-0.18°F drift over a 10 year period.
Recommended Wire: Two pair twisted unshielded cable- 18 AWG recommended.
Communication: 115kbaud Rnet
Local Access Port: 5 pin port for commissioning and maintenance.
Mounting: Standard 2x4” electrical box.
Overall Dimensions: 2 3/4"w x 4 3/4"h x 5/8"D

H. Duct Temperature Sensor:
Equal to Laboratory Control Systems Inc. Model 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 Platinum
3. Nominal resistance: 1000 ohms +/- .1% @ 0°c

Alpha .00385/ohm/ohm/°C

4. Temperature range: -40 to 250°F (-40to 121°C)
5. Maximum Error: 1.6°F (1.0°C) Over 290°F (161°C) Spa
6. Recommended current: 1.0 mA
7. Maximum current: 3.0 mA

I. **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:
Unidirectional: 0-0.1 through 0-5.0"W.C. - Selected according to required operating range.
Bi-Directional: +/-0.1 through +/-0.5” W.C. - Selected according to required operating range
Accuracy: 0.8% F.S.O. (Optional 0.4% available)
Stability: <0.5% F.S./Y.
Response Time: 250 ms
Overpressure Rating: 15 psi Proof Pressure, 25psi Burst Pressure
Power Supply: 12-36vdc
Output Signal: 4-20mA
Pressure Connections: ¼” Brass barbed fittings
Electrical Connections: Euro style pluggable terminal block accepts 12-26 gauge wire
Enclosure: NEMA Type 1 Fire Retardant ABS (Meets UL 94-5VA)
LED visual indicator standard
Mounting: Threaded fastener and 35mm DIN rail mount standard.

J. **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.

Minimum Specifications:

Ambient Operating Limit:
Temperature: 41F to 122°F (5 to 50°C)
Power Supply: None, loop powered
Input Signal: 0-10 vdc
Input resistance: 1000 ohms minimum
Output: .05-19 psi, linear to input, direct acting
Main Air Pressure: 18-25 psig (126 to 175 kPa)
Maximum Safe Air Pressure: 25psi (175 kPa)
Air Consumption: 45 scim (12.3 mL/s)maximum
Air Capacity: 1600 scim (437 mL/s) maximum
Linearity: 5% maximum of output span between 3-15 psig
Hysteresis: 0.5 psig typical
Dimensions: 1.42”W x 1.26” H x 4.17”D
Mounting: Surface mouted
Air Connections: barbed fittings for 5/32” or ¼” O.D. tubing
Electrical Connections: Screw terminals
Calibration: Factory calibrated

K. Air Flow Sensors:

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.

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.

L. Duct Velocity Transmitter Specifications:

A DVT as manufactured by Laboratory Control Systems Inc 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:

Unidirectional: 0-0.1 through 0-5.0"W.C. - Selected according to required operating range.
Accuracy: 0.8% F.S.O. (Optional 0.4% available)
Stability: <0.5% F.S./Y.
Response Time: 250 ms
Overpressure Rating: 15 psi Proof Pressure, 25psi Burst Pressure
Power Supply: 12-36vdc
Output Signal: 4-20mA
Pressure Connections: ¼” Brass barbed fittings
Electrical Connections: Euro style pluggable terminal block accepts 12-26 gauge wire
Enclosure: NEMA Type 1 Fire Retardant ABS (Meets UL 94-5VA)
LED visual indicator standard
Mounting: Threaded fastener and 35mm DIN rail mount standard.

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.

M.: 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:
Unidirectional: 0-0.1 through 0-5.0"W.C. - Selected according to required operating range.
Bi-Directional: +/-0.1 through +/-0.5" W.C. - Selected according to required operating range
Accuracy: 0.8% F.S.O. (Optional 0.4% available)
Stability: <0.5% F.S./Y.
Response Time: 250 ms
Overpressure Rating: 15 psi Proof Pressure, 25psi Burst Pressure
Power Supply: 12-36vdc
Output Signal: 4-20mA
Pressure Connections: ¼" Brass barbed fittings
Electrical Connections: Euro style pluggable terminal block accepts 12-26 gauge wire
Enclosure: NEMA Type 1 Fire Retardant ABS (Meets UL 94-5VA)
LED visual indicator standard
Mounting: Threaded fastener and 35mm DIN rail mount standard

N. Laboratory Supply Variable Air Volume (VAV) Boxes:

Furnish laboratory supply boxes equal to LCS Model LS and LSW as indicated on the drawings and specified under Section, 15840 Air terminal Devices. Controls for the lab supply boxes shall be located in the laboratory control panel for ease of adjustment, calibration, and troubleshooting. This shall apply to all supply Laboratory Supply boxes serving laboratory and support areas. Each device must be field calibrated to accurately reflect construction and last minute design changes.

O. Laboratory Supply Box Reheat Coils:

Furnish Factory Mounted reheat coils on the Laboratory Supply boxes as indicated on the drawings and specified under Section 15840, Air Terminal Devices. Supply air terminal devices requiring transitions to the coils must be supplied as an assembly from the factory, requiring no additional field labor to install.

P. General Room Exhaust Valves:

Furnish general room exhaust valves equal to LCS Model AFT as shown on the drawings and specified under Section 15840 , Air Terminal 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.

Q. General Room Exhaust Boxes:

Furnish general room exhaust Boxes equal to LCS Model XLS or XLSA (with attenuator section) as shown on the drawings and specified under Section 15840 , Air Terminal Devices. General exhaust boxes shall be similar in construction to lab supply boxes except designed for use as an exhaust box. 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.

R. Fume Hood Exhaust Valves:

Furnish Fume Hood exhaust valves equal to LCS Model SSXAFT as shown on the drawings and specified under Section 15840 , Air Terminal 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.

2.5 Sequence of Operation

A. Fume Hood Face Velocity Control:

a. Sash Position Sensing: The controller 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 by a pneumatic or high speed electronic actuator, to maintain the programmed adjustable face velocity setpoint. Response time will be 3 seconds or less.

b. 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 or high speed electronic actuator, to maintain the programmed setpoint.

c. 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.

d. 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.

e. 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:

i. Mode 1: Night setback reduces the face velocity to a preprogrammed value.

ii. Mode 2: Night setback reduces the fume hood exhaust flow to a preprogrammed value

B. Air Flow Tracking - Laboratories With Fume Hoods:

a. 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.

b. 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.

c. 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.

d. 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.

e. 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

a. 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.

b. 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

c. 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.

d. 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.

e. 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 System 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 System 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 to the control panels (as required).

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. 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. 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 System 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 on-site 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.