City of Phoenix

OFFICE OF THE CITY ENGINEER
DESIGN AND CONSTRUCTION PROCUREMENT
200 W. Washington Street, 5th Floor
Phoenix, Arizona 85003-1611

POLICE CRIME LAB HEATING, VENTILATION, AND AIR CONDITIONING AND BUILDING AUTOMATION SYSTEM CONTROLS CONSTRUCTION MANAGER AT RISK SERVICES

PW26480024
RFx 6000001540

NOTIFICATION LETTER NO. 2

FEBRUARY 5, 2024

This notification letter shall become part of the Request for Qualifications for the above referenced project.

Technical Specifications

1. Add the following sections:
    a. Section 23 0901 – Control Systems Integration
    b. Section 23 3614 – Laboratory Temperature and Airflow Control System

Questions from the site visit:

1. Q: Will individual lab spaces be shut down?
   A: The City does not have any planned shutdowns of the labs at this time, but it is understood there will be a need to shut down individual lab spaces, or partial lab spaces, once the project begins. The entire lab will not be able to be shut down, nor an entire floor, at any time as operations will need to continue during the project. A schedule for shutting down lab spaces will be determined once we know how long it will take for the work to be completed in each space, or for larger spaces, part of a space may be shut down to allow for forensic analysis to continue in the other part of a specific lab. Information that will assist in creating a shut down schedule for individual spaces includes how long it will take to complete each space.

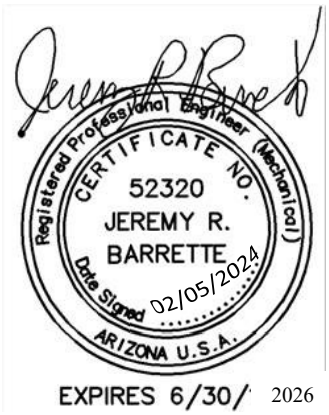
2. Q: Will the front end be installed first?
   A: The front end needs to be installed first. The project will require two control systems operating simultaneously.

3. Q: Is there any biohazard in the duct work?
   A: No.

4. Q: Are the reheat coils part of the project?
   A: The reheat coils are separate from the air flow valves.

5. Q: Do you know where the controls are located now?

A: If asking about the location of a specific “head-end” for the Triatek system, there isn’t one. It is all controlled through a software interface within the Siemens system and is located in the basement plant office.



All other terms and conditions remain unchanged.

**********END OF NOTIFICATION**********

SECTION 23 0901

CONTROL SYSTEMS INTEGRATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 20 0513 - Motors

B. Section 20 0553 - Mechanical Systems Identification

C. Section 23 0902 - Control Valves and Dampers

D. Section 23 0903 - Control Instrumentation

E. Section 23 2118 - Valves

F. Section 23 3600 - Air Terminal Devices

G. Section 23 3614 - Laboratory Temperature and Airflow Control System

H. Section 26 0000 - General Electrical Requirements

I. Section 26 0519 - Conductors and Cables

J. Section 26 0533 - Raceway and Fittings

K. Control Sequences: Refer to Drawings

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. ASHRAE FUNDAMENTALS IP - (2013) Fundamentals Handbook, I-P Edition

C. ASHRAE 135 - (2016) BACnet - A Data Communication Protocol for Building Automation and Control Networks (ANSI Approved)

1.3 DEFINITIONS

A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

1. Actuator: Control device to provide motion of valve or damper in response to control signal.
2. AI: Analog Input
3. AO: Analog Output
4. Analog: Continuously variable state over stated range of values
5. Auto-Tune: Software routine used to adjust tuning parameters based on historical data.
6. BAS: Building Automation System
7. BMS Building Management System

8. DDC: Direct Digital Control
9. DDCP: Direct Digital Control Panel
10. Discrete: Binary or digital state
11. DI: Discrete Input (Sometimes referred to as Binary Input BI)
12. DO: Discrete Output (Sometimes referred to as Binary Output BO)
13. EMCS: Energy Management and Control System (Typically interchangeable with BAS or BMS)
14. E/P: Voltage to pneumatic transducer (Often solenoid valve is referred to as an E/P transducer)
15. FA Field Adjustable
16. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
17. FLP Fail Last Position
18. FMS: Facility Management System linking two or more BAS
19. FO: Fail Open position of control device or actuator. Device moves to open position on loss of control signal or energy source.
20. I/P: Current to pneumatic transducer
21. Instrument: Device used for sensing input parameters or used for actuation.
22. Modulating: Movement of control device through an entire range of values proportional to an infinitely variable input value.
23. Motorized: Control device with actuator
24. NC: Normally Closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
25. NO: Normally Open position of switch after control signal is removed or normally open position of manually operated valves or dampers.
26. Node: DDCP, operator workstation, or other control device connected to communications network.
27. Operator: Same as actuator for motorized devices. Also refers to an individual who physically "operates" facility.
28. PC: Personal Computer
29. Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each share its database values with other devices connected to network.
30. P: Proportional control, control mode with continuous linear relationship between observed input signal and final controlled output element.
31. PI: Proportional - Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controlled variable (reset control).
32. PID: Proportional - Integral - Derivative control, control mode with continuous correction of final controlled output element versus input signal based on proportional error, its time history (reset), and rate at which its changing (derivative).
33. Point: Analog or discrete instrument with addressable database value.
34. Self-Tune: Same as Auto-Tune
35. Solenoid: Electric two-position actuator. (See E/P.)
36. TCC: Temperature Control Contractor (Same as Control Contractor)
37. TCP: Temperature Control Panel

1.4 ACCEPTABLE CONTROL CONTRACTORS

A. Control Contractor shall have full service office within 100 miles of project site. Full service office is defined as being home office of applications engineers, supervisors, and field technicians, having complete parts inventory, and having required test and diagnostic equipment. Control Contractors shall be factory authorized agent or dealer of controllers and control hardware as manufactured by:
   1. Trane Company
   2. Alerton
   3. Delta

B. Bids will be accepted only from prequalified Control Contractor per "Instruction to Bidders".

1.5 SYSTEMS DESCRIPTION

A. System shall be electric and/or electronic.

B. Damper and valve actuators shall be electronic type, unless otherwise noted.

C. Control system shall be 100% DDC unless otherwise indicated.

D. New BAS shall seamlessly integrate with one of the existing City of Phoenix web server operator interfaces, Trane, Alerton and Delta. Existing web server shall be able to backup all trending data via Historian Sequel database, access and read all input, output and calculated points and issue commands to all output points in new BAS by means of a standard web browser. Contractor shall provide necessary hardware and software components to accomplish this interface.

E. BAS network architecture shall be based on an Open implementation of BACnet using ASHRAE 135-2016 exclusively as the communications protocol for communication between DDC Hardware devices, including BAS Web Server, to allow multi-vendor interoperability.

F. Building Automation System (BAS) shall control building's HVAC components.

G. Contractor provided BAS Ethernet Network shall be physically separate from other building Ethernet networks

H. Provide BAS architecture consisting of communication network, operator workstations, web servers and modular designed controllers with all points addressable and modifiable from operator workstations or from master controller using laptop computer. BAS shall be fully expandable with addition of hardware and/or software. Expansion shall not require removal of existing controllers, sensors, actuators, or communication networks.

I. System shall support operator workstations as specified and shall be capable of additional workstations, limited only by systems maximum node capacity.

J. Operator workstations connected to building Ethernet network shall be able to access BAS information as determined by Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox, Opera, or Google Chrome). GUI software shall allow transparent access to each building component/system for control and/or monitoring.

K. System intelligence shall be such that operator workstation(s) can be used for programming controls, performing analysis on filed data, generating maintenance and operation reports and providing permanent storage for programs and data.

L. Safety devices shall function in both auto and hand modes on starter, and on VFD in auto, hand or bypass modes.

1. Dampers interlocked with fans shall operate in both auto and hand modes to prevent dead-head of fans.
2. Valves interlocked with pumps shall operate in both auto and hand modes of operation to prevent dead-head of pump.
3. All safeties shall be hardwired through starter/VFD safety circuit to prevent unsafe operation when in either auto or hand modes.

M. Safety devices shall function in both VFD and bypass modes.
1. Dampers interlocked with fans shall operate in both VFD and bypass starter modes to prevent dead-head of fans.
2. Valves interlocked with pumps shall operate in both VFD and bypass modes of operation to prevent dead-head of pump.
3. All safeties shall be hardwired through VFD/bypass starter safety circuit to prevent unsafe operation when in either VFD or bypass modes.

1.6 SCOPE OF WORK

A. Provide all labor and materials for complete fully functioning control systems in accordance with Contract Documents included in this Section plus:
1. Section 23 0902 - Control Valves and Dampers
2. Section 23 0903 - Control Instrumentation

B. Engineering services shall be performed by Factory Trained Engineers. System shall be installed either by trained mechanics directly employed by Control Contractor or by subcontractors who are under direct supervision of Control Contractor's representative. Engineer reserves right to exclude Project Managers, Engineers, Field Supervisors, or Technicians whose past experience is not sufficient to meet needs of Project.

C. Control Contractor’s Project Managers, Engineers and Digital System Programmers shall have previously performed in capacity that qualifies them to successfully engineer system of scope and magnitude similar to this Project.

D. Submit qualification of Project Managers, Engineers, Programmers, Field Supervisors, and Technicians to be assigned to this Project within 30 days after contract award. Use Qualification Form attached at end of this Section.

E. Labor shall include, but not be limited to:
1. Engineering services to size unscheduled valves and dampers based on design criteria specified in Section 23 0902 - Control Valves and Dampers, and confirm sizing of scheduled valves and dampers.
2. Engineering services to produce requested submittals and working construction drawings and record drawings as specified here within.
3. Engineering services for required software programming.
4. Engineering services for graphics programming specified.
5. Engineering services for mapping control points from Laboratory Temperature and Airflow Control System (Section 23 3614), if provided for the project.
6. Engineering services for BAS Ethernet network design.
7. Project management services as single point contact to coordinate construction related activities.
8. Field mechanics for installation of control wiring and related control devices.
9. Field technicians to startup, calibrate, adjust, and tune control loops.
10. Field technicians to perform system checkout and testing, and to complete required reports.
11. Field supervisor during controls installation and startup.

12. Field technicians to assist Mechanical Contractor and Testing and Balancing (TAB) Contractor in adjusting controls and determining setpoints related to TAB work.
13. Field representatives and/or classroom instructors to provide Owner training as specified.

F. Control Contractor shall be responsible for complete installation of control devices (except as noted), wiring, and pneumatic terminations at controller locations to accomplish control sequences specified in project manual or on drawings. Control Contractor is required to provide power for air terminal controllers and other field mounted devices that require 24 VAC, 60 Hertz and shall be powered from 120 to 24 VAC transformer panels provided by Control Contractor. Control Contractor shall also be responsible for additional instrumentation described in point schedules found in Contract Documents, which may not be directly related to specified control sequences.
   1. Control contractor shall provide unique tag numbers for all devices under this specification and reference those tag numbers in control sequences and control diagrams.
   2. If Owner has tagging convention, Control contractor shall utilize it. If no tagging convention exists, Control contractor shall provide one for all devices under this specification.

G. Mechanical Contractor shall install in-line mounted devices, such as valves, dampers, flow meters, static pressure probes, etc., furnished by Control Contractor. Control Contractor shall be responsible for installation of other control devices, such as actuators, linkages, sensors, air terminal controllers, flow transducers, remote mounted control devices, control panels, control transformers, etc.

H. Electrical work required as integral part of control work is responsibility of Control Contractor. Control Contractor is responsible for providing final power connections, including conduit, wire, and/or disconnect switches, to control devices from appropriate electrical distribution panels.
   1. Electrical Contractor will provide circuit breakers required to provide electrical power to controllers.
   2. 120 to 24 VAC transformer panels shall be provided by Control Contractor and mounted adjacent to controller panels or in Electrical Rooms, Telecommunications Rooms and/or (IDF/EIDF) rooms, or as indicated on plans and powered from dedicated electrical circuit.
   3. Should any change in number of controllers or addition of other electrical equipment after Contracts are awarded, Control Contractor shall immediately notify Electrical Contractor of change. Additional costs due to these changes shall be responsibility of Control Contractor.
   4. Coordinate with Electrical Contractor for additional power requirements.

I. Additional BAS data drops (from telecommunication room patch panel to field jacks/patch panels) that are not accounted for in contract documents can be provided by Control Contractor in one of two ways:
   1. Option 1:
      a. Control Contractor shall sub-contract at control contractor’s expense the project’s Structured Cabling Contractor to install additional data drops.
   2. Option 2:
      a. Control Contractor can provide their own data drops but must exactly match all cabling and hardware installed by Structured Cabling Contractor.
   3. If Control Contactor chooses Option 2, submit to EOR a separate control submittal including all material and proposed locations for data jacks for approval prior to installation.
   4. Coordinate final Telecommunications room patch panel connections with network installation Contractor.

J. Control Contractor shall sub-contract at control contractor’s expense the project’s Structured Cabling Contractor to provide additional BAS data drops (from telecommunication room patch panel to field jacks/patch panels) that are not accounted for in the contract documents.

Coordinate final Telecommunications room patch panel connections with network installation Contractor.

K. Control Contractor shall be responsible for maintaining master IP address list for all BAS devices throughout project to be handed over to Owner upon completion.

L. Materials shall be as specified unless approved through procedures for product substitution specified in Division 01. Control Contractor shall provide components not specifically indicated or specified, but necessary to make system function within the intent of specification.

M. If during the installation period any of the factory equipment or material provided in the system is found to be defective in material or workmanship, it shall be replaced or repaired by Contractor at no additional cost to the Owner within 24 hours from the time the problem was reported/discovered.

N. Any part/device or equipment installed as part of this contract found to be malfunctioning or defective during the warranty period shall be replaced by Contractor within 24 hours from the time the problem was reported.

O. Electrical products shall be listed and labeled by UL and comply with NEMA Standards.

P. All controls and wiring used for smoke control/life safety shall be UL 864 UUKL rated.

Q. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

R. Provide tamper resistant screws and fasteners for equipment located in accessible and/or public areas.

S. Contractor is responsible for integration of the following independent systems into BAS:
   1. Chillers:
      a. Chiller provider will provide a termination point for a single point communication connection to BAS. Contractor shall supply cabling, conduit, and gateway necessary to make an interface connection from gateway to the Chiller point of connection. Contractor is responsible for a BAS solution to communicate data directly or through a gateway to all suppliers listed in Division 23 for Chiller bidders. Contractor and Chiller provider responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems. Contractor to refer to P&IDs, DDC Point Schedules and GMP#2 Section 23 6000 Primary Cooling Equipment for programming and monitoring requirements.
   2. Boilers:
      a. Boiler provider will provide a termination point for a single point communication connection to the BAS. Contractor shall supply cabling, conduit, and gateway necessary to make an interface connection from gateway to Boiler point of connection. Contractor is responsible for a BAS solution to communicate data directly or through a gateway to all suppliers listed in Division 23 for Boiler bidders. Contractor and Boiler provider responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.
   3. Variable Frequency Drives (VFD):
      a. VFD provider will provide a termination point for a single point communication connection to the BAS utilizing BACnet MS/TP protocol. Contractor shall provide cabling and conduit to make an interface connection from the BAS to the VFD. Contractor and VFD provider responsible for translation of network protocols, testing of communications between systems, and joint commissioning of systems. Contractor to

refer to P&IDs, DDC Point Schedules, and Section 20 0514 Variable Frequency Drive (VFD) System for programming and monitoring requirements.

1.7 SUBMITTALS

A. Technical Proposal:
   1. Submit, directly to Engineer on bid day, 3 copies of technical proposal. Technical proposal shall include written and/or graphic representation of proposed BAS architecture including quantity and types of controllers to be used at each location. Show or describe routing of communication networks. Include product data sheets for proposed controllers and sensors. Provide complete, detailed description of software packages to be used. Use pre-printed shop drawing materials with technical details in lieu of sales literature whenever they are available.
   2. Submit resumes of subcontractors to be used for project. List projects of similar size and scope. List shall include name and location of project, dollar value of control contract, date completed, and references. References shall include name and phone number of contact person.
   3. Technical proposals shall not intentionally deviate from specification, but explain how proposed system meets or exceeds specification. Deviations and/or exceptions must be clearly stated in executive summary. Technical proposals will be evaluated based on completeness, conformance, and value (performance versus Bid price).

B. Extended Service Agreement:
   1. Control manufacturer shall, upon completion of warranty period, make available to Owner annual service agreement covering all labor and material required to effectively maintain control system after warranty period. Owner reserves the right to accept or reject any such offers and to cancel on-going agreements with 30-day written notice.
   2. During extended service period, Contractor shall maintain Operation and Maintenance manuals to reflect all changes made to BAS.

C. Shop Drawings:
   1. Submit manufacturer's printed product data sheets for control devices and materials listed in bill of material in Control Contractor's control drawings. Datasheets shall be submitted electronically in pdf format with programmed bookmarks. When a manufacturer’s data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Data sheets shall include sufficient technical data to describe instrument parameters required as specified.
      a. All submitted PDF documents shall have electronic bookmarks setup to quickly and easily locate documents and submitted information. Bookmarks shall be set up as follows:
         1) Shop Drawings:
            a) Each major system (AHUs, Heating systems, Cooling systems, etc.) shall have a master bookmark programmed with all documentation for the system grouped in order under a single bookmark for that system. Subgroups under the main bookmark should be divided in a minimum of: flow diagram/bill of material, wiring detail, control sequence, point list.
            b) Each minor system (Air Terminals, FCUs, Plumbing systems, Electrical systems etc..) shall have a master bookmark programmed for the type of system with bookmarks under the master for each type of minor system. All documentation for the system shall be grouped in order under a single bookmark for equipment type but subgroups for flow diagrams, control sequences, point list etc. are not required.
         2) Device Data Sheets:

a) Device Data Sheets for all equipment specified in 23 0902 and 23 0903 shall have bookmarks organized in alpha numerical order by part number. Part numbers can and should be grouped by major category such as Valves, Dampers, Temperature sensors, Actuators, etc.

3) Hyperlinks:

a) Hyperlinks can be used to enhance the bookmark tools but are not an acceptable substitute for electronic bookmarks.

b) If hyperlinks are used, they should be clearly identifiable as a hyperlink but using a different color text similar to how MS Office documents identify hyperlinks.

2. Submit data concerning type of signal wiring and installation methods including raceway types and grounding methods.
   a. Submit voltage drop calculations for all low voltage DDC circuits. Voltage drop to include number of devices and wiring run lengths, calculated voltage available at each device.
3. Submit engineering calculations for sizing air compressor assembly if pneumatic control system is specified.
4. Submit control drawings in pdf format with bookmarks provided for each system and table of contents with links to each page. Control drawings shall include, but are not limited to, the following:
   a. Overall system/network architecture drawings: Provide block diagram showing relationship of each controller, control panel, or other network devices relative to each other. Label room location of each device. Number and indicate model number of each device. Indicate network types.
   b. Control Drawings: Including graphic representation of systems with major in-line components to properly locate all control devices. Identify controlled devices with their software designation on drawings, including unique valve and damper tag numbers.
   c. Detailed wiring and piping diagrams showing point-to-point hookup details of transducers, relays, outputs, inputs and subsystem components. Label pneumatic lines and control wires with field ID numbers/colors.
   d. Bill of material identifying actual product model number used for each control device for each schematic control drawing.
      1) Bill of material shall be included on flow diagrams for each system and on panel layouts showing panel components.
   e. Drawings showing proposed locations of sensors and flow meters in ductwork and piping systems.
   f. Sequence of operation: Provide written narrative describing each control sequence indicating method of control. Identify sensors, controllers, and actuators used with references to tag number of controlled device. Include set points of each control loop.
   g. BACnet Compliance Documentation: The Protocol Implementation Conformance Statement for each component.
5. Control Instrumentation (23 0903) submittals can be submitted as separate submittals from control shop drawings but must be submitted simultaneously with control shop drawings.

D. Completion Checklist:
   1. Submit with shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. Engineer reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance.
   2. Checklist shall include references to the following additional requirements:
      a. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.

b. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.

c. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).

d. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.

e. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.

f. Performance tests of discrete control loops shall be performed by adjusting set point and verifying sequence action.

g. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms are properly acknowledged at operator's workstation.

h. Schedules for each system/device shall be verified.

i. Graphics shall be verified for functionality including password protection, floor plan displays, system displays, alarm messaging, historical trends, report generation and HVAC schedules.

j. BAS Ethernet network testing and benchmarking documentation showing network performance from switch to switch.

k. Testing of BAS to ensure cyber security. Coordinate testing requirements with Owner.

E. Control Contractor and Mechanical Contractor shall walk proposed static pressure sensor and flow meter locations and mark up drawings for review and approval by Owner and Engineer prior to installation.

1.8 WARRANTY

A. Warranty period shall begin as authorized by the Owner's representative in writing. Authorization will not be given before the following conditions are met:

1. All verified completion checklists provided to Owner.
2. Completion of all punch list items.
3. Conduction of a preliminary training session for personnel. The training shall consist of an orientation session at the job site to familiarize the personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings.
4. Completion and distribution of the as-built control drawings, including correction of all items noted by Owner and Engineer after review of the documents.

B. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system acceptance.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. A telephone number where the service supervisor can be reached at all times shall be provided. The maximum acceptable response time to provide this service at the site shall be 24 hours Monday through Friday, 48 hours on Saturday and Sunday.

D. This warranty shall apply equally to both hardware and software.

E. Service personnel shall be qualified to accomplish work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

F. Scheduled Inspections:
   1. Two inspections shall be performed prior to warranty expiration and all work required shall be performed. Inspections shall be scheduled 6 months after Owner acceptance and one month prior to end of warranty period.
   2. These inspections shall include:
      a. Visual checks and operational tests of equipment.
      b. Clean control system equipment including interior and exterior surfaces.
      c. Check and calibrate each field device. Check and calibrate 50 percent of the total analog inputs and outputs during the first inspection. Check and calibrate the remaining 50 percent of the analog inputs and outputs during the second major inspection. Certify analog test instrumentation accuracy to be twice the specified accuracy of the device being calibrated. Randomly check at least 25 percent of all digital inputs and outputs for proper operation during the first inspection. Randomly check at least 25 percent of the remaining digital inputs and outputs during the second inspection.
      d. Run system software diagnostics and correct diagnosed problems.
      e. Resolve any previous outstanding problems.
      f. Install software upgrades, patches and fixes. Contractor to provide verification to facility personnel that all upgrades, patches and fixes to be installed have been tested in accordance with site testing and deployment procedures.

G. Scheduled work shall be performed during regular working hours, Monday through Friday, excluding holidays.

H. Dated records and logs shall be kept of each task, with cumulative records for each major component, and for the complete system chronologically. A continuous log shall be maintained for all devices. The log shall contain initial analog span and zero calibration values and digital points. Complete logs shall be kept and shall be available for inspection onsite, demonstrating that planned and systematic adjustments and repairs have been accomplished for the control system.

I. Each service call request shall be recorded as received and shall include its location, date and time the call was received, nature of trouble, names of the service personnel assigned to the task, instructions describing what has to be done, the amount and nature of the materials to be used, the time and date work started, and the time and date of completion. A record of the work performed shall be submitted within 5 days after work is accomplished.

J. Recommendations for system modification shall be submitted in writing. No system modifications, including operating parameters and control settings, shall be made without prior approval of the Owner. Any modifications made to the system shall be incorporated into the Operations and Maintenance Instructions, and other documentation affected.

K. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge.

L. At the end of the warranty period, the Contractor shall provide updated copies of the latest versions of all project record documentation as described in Paragraph 1.10, Record Documents.

This includes final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.

1.9 COORDINATION WITH TAB CONTRACTOR

A. Control Contractor shall allow sufficient time to provide assistance and instruction to TAB Contractor in proper use and setting of control components such as, Operator Workstation computers, static pressure controllers, "K" Factors for VAV boxes, or any other devices that may need set points changes so that TAB work can be performed.

B. Provide required hardware and software related to control system to TAB Contractor to allow testing of systems and continued operation.

1.10 OPERATION AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements.

B. Operation and Maintenance manuals shall provide descriptions of maintenance on all system components, including sensors and controlled devices. Descriptions shall include:
   1. Product manuals for the key software tasks.
      a. Operating the system
      b. Administering the system
      c. Engineering the Operator workstation
      d. Application programming
      e. Engineering the network
      f. Setting up the web server
      g. Report creation
      h. Graphics creation
      i. Data backup & Archiving
   2. List of recommended maintenance tasks associated with the system, controllers, instruments, operator workstations, data servers, web servers, and web clients.
      a. Define the task.
      b. Recommend a frequency for the task.
      c. Reference the product manual that includes instructions on executing the task.
   3. Licenses, guarantees, and warranty documents for equipment and systems.
   4. System architecture diagram for components within the building annotated with specific location information.
   5. As-built drawing for each control panel
   6. As-built wiring design diagram for each control panel
   7. As-built system flow diagram for each system
   8. Sequence of control for each system
   9. Binding map for the building
      a. A list of the device to device data flow. This shall not include the flow of data from devices to the presentation system.
      b. Include:
         1) Description of the variable
         2) Sending device
         3) Receiving device
   10. Product data sheet for each component
   11. Troubleshooting guide

12. Repair parts list
13. Calibration instructions
14. Control Contractor's completion checklist
15. Manufacturer representative's name, address, and phone number
16. Refer to SUBMITTALS, Shop Drawings above for electronic bookmark requirements for electronically submitted Operation and Maintenance manuals.

1.11 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements.

B. Submit revised shop drawings indicating changes made during Project.
   1. Refer to SUBMITTALS, Shop Drawings above for electronic bookmark requirements for electronically submitted record drawings

C. Record drawing submittals shall be inclusive of BAS as installed and commissioned.

D. Update control diagrams to include tuning parameters and set points applicable to systems depicted as of date of system completion. This information shall be incorporated with sequence of operation for each system.

E. Include floor plans showing location of control panels and routing of BAS network cabling.

F. BACnet systems and devices:
   1. Submit finished device addressing documentation.
   2. Submit finished hardcopy of device binding database.

G. Provide passwords, if used, for back-up and restore functions for each controller.

H. Software (as installed and commissioned)
   1. All software submittals shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided as part of the BAS.
   2. Submit a copy of all software installed on the servers and workstations.
   3. Submit all licensing information for all software installed on the servers and workstations.
   4. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
   5. Submit all licensing information for all of the software used to execute the project.
   6. All software revisions shall be as installed at the time of the system acceptance.

I. Firmware Files (as installed and commissioned)
   1. All firmware files shall be provided in a format suitable for restoration of the programming and configuration of respective digital controllers, servers, workstations and peripheral devices, etc. provided in the BAS.
   2. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
   3. Submit control listing of firmware version for all firmware that is permanently burned on a chip at the factory.
   4. Submit a copy of all application files that were created during the execution of the project.
   5. Submit a copy of all graphic page files created during the execution of the project.

6. Submit a copy of all secondary graphic files such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.

1.12 OWNERSHIP OF PROPRIETARY MATERIAL

A. Owner shall retain all rights to software for this project.

B. Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.

C. Licensing agreement shall not preclude the use of the software by individuals under contract to the Owner for commissioning, servicing, or altering the system in the future. Use of the software by individuals under contract to the Owner shall be restricted to use on the Owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.

D. All project developed software, files and documentation shall become the property of Owner. These include but are not limited to:
   1. Server and Workstation software
   2. Application Programming Tools
   3. Configuration Tools
   4. Addressing Tools
   5. Application Files
   6. Configuration Files
   7. Graphic Files
   8. Report Files
   9. Graphic Symbol Libraries
   10. All Documentation.

PART 2 - PRODUCTS

2.1 CONTROL WIRING

A. Control wiring shall be in accordance with National Electrical Code and Local Electrical Codes. Final connection points at devices and panels shall be made either at terminal blocks integral to device or at separate terminal blocks mounted inside of control panel enclosures. Use of wire nuts and crimped connections are not allowed for terminating control wiring unless approved by Engineer.

B. Refer to Division 26 for specification requirements for conduits and conductors, except as noted.

C. Terminal Blocks:
   1. Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.

D. Signal and Power Conductors (24 V and Under):

1. Wires smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or where otherwise specified. Use 2-wire stranded twisted/shielded pair 24 VDC for analog and discrete input and 24 VAC/VDC output devices. For 3-lead RTD signal wiring, use #18 AWG stranded, tinned copper twisted/shielded 3-conductor. Provide isolated instrument grounding system as per manufacturer's recommendations.
2. Conductors not concealed in raceway shall have UL Listed plenum rated Teflon or low-smoke PVC jacket and insulation. Conductors not concealed in raceway used in high temperature applications or harsh environments shall have UL Listed plenum rated Teflon jacket and insulation.
3. Provide 250 ohm, 5 watt, 0.1% tolerance dropping resistors in 4 - 20 mA circuits as required to generate 1 to 5 volt signals in 24 VDC powered instrument loops.
4. 24 VAC Power Conductors shall be #18 AWG 2 wire twisted pair or larger. Provide Metal Oxide Varistors (MOVs) on 24 VAC/VDC discrete outputs connected to inductive loads to reduce noise levels (i.e., solenoid valves, motor contactors, relays, damper/valve electric actuators, etc.).
5. Stranded twisted/shielded control conductors are required with shields to be terminated within variable frequency Drive enclosures to reduce effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.

E. Communication Cable:
1. Cable not concealed in raceway shall have UL Listed plenum rated insulation.
2. Floor Level Network Communication Cable (Twisted Pair): Use control system manufacturer's standard communications cable or #22 AWG to #24 AWG twisted, shielded pairs, coaxial cable, or fiber optics for communications between remote controllers/devices

F. Transient Voltage Surge Suppression Devices:
1. Devices shall be designed for 120 V power conditioning devices for electronic equipment. Devices shall be designed, manufactured, tested, and installed in compliance with ANSI/IEEE C62.41 and C62.45, Federal Information Processing Standards Publication 94 (FIPS PUB 94), NEMA, NFPA 70, 75, and 78, and UL 1449 and 1283. Devices shall be labeled for UL 1449.
2. Clamping voltage for 120 V power systems shall be 400 V.
3. Provide visual indicator of when surge device has been used.

G. Uninterruptible Power Supply
1. Manufacturers: MGE UPS Systems, Eaton Powerware, Liebert PowerSure or approved equal
2. Provide UPS for backup power for Operator Workstations, Building Level Controllers, Floor Level Controllers and field panels required for control of emergency/standby powered equipment, UPS shall maintain control upon loss of normal power and until emergency/standby power supply is brought on line.
3. Select UPS for minimum of 5 minutes backup time for load connected. This will allow emergency/standby power sources to come on line and provide backup power to emergency/standby powered equipment.
4. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
5. Operating Parameters:
   a. Operating Temperature: 32°F to 104°F
   b. Relative Humidity: 0 to 95% rh, non-condensing
   c. Recharge Time: 8 hours, typical
6. UPS shall have self-diagnostic capability with DO to BAS to allow remote monitoring/alarming of UPS trouble or alarm conditions.

H. Uninterruptible Power Supply (Servers):
   1. Manufacturers: MGE UPS Systems, Eaton Powerware, Liebert PowerSure or approved equal
   2. Provide rack mounted dual/double conversion UPS for backup power for each rack-mounted Server. UPS shall maintain power to Server upon loss of normal power and until emergency power supply is brought on line.
   3. Select UPS for minimum of 20 minutes backup time for load connected. This will allow emergency power sources to come on line.
   4. UPS shall be provided with power management software and communication cable for interfacing with respective Server.
   5. Upon sensing loss of normal power, transfer time shall be 8 milliseconds maximum.
   6. Operating Parameters:
      a. Operating Temperature: 0 to 40°C
      b. Relative Humidity: 0 to 95% rh, non-condensing
      c. Recharge Time: 8 hours, typical

2.2 LOCAL CONTROL PANELS

A. Control panels shall meet the following minimum requirements:
   1. Outdoors: Control panels located outdoors shall comply with NEMA 3R or 4X requirements.
   2. Mechanical Rooms: Control panels located in mechanical or electrical rooms shall comply with NEMA 4 requirements.
   3. Other Locations: Control panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.

B. Local control panels shall be constructed of steel or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color. Construction shall comply with NEMA 1 Standards for interior panels, NEMA 4 for exterior panels.

C. Provide panels of adequate size to accommodate instruments for future expansion of approximately 25% beyond space required for this scope of work.

2.3 NETWORK HARDWARE

A. Ethernet Switches, Routers, and Bridges:
   1. Network hardware shall be provided and configured to form a campus-wide Fast Ethernet (a combination of 100BASE-TX and 100BASE-BX, -FX, and –SX or higher).
   2. Ethernet devices shall be IEEE Std 802.3 which shall function as the center of a distributed-star architecture and shall be "learning" type with spanning tree algorithms per IEEE Std 802.1D. All devices shall have a non-blocking architecture.
   3. The switch shall support the connected media types and shall have a minimum of 150% the required ports and no fewer than 4 ports. One port shall be switch selectable as an uplink port.
   4. Network hardware shall be compatible with the copper and fiber optic cabling installed by the Division 27 contractor.
   5. Switch located in BAS server rack shall be managed type and shall have a minimum of two fiber optic ports.
   6. Switch shall include N.O./N.C. alarm contact for monitoring by BAS.

PART 3 - EXECUTION

3.1 GENERAL

A. Install control equipment, and wiring in neat and workmanlike manner.

B. Coordinate timely delivery of materials and supervise activities of other trade contractors to install devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.

C. Install control devices in accessible location.

D. All BAS associated 120 VAC power wiring (including all input and output power supplies) shall originate from clearly-marked, BAS-dedicated circuit breakers. All input/output transducers shall be powered from the same circuit that supplies power to the associated BAS controller. All BAS equipment shall be fused in accordance with manufacturer's recommendations.

E. 120 VAC power shall not be allowed inside BAS controller panels. All 120 VAC to 24 VAC transformers and 120 VAC to 24 VDC power supplies shall be located in enclosures adjacent to the control panel being served. Terminal unit controls shall be served by consolidated 24 VAC transformer panels.

F. BAS controllers shall be labeled with the source of electrical power including panel number, circuit breaker number, and room number where electric panel is located.

G. Devices containing mercury are not allowed.

H. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.

I. During construction, Contractor shall take necessary precautions to ensure all panels, wiring, instrumentation, etc. are kept clean and dry. Upon Project completion, control panels shall be clean of wire nuts, trash, and wire stripping. All excess material is to be turned over to Owner BAS group.

J. BAS floor level network to room/equipment controllers shall be confined to the same floor the respective building level controller is located on.
   1. In applications where the floor level network must transition between floors, the transition shall be located in a clearly marked junction box on each floor of appropriate size to accommodate a screw terminal strip. Network cabling shall be labeled to indicate the previous connection prior to entering the junction box with the terminal strip. Terminal strip shall be used as a transition point from one floor to the next. Terminal strip shall be large enough to accommodate transitions to and from the floors below and above if floor transitioning is required.

K. Labels and tags shall be keyed to unique identifiers shown on As-Built drawings. Enclosures and DDC Hardware and controllers shall be labeled. Sensors, valves and actuators shall be tagged. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMA flow coefficient. Duct static pressure taps shall be tagged at location of pressure tap. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to enclosure or DDC Hardware. Labels inside protective enclosures may be attached using adhesive, but shall not be hand written.

3.2 CONTROL WIRING

A. Provide electrical wiring required for complete functional control systems, including power circuit to control panels, both line and low voltage, in accordance with applicable local codes, and latest version of National Electrical Code and NFPA. Refer to Paragraph 1.6.H. for definition of scope of Work.
   1. Voltage drops for all low voltage circuits shall be calculated prior to installing low voltage circuits. Voltage drop calculations shall be made available to Engineer on demand.

B. Control panels serving equipment fed by emergency/standby power shall also be served by emergency/standby power. Equipment fed by emergency/standby power is so indicated on mechanical equipment schedules and electrical motor schedules. Control panels shall be powered by local UPS (Uninterruptible Power Supply) to ensure continued control of equipment powered by site standby power sources when primary power source is lost. Devices such as Operator Workstations, Floor Level and Building Level Controllers, Application Specific Controllers and fume hood controls shall be provided with UPS power.

C. Where multiple controllers reside in a single control panel, provide a separate disconnect (or fuse) for each controller.

D. Power wiring to control air compressors and line dryers will be provided by Electrical Contractor. Furnish field-mounted starters to Electrical Contractor for installation and supervise installation.

E. Install control wiring in metal conduit or raceway system. Refer to Division 26 - Electrical for additional requirements.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 26 0000 – General Electrical Requirements.

G. Color-code each junction box cover plate as to signal type using 1/2" self-adhesive color dot or enamel spray paint. Use green for low voltage signal wiring, blue for pneumatic tubing, and yellow for line voltage wiring used for signal wiring or dedicated power wiring.

H. Tag each wire termination at control panels, junction boxes, and remote control devices with unique wire ID number.

I. Low voltage wiring concealed above accessible ceilings does not require raceway. Cables not in raceway shall be routed along building structure lines using Bridal Rings, J-hooks or other mounting methods as approved by Engineer. Use of wire-ties for attaching cabling to duct brackets, piping or structure is not acceptable. Diagonal routing is not allowed. Label each cable not in raceway with unique wire ID number every 50 ft.

J. Terminate low voltage DC instrument signal cable with black terminated on positive terminal and white terminated on negative unless otherwise noted.

K. Run direct current instrument conductors separately from alternating current conductors. Where allowed by NEC wiring classification, AC-DC route crossings shall be at 90 degrees. Install special sensor to transmitter cables in accordance with manufacturer's installation drawings or in compliance with manufacturer's instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.

L. All wiring terminating in a control panel/enclosure shall be landed on terminal strips, with one wire per terminal. All I/O points on a DDC/BAS controller shall be wired to panel-side of terminal strip, including all spare I/O points.

M. All communication/power/signal wiring terminating in a control panel/enclosure/junction box shall be provided with a minimum of 3” – 6” extra wiring length. Extra cable shall be loosely folded/looped and stored neatly in wireways or cable tray/headers above control panel.

N. Route intrinsic safe wiring separately from other conductors. These conductors shall not be run with, nor cross, conductors of other NEC classifications and shall require intrinsic barrier if run in the same path with wiring of other classifications.

O. Follow Control Contractor’s Company standard cabling color codes.

P. Owner’s standard cabling and color codes may be used instead of above specified cabling and color codes.

Q. Electric Signal Cables:
   1. Analog electric signal cables from electronic transmitters to controllers/receivers and from controllers to other analog devices shall be continuously shielded to reduce effects of EMI on control signals residing on those cables. Electric signal cables to discrete devices typically do not require shielding, but for better noise immunity use twisted/shielded pairs.
   2. Shields shall be grounded at power source end only and floated at other end. Pay particular attention to floating shields through termination points, maintaining only one single grounding point, and insulating from ground at other points.
   3. Provide 250 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 1 - 5 VDC signals or 500 ohm, 5 watt, 0.1% tolerance, dropping resistors as required to generate 2 - 10 VDC signals from 4 - 20 mA control loop powered by 24 VDC power supply.

R. BAS Network Communication Cable:
   1. Install special cable connectors in accordance with BAS manufacturer's recommendations.
   2. Typically, #22 AWG, but no smaller than #24 AWG, twisted pairs, twisted shielded pairs, coaxial cable, fiber optics or manufacturer's standard cabling for communications between remote control devices and BAS controllers.
   3. BAS Network communication cable shall not be spliced.
   4. Provide isolated instrument grounding system as necessary per manufacturer's recommendations.

3.3 LOCAL CONTROL PANELS

A. Provide local control panel for each system where more than one control device requires field mounting, (air handling units, exhaust fans, miscellaneous control systems including pump controls, heat exchanger controls, etc.). Single devices may be mounted on piping, wall or ductwork. Install local control panel where indicated on drawings or suitable location adjacent to system served.

B. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.

C. Label local control panels with respective unique ID numbers in accordance with Section 20 0553 - Mechanical Systems Identification.

D. All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.

E. Panel Layout:
   1. Locate controllers in lower half of panel first and upper half second.

2. Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2'-0" or above 6' above finished floor.
3. Provide separate enclosure for 120 VAC power transformer and circuitry.
4. Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
5. Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.
6. Do not place controller or control devices on enclosure sides.
7. Do not use any control panel as wire or cable pass-through to adjacent panel.

3.4 BAS ETHERNET NETWORK TESTING AND BENCHMARKING

A. Test and document connectivity, latency, and integrity of network from each switch to each BAS controller and BAS server switch and from switch-to-switch.
   1. Latency between any ports shall be equal to or less than 1 millisecond.
   2. Packet loss shall be less than 0.5% between any ports when tested with frame sizes between 64 and 1518 frames for duration of 60 seconds.

B. Test and document all telecommunication protection/security techniques employed on system including access control into BAS Ethernet network from other building networks and access control to other building networks from BAS Ethernet network. Coordinate testing procedures with Owner.

3.5 ADJUSTMENT AND COMPLETION CHECKLIST

A. After completion of installation, follow checklist procedure defined in checklist submittal to adjust and calibrate thermostats, control valves, control actuators, controllers, sensors, and other equipment provided in this Contract. Include signed and dated, completed checklist in Operation and Maintenance Manuals.

B. Upon completion of Work but before final acceptance of systems, Engineer or Owner's representative will verify performance of control loops. Control Contractor shall immediately remedy any deficiencies found. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program. Corrective modifications made by Control Contractor during warranty period shall be incorporated and updated in Operation and Maintenance Manuals.

C. After final acceptance of system, Contractor shall work with Owner to remove all existing user names and passwords for all software and hardware used on project and create new user names and passwords as required.

3.6 OWNER TRAINING

A. Provide minimum of 8 hours of on-site training to Owner's representatives. Conduct training sessions during normal business hours after system start-up and acceptance by Owner. Scheduling of training session(s) will be established by Owner. Portions of training may be performed before system is completely operational, but no sooner than one month before system is planned to be fully operational. Final training session shall be held after systems are complete including all graphics programming.

B. Course content shall include, but not be limited to, the following topics:
   1. Explanation of control sequences. Include which sensors are used and how output device operates.

2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
3. Walk-through of Project to identify controller locations and general routing of network cabling.
4. Review of operation and maintenance of hardware devices including air compressor, air dryers, controllers, instruments, and sensors. Include schedule for routine maintenance.
5. Review of operation of operator's workstation; include hardware (PC's, printers, etc.).
6. Review of operator's workstation software using specific examples of operating hardware.
7. Review of portable operator's workstation software using specific examples of operating hardware.
8. Any additional item(s) specifically requested by Owner.

C. Scheduling of training session(s) will be established by Owner.

END OF SECTION

Qualification Form

Brief resume of **key** persons, specialists, and individual consultants anticipated for this project:

a. Name & Title:	b. Project Assignment:
c. Name of Firm with which Associated:	d. Years of Experience: With this Firm_____ Other firms_____
e. Education: Degree(s)/Year/Specialization	f. Responsibility Level Proposed for this Project:

g. Other experience and qualifications relevant to the proposed project (include training courses/certifications):

Recent Relevant Experience (see example below)	**Qualifications**
▪ Company, Location - Name of Specific Project, Facility - Description of Work and Responsibilities	

SECTION 23 3614

LABORATORY TEMPERATURE AND AIRFLOW CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED WORK

A. Division 01 - Submittal Procedures

B. Section 23 0595 - Air Systems Balance

C. Section 23 0901 - Control Systems Integration

D. Section 23 0902 - Control Valves and Dampers

E. Section 23 3314 - Ductwork Specialties (Sound attenuators and access doors)

F. Section 23 8214 - Heating and Cooling Terminal Devices

1.2 DESCRIPTION

A. This specification is for procurement and installation of laboratory temperature and airflow control system, complete with air venturi valves, fume hood controllers, fume hood sash sensors, electric/pneumatic transducers, air venturi valve controllers, master controllers, control wiring, pneumatic tubing, space temperature sensors, and all accessories required, except where otherwise specified, to provide complete and functional system. System shall include all equipment necessary to control fume hoods, exhaust rate, air venturi valves, and reheat coils as specified in control sequences included on M7.XX drawings, with exception of furnishing and installing reheat coil control valves. Reheat coil control valves to be furnished by Temperature Control Contractor and installed by Mechanical Contractor. Refer to Specification Section 23 0902 - Control Valves and Dampers.

B. Air venturi valve devices shall be installed in the ductwork system by Laboratory Temperature and Airflow Control System (LTACS) Contractor. Laboratory Temperature and Airflow Control System Manufacturer shall coordinate delivery and installation schedule of air venturi valve devices with Mechanical and Controls Contractor.

C. Laboratory Temperature and Airflow Control System Contractor shall assist Project Expeditor in preparation of coordination drawings as specified in Section 20 0000 - General Mechanical Requirements. As part of this effort, this Contractor shall provide locations of control components to Project Expeditor, review schedule for preparation of Coordination Drawings as prepared by Project Expeditor, and attend meetings as required to assist in preparation of documents, and actively participate to resolve layout issues in timely manner.

1.3 SUBMITTALS

A. Refer to Division 01 - Submittal Procedures

B. Submit Shop Drawings for all supply, general exhaust, and fume exhaust air venturi valves, actuators, sash sensors, fume hood controllers/monitors, controllers, master controllers, control wiring, pneumatic tubing, space temperature/humidity sensors and all accessories. Shop drawings shall be complete in all respects and shall include, but not be limited to the following:

1. Manufacturer's printed product data sheets indicating name and model number of all pieces of equipment.

2. Name, address and phone number of supplier
3. Name, address and phone number of local representative
4. Identification as referenced in documents
5. Capacity/ratings and dimensional data
6. Materials of construction and installation requirements

C. Bill of material identifying actual product model number used for each control device for each schematic drawing.

D. Control drawings with graphic representation of system components. Identify controlled devices as referenced on plans with unique valve and damper tag numbers.

E. Electrical characteristics indicate any field wiring which is to be performed by others, type of signal wiring, and installation methods including raceway type and grounding method.

F. Supply and exhaust air venturi valve certified sound data for both casing discharge and radiated sound levels from 125 through 8000 Hz as tested in accordance with ASHRAE/ANSI Standard 130, S12.12 or AHRI Standard 880.

G. Instrument specifications

H. Controller description

I. System/network architecture configuration diagram showing all controller / control panel types and locations and interconnecting wiring and interface points.

J. Written control sequences describing method of control, alarms, setpoints referenced to tag number of device.

K. Outline drawing showing overall dimension, component location and spacing, and interfacing connections sizes and locations.

L. Identify setpoint or adjustable control range for each control device.

M. Submit Completion Check List as specified in Section 23 0901 - Control Systems Integration.

N. Shop Drawings and complete equipment and software descriptions shall be submitted in sufficient detail to assess equipment’s conformance to this specification and physical size of equipment.

O. Organize submittal with table of contents and tabs for each section arranged by logical groups of devices.

1.4 DESIGN CRITERIA

A. Unit manufacturer, or his designated representative, will be required to verify air venturi valve device performance and adjust or replace device(s) within warranty period when it is determined that problem exists in area served by device(s).

B. Actuators and linkages shall be furnished and factory installed by Laboratory Temperature and Airflow Control Manufacturer.

C. Standard actuator of manufacturer is acceptable provided it meets criteria specified herein.

D. Actuator and its controller shall be calibrated and either factory set or field set through TAB work for scheduled airflow rates. Air venturi valves shall be capable of field calibration and readjustment with external gauge taps.

E. Air consumption of each pneumatic control assembly shall not exceed 35 scim(1.2 scfh).

F. Refer to Air Venturi valve Device schedules for definition of minimum inlet static pressure requirement for each air venturi valve device as well as sizing criteria.

G. Provide all components not specifically indicated or specified, but necessary to make system function within intent of specification and in accordance with control sequences.

H. Size all control apparatus including all air venturi valves to provide stable control of systems and equipment served throughout specified operating range.

I. Any devices subject to corrosion, such as in fume hood exhaust ducts, shall be provided with appropriate corrosion protection.

1.5 CODES AND STANDARDS

A. All materials and workmanship described herein shall be in accordance with latest edition and addenda of codes and standards listed below:
   1. AMCA Air Movement and Control Association
   2. AHRI Air Conditioning, Heating, and Refrigeration Institute
   3. ASTM American Standards Testing and Materials
   4. NEC National Electrical Code
   5. NEMA National Electrical Manufacturers Association
   6. NFPA National Fire Protection Association
   7. UL Underwriters Laboratories

1.6 FCC COMPLIANCE

A. All equipment furnished under this Contract shall have been tested and made to comply with limits for Class A computing device pursuant to Subpart J of part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environment. Literature shall so note and all equipment shall be so labeled to show this compliance.

1.7 ADJUSTMENT, PERFORMANCE TEST AND CERTIFICATION

A. After completion of installation, regulate and adjust all equipment provided in this contract as outlined in Completion Check List.

B. Conduct complete performance test for all systems to assure compliance with contract documents. Any components on systems found defective or not performing satisfactorily shall be readjusted and retested after necessary corrective measures are performed. Corrective measures may include modification or addition of equipment and devices, control strategies and/or software program.

C. Provide written certification signed by applicable person(s) for incorporation in O&M manuals stating date when successful completion of performance tests is achieved. Letter shall verify all controls are installed and software programs have been completely exercised for proper equipment operation.

1.8 WARRANTY

A. Warrant all work, materials, equipment, and controls against defects in workmanship and material per Article 42 of General Conditions and provide service for period of 1 yr from date of final acceptance by Owner.

B. Replace any defective workmanship or material developing within that time as soon as possible at no charge to Owner.

C. After completion of installation, manufacturer shall regulate and adjust equipment provided in this contract prior to final acceptance.

1.9 OWNER TRAINING

A. Laboratory Temperature and Control System Contractor shall have designated representative available to monitor/modify lab control systems after systems have been started and are regularly used until Owner has completed on-site training specified.

B. Provide minimum of 8 hours of on-site training to Owner's representatives. Conduct training sessions during normal working hours after system start-up and acceptance by owner. Scheduling of training session(s) will be established by Owner and shall include both classroom and hands-on training. Portions of training may be performed before system is completely operational, but no sooner than 1 month before system is planned to be fully operational. Final training session shall be held after systems are complete, including all graphics programming.

C. Training sessions shall include, but not be limited to, the following topics:
   1. Explanation of control sequences. Include which sensors are used and how output device operates.
   2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
   3. Walk-through of Project to identify controller locations and general routing of network cabling.
   4. Review of operation and maintenance of hardware devices including controllers, instruments, and sensors. Include schedule for routine maintenance.

D. Instructions on how to monitor and operate system hardware and software, and how to change system set points, flow rates, etc and respond to alarms.

E. Review interface for troubleshooting using operator interface device.

F. Training sessions shall be conducted during separate visits to site from site visits for system adjustment, performance test and certification.

1.10 OPERATING AND MAINTENANCE MANUALS

A. Refer to Division 01 - General Requirements

B. Operating and maintenance manuals shall provide descriptions of maintenance on all system components including sensors and controlled devices. These shall include Control Contractor's completion check list, inspection requirements, periodic preventative maintenance, cleaning methods and materials, troubleshooting guide, calibration instructions and tolerances, repair parts lists, and manufacturer representative's name, address, and phone number.

C. O&M Manuals shall also include interconnection wiring diagrams with identified and numbered system components and devices.

1.11 RECORD DRAWINGS

A. Refer to Division 01 - General Requirements

B. Submit revised Shop Drawings indicating all changes made during project including any changes to operating sequences or setpoints.

C. Update control diagrams to include all tuning parameters and setpoints applicable to systems as depicted as of date of system completion. This information shall be incorporated with sequence of operation of each system.

D. Record actual locations of control components including control units, temperature/humidity sensors, air venturi valves and any controlled devices on As-Built ductwork/piping plans provided by Mechanical Contractor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND ALTERNATE BIDS

A. Design of Contract Documents, are based on laboratory temperature and airflow control system as manufactured by Phoenix Controls Corporation.

B. GENERAL

C. Materials shall be new and unused and free from defects and imperfections.

D. Laboratory temperature and airflow control system shall be fully stand-alone for each individual laboratory or laboratory support space. System shall not use or rely on information from controllers in other laboratory areas or from outside laboratory space to control functions within its laboratory. Refer to drawings for location of control panel for each lab space.

E. Laboratory airflow control system shall employ individual Average Face Velocity controllers that directly measure area of fume hood sash opening and proportionally control hood's exhaust airflow in variable volume mode to maintain constant face velocity over minimum range of 25 to 100 % of full sash opening. Safety and energy savings shall be insured through corresponding minimum change in hood exhaust flow of 4 to 1.

F. Electrically actuated venturi valve units shall be pressure independent with airflow accuracy of ±5% over airflow range of venturi valve. Air venturi valve units shall be balanced to conform to requirements of Section 23 0595 - Air Systems Test Adjust Balance.

G. Laboratory airflow control system shall use volumetric offset to maintain room pressurization. Offset airflow is indicated for each lab on Air Venturi valve Device schedule.

H. Vertical sash sensor shall be provided to measure height of each vertically moving fume hood sash. Horizontal sash sensor shall be provided for each pair of horizontal or overlapping sashes that are located on horizontal, combination, or walk-in type fume hoods. Operational life of sensors shall be minimum of 250,000 cycles. Sash sensors mounted on fume hood sashes shall extend to within 1/8” or less of the edge of the sash trim edge.

I. Provide an individual fume hood controller for each fume hood, which shall maintain face velocity set point in response to sash position. Controller shall maintain constant average face velocity as fume hood sashes are opened and closed. Controller shall modulate exhaust airflow between minimum and maximum air flow rates scheduled in Air Venturi valve Device Schedules.

J. Control wiring and pneumatic tubing shall meet requirements of specification Section 23 0901 - Control Systems Integration.

K. Control panels (including routers and power supplies) shall be located near entry to each lab as shown on plans. Coordinate location of control panel with all trades to provide access to panel for maintenance. Provide communications jack as part of or adjacent to space temperature sensor to allow communication between laptop computer and control panel. Provide one control panel for each lab as shown on plans.

L. Provide sound attenuator for each air venturi valve device. Refer to Section 23 3314 - Ductwork Specialties for sound attenuator specification.

2.2 LABORATORY CONTROLS SYSTEM

A. General:
   1. The following requirements apply to laboratory temperature and airflow control system manufactured by Phoenix Controls Corporation or approved equal.

B. Air Venturi Devices - General:
   1. Air venturi valves shall be pressure independent over a 0.3” or 0.6 to 3.0” WG drop across the air venturi valve. 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 manifold system.
   2. Airflow accuracy shall be ±5% of airflow (not velocity pressure) over an airflow turndown range of no less than 10 to 1.
   3. Provide differential pressure switch mounted across each air venturi valve or other means to signal alarm under low flow condition at each fume hood.

C. Supply and General Exhaust Air Venturi valves:
   1. Air venturi valves for non-corrosive airstreams, such as supply and general exhaust air, shall be constructed of 16 ga aluminum. The air venturi valve shaft and shaft support bracket shall be made of 316 stainless steel. The pivot arm and internal mounting brackets shall be made of a combination of aluminum and stainless steel. The pressure independent springs shall be of combination 302 and 316 stainless steel. All shaft bearing surfaces shall be made of a Teflon or Celenex composite.
   2. Refer to Air Venturi valve Devices schedule for definition of materials of construction for each air venturi valve.
   3. Provide external insulation of each supply air venturi valve device as specified in Section 20 0700 - Mechanical Systems Insulation.

D. Fume Exhaust Air Venturi valves:
   1. Air venturi valves for corrosive airstreams, such as fume hoods, biosafety cabinets, snorkel, flammable storage cabinets and equipment exhaust shall have the following construction:
      a. Valve body and cone: Baked phenolic coated aluminum
      b. Shaft: Teflon coated 316 SS
      c. Shaft support brackets: Baked phenolic coated 316 SS
      d. Spring: Baked phenolic coated 302/304 SS
      e. Pivot arm: Baked phenolic coated 316 SS
   2. Refer to Air Venturi valve Devices schedules for definition of materials of construction for each air venturi valve.

E. Air Venturi valve Actuators

1. For VAV operation, pneumatic actuator shall be factory mounted to air venturi valve. Loss of pneumatic main air or control power shall cause exhaust air venturi valves to fail open to maximum scheduled design flow and supply air venturi valves to fail to minimum scheduled design flow. Constant volume air venturi valves do not require actuators and shall be manually set for scheduled air flow.

F. Certification

1. Each air venturi valve shall be factory calibrated to job specific airflows as detailed on plans and specifications using NIST traceable air stations and instrumentation having combined accuracy of at least ±1% of signal over entire range of measurement.
2. Air venturi valves shall be individually marked with air venturi valve specific model number, and quality control inspection numbers. Information shall be stored on computer CD diskette in ASCII Format by manufacturer for future retrieval or for hard copy printout to be included with as-built documentation.

G. Air Venturi valve Controllers:

1. Controller shall use electronic-based, closed loop control to regulate airflow.
2. Response time to vary air venturi valve's airflow to within 90% of its commanded setpoint value shall be no more than one (1) second with less than 5% undershoot or overshoot.

H. Laboratory Temperature and Airflow Control System :

1. A Celeris 2 Controller(s) mounted on supply air venturi valve(s) with I-to-P interfaces with Phoenix devices shall control the supply and/or general exhaust air flow air venturi valve devices to maintain proper room pressurization polarity (positive or negative). Each laboratory suite shall have a dedicated sub network defined by a Celeris 2 router.
2. Supply/exhaust venturi valve controller shall be microprocessor-based digital controller. It shall control and communicate digitally via LON – 78kbps (a high-speed room level digital network) with up to thirty two digital fume hood, snorkel, flammable storage, equipment, general exhaust, makeup, and laboratory office air flow control devices within a particular pressurization zone.
3. Supply/exhaust venturi valve controller shall maintain a constant design offset between the sum of the room's total exhaust and make-up/supply air flows. This offset shall be field adjustable and represents the volume of air which will enter (or exit) the room from adjacent spaces.
4. LON routers shall have the capability for full stand alone operation and shall be capable of communicating digitally with up to 100 routers or LON network devices over a secondary high-speed building wide digital laboratory control system digital network Lon-1.25Mbs. High-speed building wide network not provided for this work.
5. Venturi valve controllers shall provide an EIA-232 port for connecting a notebook computer, desktop computer, modem, or alarm printer. This EIA-232 port shall provide access to all points of the LON networks.
6. Venturi valve controllers shall accommodate sufficient point to address temperature control and non-network sensors.
7. Routers shall be panel mounted in a NEMA enclosure and shall operate on 24 V AC power. Mount 24 V AC transformers for the routers in an enclosure that is accessible or adjacent to the routers.
8. All network components shall meet FCC Part Subpart L Class A, and be UL 916 listed.
9. Supply air venturi valve controller shall provide control signal to reheat coil control valve to maintain space temperature. Provide devices as required to interface with pneumatic or electronic control of reheat coil control valves. Refer to Specification Section 23 0901.

I. Laboratory Temperature and Airflow Control System :

1. A Traccel Controller(s) mounted on supply or exhaust air venturi valve(s) with interfaces with Phoenix devices shall control the supply and/or general exhaust air flow air venturi valve devices to maintain proper room pressurization polarity (positive or negative). Each laboratory suite shall have a dedicated sub-network defined by Traccel pairs or enhanced pairs.
2. The supply/exhaust venturi valve controllers shall be microprocessor-based digital controllers. They shall control and communicate digitally via BACnet MS/TP Communication Protocol to provide air flow control within a particular pressurization zone.
3. The supply/exhaust venturi valve controllers shall maintain a constant design offset between the room exhaust and make-up/supply air flows. This offset shall be field adjustable and represents the volume of air which will enter (or exit) the room from adjacent spaces.
4. The venturi valve controllers shall accommodate sufficient point capacity to address temperature control and non-network sensors.
5. All network components shall meet FCC Part Subpart L Class A, and be UL 916 listed.
6. The supply air venturi valve controller shall provide control signal to reheat coil control valve to maintain space temperature. Provide devices as required to interface with electronic control of reheat coil control valves. Refer to Specification Section 23 0901.

J. Fume Hood Controller:

1. Provide for each fume hood an individual fume hood controller, which shall maintain face velocity setpoint (adjustable) in response to sash position. Controller shall maintain constant average velocity as fume hood sash is raised and lowered, or moved horizontally. The controller shall calculate average face velocity from exhaust cfm and hood open area. This face velocity is compared to the setpoint to calculate the required exhaust air flow. The actual airflow must be measured and used for control.
2. Controller shall be UL 916 Listed.
3. Controller shall support fume hood sash configurations utilized in this project. Coordinate with fume hood manufacturer.
4. Initial setpoint for face velocity shall be 100 fpm with 18” sash open height for all hoods except radioisotope hoods, which have setpoint of 125 fpm with 18” sash open height.
5. Provide general alarm output for use with auxiliary devices.
6. Momentary or extended losses of power shall not change or affect any of control system's setpoints, calibration settings, or emergency exhaust mode status. After power returns system shall continue operation exactly as before without need for operator intervention. Under no circumstances shall loss of power command exhaust system to full flow upon return of power.

K. Fume Hood Monitor:

1. A FHM 430-ENG fume hood monitor shall be provided for each fume hood to comply with laboratory safety standards. Standard Operation: Fume hood is operating within acceptable tolerance levels (Face Velocity = SETPOINT ±15%)
2. Standby Operation: (Setback feature based on hood zone presence sensor OR time of day is when configured into system)
3. Caution/Low Flow Alert (also triggers integral audible alarm) as derived by:
    a. Insufficient exhaust static pressure as indicated by PDS (integral to controller) across VEV-(*) Static Pressure < 0.15 kPa (0.6" WC).
    b. Inferred air flow (as indicated by integral actuator position feedback sensor) does not match controller output.
    c. Emergency Exhaust Alert (also triggers integral audible alarm): hood is operating in Emergency Exhaust Mode as initiated by integral Emergency Exhaust pushbutton on FHM.
4. Device shall provide the following control functions:

a. Alarm mute: Integral pushbutton to silence the audible alarm except during emergency purge mode. During a non-emergency mode, the audible alarm shall re-activate if it has not cleared after a 10 to 15 minute period from the Alarm mute button being pressed.

b. Emergency Exhaust: Integral pushbutton to command exhaust valve VEV-(*) 100% open.

c. There shall be no local indication of face velocity.

L. Room Temperature Sensors:

1. Sensors shall be 10K ohm thermistor type by Automation Components, Inc. (ACI) or Building Automation Products Incorporated (BAPI). Thermistor shall incorporate jumpers and RJ-11 connector specific to the “Phoenix” option. Sensor shall include communication jack to allow remote programming via laptop computer. Temperature sensors shall have remote sensor located in room general exhaust duct and adjustable setpoint adjustment and temperature adjustment in wall enclosure for each laboratory or laboratory support space and shall be programmable with adjustable deadband set point between 72°F and 78°F.

2. For spaces subject to wash down, wipe down or vapor de-contamination consider using flush mount 316L stainless steel temperature sensors.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Furnish and install fume hood monitors and sash sensors at each fume hood. Coordinate installation requirements with fume hood manufacturer.

B. Install units as shown on drawings, schedules and details. Coordinate with Mechanical Contractor to verify appropriate ductwork configuration to allow for accurate measurement and control of airflow.

C. Laboratory Temperature and Airflow Control System manufacturer shall furnish, install and terminate all low voltage control wiring and 24 VAC power supplies. Laboratory Temperature and Airflow Control System manufacturer shall furnish and install pneumatic control tubing required for laboratory control devices that are pneumatically operated.

D. Air Venturi valves and Reheat Coils:

1. Laboratory Temperature and Airflow Control System Contractor shall furnish to Mechanical Contractor to install air venturi valves, sound attenuators, reheat coils and access doors as shown on drawings and according to manufacturer’s instructions. Mechanical Contractor shall install reheat coil control valves furnished by Temperature Control Contractor. Mechanical Contractor shall provide necessary ductwork transitions as required for mounting equipment provided by LTACS Contractor.

2. Mount actuators on same side of air venturi valve device as coil connections to ensure service access.

3. Connect air venturi valves to ductwork with removable type joints as detailed.

4. Transition from supply air venturi valve to reheat coil shall not exceed 15° per side.

5. Provide access doors for supply air venturi valves with reheat coils. Mount access door at inlet side of coil. Refer to Section 23 3314 - Ductwork Specialties for access door requirements.

E. Fume Hood Controls:

1. Furnish to fume hood manufacturer templates for required hood mounted devices including vertical and horizontal sash sensors, interface boxes, and fume hood monitors required for complete installation of fume hood exhaust air control system. Fume hood manufacturer shall provide necessary cut outs with blank cover plates.

2. Fume hood size and sash configuration are called out in Lab Furnishings documents. Verify with fume hood manufacturer fume hood sizes, sash configurations and installation requirements for each device.
3. Laboratory Temperature and Airflow Control System manufacturer shall field install, mount and wire required hood mounted devices.

F. Control Air:
1. Source for control air will be provided at each floor. Verify locations and pressures required with Mechanical and/or Piping Contractors.
2. Laboratory Temperature and Airflow Control System manufacturer shall provide pneumatic piping and devices required for complete and proper system functioning from control air source at each floor.
3. Provide filter stations to Temperature Control Contractor to be mounted in control air piping at source of control air to provide required air quality.

G. Control and Power Wiring:
1. Laboratory Temperature and Airflow Control System (LTACS) manufacturer shall provide control wiring from laboratory control panel to and between other laboratory control system components as required for complete and proper functioning, including but not limited to air venturi valves, control valves, sensors, transducers, controllers, panels, and interface modules.
2. Electrical Contractor will provide one spare 20 A circuit at each emergency power electrical panel, serving laboratory. LTACS supplier shall provide required conduit, wire, junction boxes, disconnect switches and circuit breakers as specified in Division 26 as required to wire electrical panel to each laboratory control panel.
3. LTACS supplier will provide power wiring to routers and venturi valve controllers in each laboratory suite.

H. Laboratory Control Panels and Power Supplies:
1. Mount laboratory control panels and power supplies in accessible location within laboratory room as shown on plans.
2. Coordinate location of electrical power panels with Division 26 Contractor.

I. Laboratory Control System Start-up:
1. System startup shall be provided by factory authorized representative of system manufacturer.
2. Coordinate timing of start-up with Mechanical Contractor to confirm HVAC Systems are operating as specified.
3. Startup shall be performed on complete laboratory temperature and air flow control system and shall include calibration of each laboratory control system component; check out of air venturi valves, actuators, fume hood sash sensors, temperature sensors, and verification that each system operates in compliance with specified control sequences.
4. Laboratory Temperature and Airflow Control System manufacturer shall measure and set up fume hood average face velocity. Coordinate with and work in conjunction with TAB Contractor.
5. Laboratory Temperature and Airflow Control System manufacturer shall set up system supply, general exhaust, and fume exhaust air flows in cooperation with TAB Contractor. TAB Contractor will take required air flow measurements.
6. Laboratory Temperature and Airflow Control System manufacturer shall provide a visual demonstration that the laboratory airflow systems are maintaining specified hood containment performance requirements. If the performance requirements cannot be demonstrated, then system supplier shall be responsible for any costs and labor necessary to meet minimum performance requirements. Coordinate with and work in conjunction with TAB Contractor.

7. Laboratory Temperature and Airflow Control System manufacturer shall demonstrate that, with specified room offset, system maintains proper room directional air flows under both static and dynamic operating conditions, and can recover to proper flow direction within one second of change in room/system conditions such as raising and lowering of any hood sashes. Verification shall be provided by temporary visual indication, using smoke wand. If performance requirements can not be demonstrated, then laboratory control system manufacturer shall be responsible for any costs and labor necessary to meet minimum performance requirements. Coordinate with and work in conjunction with TAB Contractor.

END OF SECTION