## PART 1 - GENERAL

### 1.01 SUMMARY

A. Section includes control equipment and software.

B. Related Sections:

1. Section 23 09 93 - Sequence of Operations for HVAC Controls: Sequences of operation implemented using products specified in this section.

2. Section 26 05 03 - Equipment Wiring Connections: Execution requirements for electric connections specified by this section.

3. Section 26 09 43 - Central Lighting Controls.

### 1.02 REFERENCES

A. American National Standards Institute:

1. ANSI MC85.1 - Terminology for Automatic Control.

2. ANSI/ASHRAE Standard 135 – BACNET – A Data Communication Protocol for Building Management and Control Networks.

3. National Fire Protection Association (NFPA) Standards.

4. National Electric Code (NEC) and applicable local Electric Code.

5. Underwriters Laboratories (UL) listing and labels.

6. UL 864 UUKL Smoke Control.

7. UL 268 Smoke Detectors.

8. UL 916 Energy Management.

9. NFPA 70 - National Electrical Code.

10. NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.

11. NFPA 92A and 92B Smoke Purge/Control Equipment.

12. Factory Mutual (FM).

13. American National Standards Institute (ANSI).

14. National Electric Manufacturer’s Association (NEMA).

15. American Society of Mechanical Engineers (ASME).

16. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).

17. Air Movement and Control Association (AMCA).

18. Institute of Electrical and Electronic Engineers (IEEE).

19. American Standard Code for Information Interchange (ASCII).

20. Electronics Industries Association (EIA).

21. Occupational Safety and Health Administration (OSHA).

22. American Society for Testing and Materials (ASTM).

23. Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.

24. Americans Disability Act (ADA).

25. ANSI/EIA 909.1-A-1999 (LonWorks).

26. ANSI/ASHRAE Standard 195-2008 (BACnet).

B. In the case of conflicts or discrepancies, the more stringent regulation shall apply.

C. All work shall meet the approval of the Authorities Having Jurisdiction at the project site.

1.03 SYSTEM DESCRIPTION

A. The Building Management System (BMS) shall be an extension of the existing campus wide Johnson Controls Metasys System. The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems. The Building Management System (BMS) shall be connected to the owner's LAN via a CAT6A (or building standard) cable. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the BMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.

B. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.

C. The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Drawings and the associated interfacing work as referenced in the related documents.

D. The BMS work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, programming, color graphics, preparing flow diagrams, interface, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.

E. Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.

F. Manage and coordinate the BMS work in a timely manner in consideration of the Project schedules. Coordinate with the associated work of other trades so as to not impede or delay the work of associated trades.

G. The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

1. Operator information, alarm management and control functions.

2. Enterprise-level information and control access.

3. Information management including monitoring, transmission, archiving, retrieval, and reporting functions.

4. Diagnostic monitoring, reset, alarm and reporting of BMS functions.

5. Offsite monitoring and management access.

6. Energy management.

7. Standard applications for terminal HVAC systems.

8. Lighting Controls.

H. Provide installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

I. Furnish and install a Laboratory Airflow Control System (LACS) in conjunction with the central Building Management System (BMS) to maintain laboratory room supply and exhaust airflows, room ventilation rates, room static pressurization, room ambient temperatures & humidity's and the laboratory exhaust system functionality as specified herein. LACS shall be tracking type and shall track supply air, general exhaust and hood exhaust (where applicable) for required air changes and proper air pressurization in each laboratory. Each laboratory shall have its own independent controls and tracking system.

1. The LACS shall also ensure that all VAV fume hood average face velocities and minimum exhaust airflows are maintained as required and as indicated on the drawings.

2. The LACS shall also ensure that all biological safety cabinets and other required exhaust airflows listed in the project plan schedules are maintained.

3. The LACS shall also provide the laboratory emergency control modes as detailed in this specification.

4. The LACS shall comply with the functional requirements of U.S. OSHA 29 CFR, (Canada Public Works MD 1580), NFPA 45, AIHA Z9.5, and all applicable Local and State (Provincial) codes

J. The LACS shall be tracking type and include all laboratory room supply and exhaust airflow terminals, reheat coils, reheat coil valves, air terminal actuators, sensors, associated instrumentation and the control units and associated interconnecting

wiring and pneumatic tubing. Any and all associated components required to implement a fully functioning and integrated system as specified herein shall also be provided. System verification and other documentation as specified under the commissioning requirements and commissioning plan section shall also be included.

K. All LACS data shall be capable of being accessed by authorized persons via the facility BMS network as well as via the Intranet using standard web browsers to obtain LACS data in graphical form as well as in specific user defined and configured LACS summary and status reports.

L. The LACS shall be as manufactured by Laboratory Controls Systems, Inc. or approved equal. LACS shall communicate directly and shall be compatible with Johnson Controls BMS and controls system network.

M. Lighting Control BMS Interface:

1. The lighting control system shall be interfaced to systems that utilize the Internet Protocol on an Ethernet network, or the EIB standard. This will allow the BMS systems to control and retrieve the status of inputs and outputs in the lighting control system. Coordinate with lighting controls for exact interface and provide all items.

2. The lighting control system shall be able to interface to BMS with the use of OPC technology

N. The entire system shall meet all IBC-NJ requirements.

1.04 SUBMITTALS

A. Division 01 - Submittal Procedures: Submittal procedures.

B. Shop Drawings, Product Data, and Samples:

1. The BMS contractor shall submit a list of all shop drawings with submittals dates within 30 days of contract award.

2. Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Architect and Engineer for Contract compliance.

3. Allow 20 working days for the review of each package by the Architect and Engineer in the scheduling of the total BMS work.

4. Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Owner.

5. Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.

6. The BMS Contractor shall correct any errors or omissions noted in the first review.

7. At a minimum, submit the following:

a. BMS network architecture diagrams including all nodes and interconnections.

b. Systems schematics, sequences and flow diagrams, wiring diagrams.

c. Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.

d. Samples of Graphic Display screen types and associated menus.

e. Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.

f. Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.

g. Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.

h. Room Schedule including a separate line for each VAV box and/or terminal unit, fin tube radiator controls indicating location and address.

i. Details of all BMS interfaces and connections to the work of other trades.

j. Details of BMS interface with LACS.

k. Product data sheets or marked catalog pages including part number, photo and description for all products including software.

l. Details of BMS interface with lighting controls.

m. Air flow measuring stations, water flow, steam and energy measuring stations.

1.05 CLOSEOUT SUBMITTALS

A. Division 01 - Execution and Closeout Requirements: Requirements for submittals.

B. Operation and Maintenance Manuals:

1. Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Owner's Representative upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:

a. Table of contents.

b. As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.

c. Manufacturers product data sheets or catalog pages for all products including software.

d. System Operator's manuals.

e. Archive copy of all site-specific databases and sequences.

f. BMS network diagrams.

g. Interfaces to all third-party products and work by other trades.

2. The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

1.06 QUALITY ASSURANCE

A. General:

1. The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems. Independent contractor or vendor using components and products from specified manufacturer are not acceptable.

2. The BMS Contractor shall be a recognized national manufacturer, installer and service provider of BMS.

3. The BMS Contractor shall have a branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

4. As evidence and assurance of the contractor's ability to support the Owner's system with service and parts, the contractor must have been in the BMS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this contract in each of the preceding five years.

5. The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

6. All products shall be from the same manufacturer.

B. Workplace Safety and Hazardous Materials:

1. Provide a safety program in compliance with the Contract Documents.

2. The BMS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.

3. The Contractor and its employees and subtrades shall comply with federal, state and local safety regulations.

4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work, and that their employees receive the training required by the OSHA rules that have jurisdiction for at least each topic listed in the Safety Certification Manual.

5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.

6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.

7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.

8. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the AHJ at the Project site.

9. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

C. Quality Management Program:

1. Designate a competent and experienced employee to provide BMS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Contractor. At minimum, the Project Manager shall:

a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.

b. Manage the financial aspects of the BMS Contract.

c. Coordinate as necessary with other trades.

d. Be responsible for the work and actions of the BMS workforce on site.

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

E. All BMS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX, and be so listed at the time of bid. All floor level controllers shall comply, at a

minimum, with UL Standard UL 91 6category PAZX; Standard UL 864, categories UDTZ, and QVAX and be so listed at the time of Bid. The purpose of the regulation is to minimize electromagnetic interference between electronic products, which may diminish the performance of electrical products or disrupt essential communications.

F. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

G. The manufacturer of the Building Management System shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

H. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network.

I. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

J. LACS Quality Assurance Requirements:

1. LACS components shall be the standard catalogued products of the LACS supplier and shall be the most recent product design that complies with the specified requirements.

2. The LACS supplier shall provide a one full year warranty on the entire LACS including any service/replacement labor during the warranty period shall start on the date of acceptance by Owner. Any LACS component or system performance problem during the warranty period shall be corrected by the LACS supplier at no cost to the owner.

3. The LACS supplier shall have a fully staffed support facility within 50 miles of the project site with fully qualified, factory trained technical support personnel, spare parts and all necessary test, diagnostic and service equipment.

4. The complete installation of the LACS shall be the responsibility of the LACS supplier and the checkout, startup and verification of specified performance of the LACS shall be by factory trained local branch office employees of the LACS supplier.

1.07 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.08 WARRANTY

A. Division 01 - Execution and Closeout Requirements: Product warranties and product bonds.

B. Standard Material and Labor Warranty:

1. Provide a one-year labor and material warranty on the BMS and components from the date of acceptance of the system by the Owner.

2. If within twelve (12) months from the date of acceptance of product, upon written notice from the owner, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.

3. Maintain an adequate supply of materials within 100 miles of the Project site such that replacement of key parts and labor support, including programming. Warranty work shall be done during BMS Contractor's normal business hours.

1.09 MAINTENANCE SERVICE

A. Division 01 - Execution and Closeout Requirements: Requirements for maintenance service.

B. Furnish service and maintenance of control systems for one (1) year from Date of Substantial Completion.

C. Furnish complete service of controls systems, including callbacks. Make minimum of 4 complete normal inspections of approximately 8 hours duration in addition to normal service calls to inspect, calibrate, and adjust controls. Submit written report after each inspection.

D. Furnish four (4) complete inspections per year, one in each season, to inspect, calibrate, and adjust controls. Submit written report after each inspection.

E. Examine unit components bi-monthly. Clean, adjust, and lubricate equipment.

F. Include systematic examination, adjustment, and lubrication of unit, and controls checkout and adjustments. Repair or replace parts in accordance with manufacturer's operating and maintenance data. Use parts produced by manufacturer of original equipment.

G. Perform work without removing units from service during building normal occupied hours.

H. Provide emergency call back service during working hours for this maintenance period.

I. Maintain locally, near Place of the Work, adequate stock of parts for replacement or emergency purposes. Have personnel available to ensure fulfillment of this maintenance service, without unreasonable loss of time.

J. Perform maintenance work using competent and qualified personnel under supervision and in direct employ of manufacturer or original installer.

K. Do not assign or transfer maintenance service to agent or subcontractor without prior written consent of Owner.

1.10 EXTRA MATERIALS

A. Division 01 - Execution and Closeout Requirements: Spare parts and maintenance products.

B. Furnish two printer ink cartridges and cartons of printer paper.

PART 2 - PRODUCTS

2.01 GENERAL DESCRIPTION

A. The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other owner provided networks.

B. The Building Management System shall consist of the following:

1. Standalone Network Automation Engine(s)

2. Field Equipment Controller(s)

3. Input/Output Module(s)

4. Local Display Device(s)

5. Portable Operator's Terminal(s)

6. Distributed User Interface(s)

7. Network processing, data storage and communications equipment

8. Other components required for a complete and working BMS

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

1. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2. The System shall maintain all settings and overrides through a system reboot.

E. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution.

F. System shall have automatic restart capability; automatically restart field equipment on restoration of power. Furnish time delay between individual equipment restart and time of day start/stop.

G. Manufacturers:

1. Johnson Controls Branch Office– contact Mohammed Taha at 732-225-6762

**2. Siemens Technologies/Apogee, for Lab controls only.**

2.02 BMS ARCHITECTURE

A. Automation Network:

1. The automation network shall be based on a PC industry standard of Ethernet TCP/IP. All wiring for the automation network and all devices/controls specified herein shall be provided by the BMS Contractor. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.

2. The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.

3. All BMS devices on the automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

4. Network Automation Engines (NAE) shall reside on the automation network.

5. The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

6. The automation network shall include all wiring, devices, software, etc. as required for a complete and operational system.

B. Control Network:

1. Network Automation Engines (NAE) shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:

a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9

1) The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

2) The NAE shall be tested and certified as a BACnet Building Controller (B-BC).

b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).

c. The Johnson Controls N2 Field Bus.

2. Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.

3. DDC Controllers shall reside on the control network.

4. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

5. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

6. The PICS shall be submitted 10 days prior to bidding.

C. Integration:

1. Hardwired:

a. Analog and digital signal values shall be passed from one system to another via hardwired connections.

b. There will be one separate physical point on each system for each point to be integrated between the systems.

2. Direct Protocol (Integrator Panel):

a. The BMS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BMS system and 3rd party manufacturers' control panels. The BMS shall receive, react to, and return information from multiple building systems, including but not limited to the chillers, generators, packaged AC units, variable frequency drives, power monitoring system and lighting control systems.

b. All data required by the application shall be mapped into the Automation Engine's database, and shall be transparent to the operator.

c. Point inputs and outputs from the third-party controllers shall have real-time interoperability with BMS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Local Area Network Communications.

3. BACnet Protocol Integration – BACnet:

a. The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2008.

b. A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

c. The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

d. All panels, controllers and work stations shall be provided with local UPS, surge protectors at plug-in or power connection points.

2.03 USER INTERFACE

A. Site Management User Interface Application Components:

1. Operator Interface:

a. An integrated browser based client application shall be used as the user operator interface program.

b. The System shall employ an event-driven rather than a device polling methodology to dynamically capture and present new data to the user.

c. All Inputs, Outputs, Setpoints and all other parameters as defined within Part 3,Section 23 09 93, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.

d. The user interface software shall provide help menus and instructions for each operation and/or application.

e. The system shall support customization of the UI configuration and a home page display for each operator.

f. The system shall support user preferences in the following screen presentations:

1) Alarm

2) Trend

3) Display

4) Applications

g. All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: set points, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

h. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

1) User access for selective information retrieval and control command execution

2) Monitoring and reporting

3) Alarm, non-normal, and return to normal condition annunciation

4) Selective operator override and other control actions

5) Information archiving, manipulation, formatting, display and reporting

6) BMS internal performance supervision and diagnostics

7) On-line access to user HELP menus

8) On-line access to current BMS as-built records and documentation

9) Means for the controlled re-programming, re-configuration of BMS operation and for the manipulation of BMS database information in compliance with the prevailing codes, approvals and regulations for individual BMS applications

i. The system shall support a list of application programs configured by the users that are called up by the following means:

1) The Tools Menu

2) Hyperlinks within the graphics displays

3) Key sequences

j. The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

2. Navigation Trees:

a. The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.

b. Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.

c. The navigation trees shall be "dockable" to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar. A simple keystroke will reattach the navigation to the primary display of the user interface.

3. Alarms:

a. Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:

1) Log date and time of alarm occurrence.

2) Generate a "Pop-Up" window, with audible alarm, informing a user that an alarm has been received.

3) Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.

4) Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.

5) Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.

6) Any attribute of any object in the system may be designated to report an alarm.

b. The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions.

c. The BMS shall allow a minimum of 4 categories of alarm sounds customizable through user defined wav.files. BMS shall provide storage of alarm for at least one (1) year.

d. The BMS shall annunciate application alarms at minimum, as required by Part 3 and Section 23 09 93.

4. Reports and Summaries:

a. Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:

1) All points in the BMS

2) All points in each BMS application

3) All points in a specific controller

4) All points in a user-defined group of points

5) All points currently in alarm

6) All points locked out

7) All user defined and adjustable variables, schedules, interlocks and the like.

b. Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.

c. Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.

d. Provide the capability to view, command and modify large quantities of similar data in tailored summaries created online without the use of a secondary application like a spreadsheet. Summary definition shall allow up to seven user defined columns describing attributes to be displayed including custom column labels. Up to 100 rows per

summary shall be supported. Summary viewing shall be available over the network using a standard Web browser.

5. Schedules:

   a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:

      1) Weekly schedules

      2) Exception Schedules

      3) Monthly calendars

   b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.

   c. It shall be possible to define one or more exception schedules for each schedule including references to calendars.

   d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.

   e. Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.

   f. Schedules and Calendars shall comply with ASHRAE SP135/2008 BACnet Standard.

   g. Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

   h. Software shall be provided to configure and implement optimal start and stop programming based on existing indoor and outdoor environmental conditions as well as equipment operating history.

   i. Coordinate schedules with Owner.

6. Password:

   a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.

   b. Each user shall have the following: a user name (accept 24 characters minimum), a password (accept 12 characters minimum), and access levels.

   c. The system shall allow each user to change his or her password at will.

d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.

e. A minimum of six levels of access shall be supported individually or in any combination as follows:

1) Level 1 = View Data

2) Level 2 = Command

3) Level 3 = Operator Overrides

4) Level 4 = Database Modification

5) Level 5 = Database Configuration

6) Level 6 = All privileges, including Password Add/Modify

f. A minimum of 100 unique passwords shall be supported.

g. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.

h. Operators shall be further limited to only access, command, and modify those buildings, systems, and subsystems for which they have responsibility. Provide a minimum of 100 categories of systems to which individual operators may be assigned.

i. The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

7. Screen Manager:

a. The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

8. Dynamic Color Graphics:

a. The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.

b. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.

1) The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

c. Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:

1) All graphics shall be fully scalable

2) The graphics shall support a maintained aspect ratio.

3) Multiple fonts shall be supported.

4) Unique background shall be assignable on a per graphic basis.

5) The color of all animations and values on displays shall indicate the status of the object attribute.

6) Graphics that represent buildings or systems shall allow natural links and transitions between related detailed tabular views of data that compliment the graphic.

d. Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment directly from the graphic.

e. Floor Plan graphics – The user interface shall provide graphic applications that summarize conditions on a floor. Floor plan graphics shall indicate thermal comfort using dynamic colors to represent zone temperature deviations from zone setpoint(s). Floor plan graphics shall display overall metrics for each zone in the floor.

f. Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

g. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.

1) The graphic editing tool shall provide a library of standard HVAC equipment, floor plan, lighting, security and network symbols.

2) The graphic editing tool shall provide for the creation and positioning of library symbols by dragging from tool bars or drop-downs and positioning where required.

3) The graphics editing tool shall permit the importing of AutoCAD drawings for use in the system.

4) The graphic editing tool shall be able to add additional content to any graphic by importing images in the SVG, PNG or JPG file formats.

5) Provide color graphics with flow diagrams for each system and each piece of equipment complete with set points, measured

values, point identification, min/max allowable set points, status, modes, alarms, safeties and positions.

9. Historical Trending And Data Collection:

   a. Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:

      1) Any point, physical or calculated, may be designated for trending. Two methods of collection shall be allowed:

         a) Defined time interval

         b) Upon a change of value

      2) Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

   b. Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis.

   c. The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in SQL database format.

10. Trend Data Viewing and Analysis:

   a. Provide a trend viewing utility that shall have access to all database points.

   b. It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.

   c. The trend viewing utility shall have the capability to define trend study displays to include multiple trends

   d. Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.

   e. Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.

   f. Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.

   g. The Display shall support the user's ability to change colors, sample sizes, and types of markers.

11. Database Management:

a. Where a separate SQL database is utilized for information storage the System shall provide a Database Manager that separates the database monitoring and managing functions by supporting two separate windows.

b. Database secure access shall be accomplished using standard SQL authentication including the ability to access data for use outside of the Building Automation application.

c. The database managing function shall include summarized information on trend, alarm, event, and audit for the following database management actions:

1) Backup

2) Purge

3) Restore

d. The Database Manager shall support four tabs:

1) Statistics – shall display Database Server information and Trend, Alarm (Event), and Audit information on the Metasys Databases.

2) Maintenance – shall provide an easy method of purging records from the Metasys Server trend, alarm (event), and audit databases by supporting separate screens for creating a backup prior to purging, selecting the database, and allowing for the retention of a selected number of day's data.

3) Backup – Shall provide the means to create a database backup file and select a storage location.

4) Restore – shall provide a restricted means of restoring a database by requiring the user to log into an Expert Mode in order to view the Restore screen.

e. The Status Bar shall appear at the bottom of all Metasys Database Manager Tabs and shall provide information on the current database activity. The following icons shall be provided:

1) Ready

2) Purging Record from a database

3) Action Failed

4) Refreshing Statistics

5) Restoring database

6) Shrinking a database

7) Backing up a database

8) Resetting internet information Services

9) Starting the Metasys Device Manager

10) Shutting down the Metasys Device Manager

11) Action successful

f. The Database Manager monitoring functions shall be accessed through the Monitoring Settings window and shall continuously read database information once the user has logged in.

g. The System shall provide user notification via taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.

h. The Monitoring Settings window shall have the following sections:

1) General – Shall allow the user to set and review scan intervals and start times.

2) Email – Shall allow the user to create and review e-mail and phone text messages to be delivered when a Warning or Alarm is generated.

3) Warning – shall allow the user to define the Warning limit parameters, set the Reminder Frequency, and link the e-mail message.

4) Alarm – shall allow the user to define the Alarm limit parameters, set the Reminder Frequency, and link the e-mail message.

5) Database login – Shall protect the system from unauthorized database manipulation by creating a Read Access and a Write Access for each of the Trend, Alarm (Event) and Audit databases as well as an Expert Mode required to restore a database.

i. The Monitoring Settings Taskbar shall provide the following informational icons:

1) Normal – Indicates by color and size that all databases are within their limits.

2) Warning - Indicates by color and size that one or more databases have exceeded their Warning limit.

3) Alarm - Indicates by color and size that one or more databases have exceeded their Alarm limit.

j. The System shall provide user notification via Taskbar icons and e-mail messages when a database value has exceeded a warning or alarm limit.

## 2.04 NETWORK AUTOMATION ENGINES (NAE)

A. Network Automation Engine (NAE 55XX):

1. The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines. All controllers shall be located within NEMA 4 enclosures and shall be provided with battery backup, a minimum of 100 hours for complete system, including RAM without interruption with automatic battery charger.

2. Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.

3. User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.

    a. The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.

    b. The NAE shall support up a minimum of four (4) concurrent users.

    c. The web based user shall have the capability to access all system data through one NAE.

    d. Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.

    e. Systems that require the user to address more than one NAE to access all system information are not acceptable.

    f. The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.

    g. Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.

    h. The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:

        1) Configuration

        2) Commissioning

        3) Data Archiving

        4) Monitoring

        5) Commanding

        6) System Diagnostics

    i. Systems that require workstation software or modified web browsers are not acceptable.

j. The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

4. Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.

5. Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

6. Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.

7. The NAE shall include troubleshooting LED indicators to identify the following conditions:

   a. Power - On/Off

   b. Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic

   c. Ethernet Connection Speed – 10 Mbps/100 Mbps/1000 Mbps

   d. FC Bus A – Normal Communications/No Field Communications

   e. FC Bus B – Normal Communications/No Field Communications

   f. Peer Communication – Data Traffic between NAE Devices

   g. Run – NAE Running/NAE in Startup/NAE Shutting Down/Software Not Running

   h. Bat Fault – Battery Defective, Data Protection Battery Not Installed

   i. 24 VAC – 24 VAC Present/Loss Of 24VAC

   j. Fault – General Fault

   k. Modem RX – NAE Modem Receiving Data

   l. Modem TX – NAE Modem Transmitting Data

8. Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

   a. Two (2) USB port

   b. Two (2) URS-232 serial data communication port

   c. Two (2) RS-485 port

   d. One (1) Ethernet port

9. Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

10. Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

    a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.

    b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

11. Certification – The NAE shall be listed by Underwriters Laboratories (UL).

12. Controller network – The NAE shall support the following communication protocols on the controller network:

    a. The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

        1) The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

        2) The NAE shall be tested and certified as a BACnet Building Controller (B-BC).

        3) A BACnet Protocol Implementation Conformance Statement shall be provided for the NAE.

        4) The Conformance Statements shall be submitted 10 days prior to bidding.

        5) The NAE shall support a minimum of 100 control devices.

    b. The NAE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10.

        1) All LonWorks controls devices shall be LonMark certified.

        2) The NAE shall support a minimum of 255 LonWorks enabled control devices.

    c. The NAE shall support the Johnson Controls N2 Field Bus.

        1) The NAE shall support a minimum of 100 N2 control devices.

        2) The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.

        3) The Bus shall employ a master/slave protocol where the NAE is the master.

4) The Bus shall employ a four (4) level priority system for polling frequency.

5) The Bus shall be optically isolated from the NAE.

6) The Bus shall support the Metasys Integrator System.

2.05 DDC SYSTEM CONTROLLERS

A. Field Equipment Controller (FEC X611):

1. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.

a. The FEC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

1) The FEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

2) The FEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

3) A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.

4) The Conformance Statement shall be submitted 10 days prior to bidding.

b. Each FEC shall have at least 20% spare input/output capacity for future use.

2. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

3. Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable. The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

4. The FEC shall include troubleshooting LED indicators to identify the following conditions:

a. Power On

b. Power Off

c. Download or Startup in progress, not ready for normal operation

d. No Faults

e. Device Fault

f. Field Controller Bus - Normal Data Transmission

g. Field Controller Bus - No Data Transmission

h. Field Controller Bus - No Communication

i. Sensor-Actuator Bus - Normal Data Transmission

j. Sensor-Actuator Bus - No Data Transmission

k. Sensor-Actuator Bus - No Communication

5. The FEC shall accommodate the direct wiring of analog and binary I/O field points.

6. The FEC shall support the following types of inputs and outputs:

   a. Universal Inputs - shall be configured to monitor any of the following:

      1) Analog Input, Voltage Mode

      2) Analog Input, Current Mode

      3) Analog Input, Resistive Mode

      4) Binary Input, Dry Contact Maintained Mode

      5) Binary Input, Pulse Counter Mode

   b. Binary Inputs - shall be configured to monitor either of the following:

      1) Dry Contact Maintained Mode

      2) Pulse Counter Mode

   c. Analog Outputs - shall be configured to output either of the following:

      1) Analog Output, Voltage Mode

      2) Analog Output, current Mode

   d. Binary Outputs - shall output the following:

      1) 24 VAC Triac

   e. Configurable Outputs - shall be capable of the following:

      1) Analog Output, Voltage Mode

      2) Binary Output Mode

7. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).

   a. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.

   b. The FC Bus shall support communications between the FECs and the NAE.

c. The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.

d. The FC Bus shall support a minimum of 100 IOMs and FECs in any combination.

e. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.

8. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).

a. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard Protocol SSPC-135, Clause 9.

b. The SA Bus shall support a minimum of 10 devices per trunk.

c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.

9. The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.

10. The FEC shall support, but not be limited to, the following applications:

a. Heating central plant applications

b. Built-up air handling units for special applications

c. Terminal & package units

d. Special programs as required for systems control

2.06 FIELD DEVICES

A. Input/Output Module (IOM X711):

1. The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.

2. The IOM shall communicate with the FEC over the FC Bus or the SA Bus.

3. The IOM shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

a. The IOM shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

b. The IOM shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

c. A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.

d. The Conformance Statement shall be submitted 10 days prior to bidding.

4. The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

5. The IOM shall have a minimum of 4 points to a maximum of 17 points.

6. The IOM shall support the following types of inputs and outputs:

   a. Universal Inputs - shall be configured to monitor any of the following:

      1) Analog Input, Voltage Mode

      2) Analog Input, Current Mode

      3) Analog Input, Resistive Mode

      4) Binary Input, Dry Contact Maintained Mode

      5) Binary Input, Pulse Counter Mode

   b. Binary Inputs - shall be configured to monitor either of the following:

      1) Dry Contact Maintained Mode

      2) Pulse Counter Mode

   c. Analog Outputs - shall be configured to output either of the following:

      1) Analog Output, Voltage Mode

      2) Analog Output, current Mode

   d. Binary Outputs - shall output the following:

      1) 24 VAC Triac

   e. Configurable Outputs - shall be capable of the following:

      1) Analog Output, Voltage Mode

      2) Binary Output Mode

7. The IOM shall include troubleshooting LED indicators to identify the following conditions:

   a. Power On

   b. Power Off

   c. Download or Startup in progress, not ready for normal operation

   d. No Faults

   e. Device Fault

   f. Normal Data Transmission

g. No Data Transmission

h. No Communication

B. Networked Thermostat (TEC 26X6):

1. The networked thermostat shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters or other similar equipment.

2. The TEC shall communicate over the Field Controller Bus (FC) using BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.

3. The TEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

a. The TEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

b. A BACnet Protocol Implementation Conformance Statement shall be provided for the TEC.

c. The Conformance Statement shall be submitted 10 days prior to bidding.

4. The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interfaceable through a Network Automation Engine.

5. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.

a. Two line, 8 character backlit display.

b. LED indicators for Fan, Heat, and Cool status.

c. Five (5) User Interface Keys:

1) Mode

2) Fan

3) Override

4) Degrees C/F

5) Up/Down

d. The display shall continuously scroll through the following parameters:

1) Room Temperature

2) System Mode

3) Schedule Status – Occupied/Unoccupied/Override

4) Applicable Alarms

6. The Networked Thermostat shall provide the flexibility to support any one of the following inputs:

    a. Integral Indoor Air Temperature Sensor

    b. Duct Mount Air Temperature Sensor

    c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator

    d. Two configurable binary inputs

7. The Networked Thermostat shall provide the flexibility to support any one of the following outputs:

    a. Three Speed Fan Control

    b. Two On/Off

    c. Two Floating

    d. Two Proportional (0 to 10V)

8. The Networked Thermostat shall provide a minimum of six (6) levels of keypad lockout.

9. The Networked Thermostat shall provide the flexibility to adjust the following parameters:

    a. Adjustable Temporary Occupancy from 0 to 24 hours

    b. Adjustable heating/cooling deadband from 2° F to 5° F

    c. Adjustable heating/cooling cycles per hour from 4 to 8

10. Where required by application and indicated on plans or room schedules provide the Networked Thermostat with an integral Passive Infra-Red (PIR) occupancy sensor.

11. The Networked Thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

C. Networked Thermostat (TEC 26X7):

1. The Networked Thermostat shall be capable of controlling a pressure ~~dependant~~ **independent** Variable Air Volume System or other similar zoning type systems employing reheat including local hydronic reheat valves.

2. The Networked Thermostat shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.

3. The TEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

    a. The TEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

b. A BACnet Protocol Implementation Conformance Statement shall be provided for the TEC.

c. The Conformance Statement shall be submitted 10 days prior to bidding.

4. The Networked Thermostat shall be capable of remote read/write and parameter adjustment from the web based User Interface (UI) through an NAE.

5. The Networked Thermostat shall include an intuitive UI providing plain text messages.

   a. Two line, 8 character backlit display

   b. LED indicators for Heating, and cooling status

   c. Three (3) User Interface Keys

      1) Override

      2) Up

      3) Down

   d. The display shall continuously scroll through the following parameters:

      1) Room Temperature

      2) System Mode

      3) Schedule Status – Occupied/Unoccupied/Override

      4) Applicable Alarms

6. The Networked Thermostat shall provide the flexibility to support any one of the following inputs:

   a. Integral Indoor Air Temperature Sensor

   b. Duct Mount Air Temperature Sensor

   c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator

   d. Two configurable binary inputs

7. The Networked Thermostat shall provide the flexibility to support either of the following outputs:

   a. Two On/Off or Floating

   b. Two Proportional (0 to 10V)

8. The Networked Thermostat shall provide a minimum of six (6) levels of keypad lockout.

9. The Networked Thermostat shall provide the flexibility to adjust the following parameters:

    a. Adjustable Temporary Occupancy from 0 to 24 hours

    b. Adjustable heating/cooling deadband from 2º F to 5º F

    c. Adjustable heating/cooling cycles per hour from 4 to 8

10. The Networked Thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

D. VAV Modular Assembly (VMA 16X0):

1. The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.

2. The VMA shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

    a. The VMA shall be tested and certified as a BACnet Application Specific Controller (B-ASC).

    b. A BACnet Protocol Implementation Conformance Statement shall be provided for the VMA.

    c. The Conformance Statement shall be submitted 10 days prior to bidding.

3. The VAV Modular Assembly shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.

4. The VAV Modular Assembly shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.

5. The VAV Modular Assembly shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.

6. The VAV Modular Assembly shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

7. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.

8. The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.

9. Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.

10. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.

11. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.

12. The controller shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.

13. Control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.

14. The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.

15. The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

16. The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain ("K" factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.

17. Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop's sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.

    a. Absolute temperature loop error

    b. Signed temperature loop error

    c. Absolute airflow loop error

    d. Signed airflow loop error

    e. Average damper actuator duty cycle

18. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

    a. Unreliable space temperature sensor

    b. Unreliable differential pressure sensor

    c. Starved box

    d. Actuator stall

e. Insufficient cooling

f. Insufficient heating

19. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information shall alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

20. The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow Based on the percent of outdoor air in the primary air stream.

21. The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

22. Inputs:

    a. Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

        1) 0-10 VDC Sensors

        2) 1000ohm RTDs

        3) NTC Thermistors

    b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input "bouncing."

    c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

    d. Provide side loop application for humidity control.

23. Outputs:

    a. Analog outputs shall provide the following control outputs:

        1) 0-10 VDC

    b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.

    c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

24. Application Configuration:

    a. The VAV Modular Assembly shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.

25. Sensor Support:

a. The VAV Modular Assembly shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.

b. The VMA shall support an LCD display room sensor.

c. The VMA shall also support standard room sensors as defined by analog input requirements.

d. The VMA shall support humidity sensors defined by the AI side loop.

E. Network Sensors (NS-XXX-700X):

1. The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:

a. Zone Temperature

b. Zone Humidity

c. Zone Setpoint

d. Discharge Air Temperature

e. Zone $CO_2$

2. The NS shall transmit the information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.

3. The NS shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.

a. The NS shall be tested and certified as a BACnet Smart Sensors (B-SS).

b. A BACnet Protocol Implementation Conformance Statement shall be provided for the NS.

c. The Conformance Statement shall be submitted 10 days prior to bidding.

4. The Network Zone Temperature Sensors shall include the following items:

a. A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint

b. An LED to indicate the status of the Override feature

c. A button to toggle the temperature display between Fahrenheit and Celsius

d. A button to program the display for temperature or humidity

e. A button to initiate a timed override command

f. Available in either surface mount, wall mount, or flush mount

g. Available with either screw terminals or phone jack

5. The Network Discharge Air Sensors shall include the following:

   a. 4 inch or 8 inch duct insertion probe

   b. 10 foot pigtail lead

   c. Dip Switches for programmable address selection

   d. Ability to provide an averaging temperature from multiple locations

   e. Ability to provide a selectable temperature from multiple locations

6. The Network $CO_2$ Zone Sensors shall include the following:

   a. Available in either surface mount or wall mount

   b. Available with screw terminals or phone jack

2.07 SYSTEM TOOLS

A. System Configuration Tool (SCT):

1. The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Automation Engine (NAE) or a Network Integration Engine (NIE).

2. The configuration tool shall provide an archive database for the configuration and application data.

3. The configuration tool shall have the same look-and-feel at the User Interface (UI) regardless of whether the configuration is being done online or offline.

4. The configuration tool shall include the following features:

   a. Basic system navigation tree for connected networks

   b. Integration of Metasys N1, LonWorks, and BACnet enabled devices

   c. Customized user navigation trees

   d. Point naming operating parameter setting

   e. Graphic diagram configuration

   f. Alarm and event message routing

   g. Graphical logic connector tool for custom programming

   h. Downloading, uploading, and archiving databases

5. The configuration tool shall have the capability to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:

   a. BACnet Devices

b. LonWorks devices

c. N2 Bus devices

d. Metasys N1 networks

6. The configuration tool shall be capable of programming the Field Equipment Controllers.

a. The configuration tool shall provide the capability to configure, simulate, and commission the Field Equipment Controllers.

b. The configuration tool shall allow the FECs to be run in Simulation Mode to verify the applications.

c. The configuration tool shall contain a library of standard applications to be used for configuration.

7. The configuration tool shall be capable of programming the field devices.

a. The configuration tool shall provide the capability to configure, simulate, and commission the field devices.

b. The configuration tool shall allow the field devices to be run in Simulation Mode to verify the applications.

c. The configuration tool shall contain a library of standard applications to be used for configuration

2.08 OPERATOR WORKSTATION

A. Manufacturers: Subject to requirements of the specification, provide the following manufacturer's products by one of the following or approved equal:

1. Dell

2. HP

B. Furnish materials in accordance with IBC-NJ.

C. Workstation shall be located in a lockable cabinet manufactured by Hoffman. Controls contractor shall provide cabinet. Submit cabinet for approval.

D. Furnish each operator workstation consisting of the following:

1. Personal Computer: IBM PC compatible with sufficient memory and hard drive storage to support graphics, reports and communication requirements. Furnish with the following minimum configuration requirements:

a. Processor: Quad Core I 7.

b. Hard Drive: 256 Gigabyte SSD.

c. Memory: 12 Gigabyte DDR SDRAM.

d. Drive 1: 48x CD Burner, DVD combination.

e. Drive 2: 16x DVD-ROM, DVD combination.

f. Modem: Auto-dial telephone, 56,000 baud.

g. Ports: Required serial, parallel, network communications, USB, and cables for proper system operation.

h. Expansion Slots: 1 used for LAN card, 1 available.

i. LAN Card: EtherNet - RJ45 (100 base-T minimum).

j. Mouse: two-button optical type, wireless.

k. Keyboard: 104 key.

2. Monitor: Minimum of 17 inch (432 mm) color, flat panel LCD display.

3. Operating System: Windows XP.

4. Printer: Furnish each operator workstation with laser printer and associated cables. Printer capable of minimum of 25 pages per minute (PPM) operation and compatible with standard parallel or USB communications or network capable.

5. System Support: Minimum ten (10) work stations connected to multi-user, multi-tasking environment with concurrent capability to:

a. Access DDC network.

b. Access or control same control unit.

c. Access or modify same control unit database.

d. Archive data, alarms, and network actions to hard disk regardless of what application programs are being currently executed.

e. Develop and edit database.

f. Implement and tune DDC control.

g. Develop graphics.

h. Control facility.

E. Workstation shall be located in a lockable cabinet manufactured by Hoffman. Controls contractor to provide cabinet. Submit for approval.

2.09 PORTABLE OPERATOR'S TERMINAL

A. Manufacturers: Subject to requirements of the specification, provide the following manufacturer’s products by one of the following or approved equal:

1. Dell Corporation.

2. HP.

B. Furnish device capable of accessing system data and capable of being connected to any point on system network or connected directly to any controller for programming, set-up, and troubleshooting. Portable Operators Terminal uses Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE Standard 135, to communicate with BACnet objects in internetwork. Objects supported include: Analog input, analog output, analog value, binary input, binary output, binary value, device.

C. Furnish IBM compatible notebook-style PC including software and hardware required with:

1. Processor: Quad Core I 7.

2. Hard Drive: 256 Gigabyte SSD.

3. Memory: 8 Gigabyte DDR SDRAM.

4. Drive 1: 48x CD Burner, DVD combination.

5. Drive 2: 16x DVD-ROM, DVD combination.

6. Modem: Auto-dial telephone, 56,000 baud.

7. Ports: Required serial, parallel, network communications, USB, and cables for proper system operation.

8. Expansion Slots: 1 used for LAN card, 1 available.

9. LAN Card: EtherNet - RJ45 (100 base-T minimum).

10. Mouse: two-button optical type wireless.

11. Keyboard: 104 key.

D. Automatic Restart: Automatically start field equipment on restoration of power. Furnish time delay between individual equipment restart and time of day start/stop.

2.10 LOAD CONTROL PROGRAMS

A. General: Support inch-pounds and S.I. metric units of measurement.

B. Demand Limiting:

1. Monitor total power consumption for each power meter and shed associated loads automatically to reduce power consumption to an operator set maximum demand level.

2. Input: Pulse count from incoming power meter connected to pulse accumulator in control unit.

3. Forecast demand (kW): Predicted by sliding window method.

4. Automatically shed loads throughout the demand interval selecting loads with independently adjustable on and off time of between one and 255 minutes.

5. Demand Target: Minimum of 3 for each demand meter; change targets based upon (1) time, (2) status of pre-selected points, or (3) temperature.

6. Load: Assign load shed priority, minimum "ON" time and maximum "OFF" time.

7. Limits: Include control band (upper and lower limits).

8. Output advisory when loads are not available to satisfy required shed quantity, advise shed requirements and requiring operator acknowledgment.

C. Duty Cycling:

1. Periodically stop and start loads, based on space temperature, and according to various On/Off patterns.

2. Modify off portion of cycle based on operator specified comfort parameters. Maintain total cycle time by increasing on portion of cycle by equal quantity off portion is reduced.

3. Set and modify following parameters for each individual load:

a. Minimum and maximum off time.

b. On/Off time in one-minute increments.

c. Time period from beginning of interval until cycling of load.

d. Manually override the DDC program and place a load in an On or Off state.

e. Cooling Target Temperature and Differential.

f. Heating Target Temperature and Differential.

g. Cycle off adjustment.

D. Automatic Time Scheduling:

1. Self-contained programs for automatic start/stop/scheduling of building loads.

2. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary day schedules.

3. Special day's schedule supporting up to 30 unique date/duration combinations.

4. Number of loads assigned to time program; with each load having individual time program.

5. Each load assigned at least 16 control actions for each day with 1 minute resolution.

6. Furnish the following time schedule operations:

a. Start.

b. Optimized Start.

c. Stop.

d. Optimized Stop.

e. Cycle.

f. Optimized Cycle.

7. Capable of specifying minimum of 30 holiday periods up to 100 days in length for the year.

8. Create temporary schedules.

9. Broadcast temporary "special day" date and duration.

E. Start/Stop Time Optimization:

1. Perform optimized start/stop as function of outside conditions, inside conditions, or both.

2. Adaptive and self-tuning, adjusting to changing conditions unattended.

3. For each point under control, establish and modify:

a. Occupancy period.

b. Desired temperature at beginning of occupancy period.

c. Desired temperature at end of occupancy period.

F. Night Setback/Setup Program: Reduce heating space temperature set point or raise cooling space temperature set-point during unoccupied hours; in conjunction with scheduled start/stop and optimum start/stop programs.

G. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.

1. Employ arithmetic, algebraic, Boolean, and special function operations.

2. Treat calculated values like any other analog value; use for any function where a "hard wired point" might be used.

H. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.

1. Define time interval between each control action between 0 to 3600 seconds.

2. Output may be analog value.

3. Provide for "skip" logic.

4. Verify completion of one action before proceeding to next action. When not verified, program capable of skipping to next action.

I. Direct Digital Control: Furnish with each control unit Direct Digital Control software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.

1. Control loops: Defined using "modules" are analogous to standard control devices.

2. Output: Paired or individual digital outputs for pulse width modulation, and analog outputs.

3. Firmware:

a. PID with analog or pulse-width modulation output.

b. Floating control with pulse-width modulated outputs.

c. Two-position control.

d. Primary and secondary reset schedule selector.

e. Hi/Low signal selector.

f. Single pole double-throw relay.

g. Single pole double throw time delay relay with delay before break, delay before make and interval time capabilities.

4. Direct Digital Control loop: Downloaded upon creation or on operator request. On sensor failure, program executes user defined failsafe output.

5. Display: Value or state of each of lines interconnecting DDC modules.

J. Fine Tuning Direct Digital Control PID or floating loops:

1. Display information:

a. Control loop being tuned.

b. Input (process) variable.

c. Output (control) variable.

d. Set-point of loop.

e. Proportional band.

f. Integral (reset) Interval.

g. Derivative (rate) Interval.

2. Display format: Graphic, with automatic scaling; with input and output variable superimposed on graph of "time" versus "variable".

K. Trend logging:

1. Each control unit capable of storing samples of control unit's data points.

2. Update file continuously at operator assigned intervals.

3. Automatically initiate upload requests and then stores data on hard disk.

4. Time synchronize sampling at operator specified times and intervals with sample resolution of one minute.

5. Co-ordinate sampling with specified on/off point- state.

6. Display trend samples on workstation in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time versus data.

2.11 HVAC CONTROL PROGRAMS

A. General:

1. Support Inch-pounds and S.I. metric units of measurement.

2. Identify each Control system.

B. Optimal Run Time:

1. Control start-up and shutdown times of equipment for both heating and cooling.

2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.

3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.

4. Use outside air temperature to determine early shut down with ventilation override.

5. Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.

6. Operator commands:

a. Define time schedule.

b. Add/delete fan status point.

c. Add/delete outside air temperature point.

d. Add/delete mass temperature point.

e. Define heating/cooling parameters.

f. Define mass sensor heating/cooling parameters.

g. Lock/unlock program.

h. Request optimal run-time control summary.

i. Request optimal run-time mass temperature summary.

j. Request point summary.

k. Request saving profile summary.

7. Control Summary:

a. Control system begin/end status.

b. Optimal run time lock/unlock control status.

c. Heating/cooling mode status.

d. Optimal run time schedule.

e. Start/Stop times.

f. Selected mass temperature point ID.

g. Optimal run-time system normal start-times.

h. Occupancy and vacancy times.

i. Optimal run time system heating/cooling mode parameters.

8. Mass Temperature Summary:

a. Mass temperature point type and ID.

b. Desired and current mass temperature values.

c. Calculated warm-up/cool-down time for each mass temperature.

d. Heating/cooling season limits.

e. Break point temperature for cooling mode analysis.

9. Point summary:

a. Control system identifier and status.

b. Point ID and status.

c. Outside air temperature point ID and status.

d. Mass temperature point ID and status.

e. Calculated optimal start and stop times.

f. Period start.

C. Supply Air Reset:

1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.

2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:

a. Raising cooling temperatures to highest possible value.

b. Reducing heating temperatures to lowest possible level.

3. Operator Commands:

a. Add/delete fan status point.

b. Lock/unlock program.

c. Request point summary.

d. Add/Delete discharge controller point.

e. Define discharge controller parameters.

f. Add/delete air flow rate.

g. Define space load and load parameters.

h. Request space load summary.

4. Control Summary:

a. Control system status (begin/end).

b. Supply air reset system status.

c. Optimal run time system status.

d. Heating and cooling loop.

e. High/low limits.

f. Deadband.

g. Response timer.

h. Reset times.

5. Space Load Summary:

a. System status.

b. Optimal run time status.

c. Heating/cooling loop status.

d. Space load point ID.

e. Current space load point value.

f. Control heat/cool limited.

g. Gain factor.

h. Calculated reset values.

i. Fan status point ID and status.

j. Control discharge temperature point ID and status.

k. Space load point ID and status.

l. Airflow rate point ID and status.

D. Static Pressure Reset:

1. Monitor static pressure in supply and exhaust air system and corresponding VAV box position.

2. Reduce static pressure setpoint and resultant fan speed to utilize minimum fan energy.

E. Enthalpy Switchover:

1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.

2. Operator Commands:

a. Add/delete fan status point.

b. Add/delete outside air temperature point.

c. Add/delete discharge controller point.

d. Define discharge controller parameters.

e. Add/delete return air temperature point.

f. Add/delete outside air dewpoint/humidity point.

g. Add/delete return air dewpoint/humidity point.

h. Add/delete damper switch.

i. Add/delete minimum outside air.

j. Add/delete atmospheric pressure.

k. Add/delete heating override switch.

l. Add/delete evaporative cooling switch.

m. Add/delete air flow rate.

n. Define enthalpy deadband.

o. Lock/unlock program.

p. Request control summary.

q. Request HVAC point summary.

3. Control Summary:

a. HVAC control system begin/end status.

b. Enthalpy switchover optimal system status.

c. Optimal return time system status.

d. Current outside air enthalpy.

e. Calculated mixed air enthalpy.

f. Calculated cooling cool enthalpy using outside air.

g. Calculated cooling cool enthalpy using mixed air.

h. Calculated enthalpy difference.

i. Enthalpy switchover deadband.

j. Status of damper mode switch.

F. Freeze protection.

G. Smoke Control.

2.12 PROGRAMMING APPLICATION FEATURES

A. Trend Point:

1. Sample up to 50 points, real or computed, with each point capable of collecting 10,000 samples at intervals specified in minutes, hours, days, or month.

2. Output trend logs as line-graphs or bar graphs. Output graphic on terminal, with each point for line and bar graphs designated with a unique color, vertical scale either actual values or percent of range, and horizontal scale time base. Print trend logs up to 12 columns of one point/column.

B. Alarm Messages:

1. Allow definition of minimum of 100 messages, each having minimum length of 100 characters for each individual message.

2. Assign alarm messages to system messages including point's alarm condition, point's off-normal condition, totaled point's warning limit, hardware elements advisories.

3. Output assigned alarm with "message requiring acknowledgment".

4. Operator commands include define, modify, or delete; output summary listing current alarms and assignments; output summary defining assigned points.

C. Weekly Scheduling:

1. Automatically initiate equipment or system commands, based on selected time schedule for points specified.

2. Program times for each day of week, for each point, with one minute resolution.

3. Automatically generate alarm output for points not responding to command.

4. Allow for holidays, minimum of 366 consecutive holidays.

5. Operator Commands:

    a. System logs and summaries.

    b. Start of stop point.

    c. Lock or unlock control or alarm input.

    d. Add, delete, or modify analog limits and differentials.

    e. Adjust point operation position.

    f. Change point operational mode.

    g. Open or close point.

    h. Enable/disable, lock/unlock, or execute interlock sequence or computation profile.

    i. Begin or end point totals.

    j. Modify total values and limits.

    k. Access or secure point.

    l. Begin or end HVAC or load control system.

    m. Modify load parameter.

    n. Modify demand limiting and duty cycle targets.

6. Output summary: Listing of programmed function points, associated program times, and respective day of week programmed points by software groups or time of day.

D. Interlocking:

1. Permit events to occur, based on changing condition of one or more associated master points.

2. Binary contact, high/low limit of analog point or computed point capable of being used as master. Master capable of monitoring or commanding multiple slaves.

3. Operator Commands:

    a. Define single master/multiple master interlock process.

    b. Define logic interlock process.

    c. Lock/unlock program.

d. Enable/disable interlock process.

e. Execute terminate interlock process.

f. Request interlock type summary.

E. Interface to World Wide Web:

1. Contractor shall provide all programming and interfaces as required to display and access all system features, including alarms, maintenance messages, graphics, etc. on the World Wide Web.

2. The central BMS console shall be arranged to monitor, control and supervise all system items specified in this section, remotely, via the World Wide Web, using secured network connections. Specific alarms as defined by the Owner shall be connected to the Campus Public Safety Network. Contractor shall be responsible for all software and hardware requirements, as required for a complete and operational system. Contractor shall be responsible for coordinating network interface requirements with the Owner.

3. Coordinate Uniform Resource Locator (URL) address name with Owner and provide all fees associated with obtaining rights to URL. Contractor shall be responsible for coordinating and obtaining Internet Service Provider.

2.13 INPUT DEVICES

A. General Requirements:

1. Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

B. Temperature Sensors:

1. General Requirements:

a. Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.

b. The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.

c. The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

| Point Type | Accuracy |
|---|---|
| Chilled Water | ± .5°F. |
| Room Temp | ± .5°F. |
| Duct Temperature | ± .5°F. |
| All Others | ± .75°F. |

2. Room Temperature Sensors with Integral Display

a. Room sensors shall be constructed for either surface or wall box mounting.

b. Room sensors shall have an integral LCD display and four button keypad with the following capabilities:

1) Display room and outside air temperatures.

2) Display and adjust room comfort setpoint.

3) Display and adjust fan operation status.

4) Timed override request push button with LED status for activation of after-hours operation.

5) Display controller mode.

6) Password selectable adjustment of setpoint and override modes.

3. Thermowells:

a. When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.

b. Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.

c. Thermo wells and sensors shall be mounted in a threadolet or 1/2" NFT saddle and allow easy access to the sensor for repair or replacement.

d. Thermo wells shall be constructed of 316 stainless steel.

4. Outside Air Sensors:

a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.

b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.

c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

5. Duct Mount Sensors:

a. Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.

b. Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

c. For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

d. Rigid or averaging type as indicated in sequence of operations. Averaging sensor minimum length: 5 feet (1.5 meters) in length.

e. Duct Cross Sections Greater Than 10 square feet (0.9 square meters): Furnish serpentine averaging element to sense stratified air temperatures.

6. Averaging Sensors:

a. For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

b. For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

c. Capillary supports at the sides of the duct shall be provided to support the sensing string.

7. Line Voltage Thermostats:

a. Integral manual On/Off/Auto selector switch, single or two-pole.

b. Dead band: Maximum 2 degrees F (one degree C).

c. Cover: Locking with set point adjustment and setpoint indication with thermometer.

d. Motor capacity rating.

8. Liquid immersion temperature:

| | |
|---|---|
| Temperature monitoring range | +30/250°F (-1°/121°C) |
| Output signal | Changing resistance |
| Accuracy at Calibration point | ±0.5°F (+/-0.3°C) |

9. Duct (single point) temperature:

| | |
|---|---|
| Temperature monitoring range | +20/120°F (-7°/49°C) |
| Output signal | Changing resistance |
| Accuracy at Calibration point | ±0.5°F (+/-0.3°C) |

10. Duct Average temperature:

| | |
|---|---|
| Temperature monitoring range | +20° ±120°F(-7°/+49°C) |
| Output signal | 4 – 20 mA DC |
| Accuracy at Calibration point | ±0.5°F (±03°C) |
| Sensor Probe Length | 25’ L (7.3m) |

11. Manufacturers: Johnson Controls, Setra.

C. Outdoor Reset Thermostat:

1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.

2. Scale range: -10 to 70 degrees F (2 to 35 degrees C).

D. Electric Low Limit Duct Thermostat:

1. Snap acting, single pole, single throw, automatic reset switch tripping when temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.

2. Bulb length: Minimum 20 feet (6 m).

3. Furnish one thermostat for every 20 sq. ft (1.86 sq m) of coil surface.

E. Electric High Limit Duct Thermostat:

1. Snap acting, single pole, single throw, automatic reset switch tripping when temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.

2. Bulb length: Minimum 20 feet (6 m).

3. Furnish one thermostat for every 20 sq. ft (1.86 sq m) of coil surface.

F. Humidity Sensors:

1. The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.

2. The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.

3. The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion, shall be 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.

4. Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.

5. A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

6. Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

7. Manufacturers: Johnson Controls, Veris Industries, and Mamac.

G. Temperature Transmitter - Water Side:

1. Transmitter shall provide a 4-20 ma DC output signal linear over calibrated temperature range.

2. Transmitter shall have the capability to adjust zero and span externally over the full range of the instrument.

3. Transmitter shall be capable of operating from -25°C to +85°C.

4. Transmitter output shall fail upscale on loss of sensor input.

5. Stability shall be ±0.20% of calibrated span for six months.

6. Accuracy (including linearity, repeatability, and hysteresis) shall be ±0.20% of calibrated span.

7. Transmitter shall be furnished with mounting bracket for mounting to a 2 inch pipe stand. Transmitter shall be capable to be pipe or panel mounted in any position with no effect upon operation.

8. Transmitter to be furnished complete with integrally mounted 100 Ohm Platinum RTD sensor.

H. Differential Temperature Transmitter - Water Side:

1. Transmitter shall provide a 4-20 ma DC output signal linear over calibrated temperature range.

2. Transmitter shall have the capability to adjust zero and span externally over the full range of the instrument.

3. Transmitter shall be capable of operating from -25°C to +85°C.

4. Transmitter output shall fail upscale on loss of sensor input.

5. Stability shall be ±0.20% of calibrated span for six months.

6. Accuracy (including linearity, repeatability, and hysteresis) shall be ±0.10% of calibrated span.

7. Transmitter shall be capable to be pipe or panel mounted in any position with no effect upon operation.

8. Transmitter to be furnished complete with two (2) 100 Ohm Platinum RTD sensors wired in compensation loop configuration. Johnson Yokagawa or approved equal.

9. Transmitter shall be furnished with mounting bracket for mounting to a 2 inch pipe stand.

I. Natural Gas Flow Meters:

1. Meters shall be clamp-on type similar to Parametrics with 4-20 mA and pulse output.

J. Differential Pressure Transmitters:

1. General Air and Water Pressure Transmitter Requirements:

a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

b. Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.

d. A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2. Low Differential Water Pressure Applications (0" - 20" w.c.)

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

1) .01-20" w.c. input differential pressure range.

2) 4-20 mA output.

3) Maintain accuracy up to 20 to 1 ratio turndown.

4) Reference Accuracy: +0.2% of full span.

c. Manufacturers: Setra and Mamac.

3. Medium to High Differential Water Pressure Applications (Over 21" w.c.):

a. The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:

1) Differential pressure range 10" w.c. to 300 PSI.

2) Reference Accuracy: $\pm$1% of full span (includes non-linearity, hysteresis, and repeatability).

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

c. Manufacturers: Setra and Mamac.

4. Building Differential Air Pressure Applications (-1" to +1" w.c.):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

1) -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)

2) 4-20 mA output.

3) Maintain accuracy up to 20 to 1 ratio turndown.

4) Reference Accuracy: +0.2% of full span.

c. Manufacturers: Johnson Controls and Setra.

5. Low Differential Air Pressure Applications (0" to 5" w.c.):

a. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

b. The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

1) (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)

2) 4-20 mA output.

3) Maintain accuracy up to 20 to 1 ratio turndown.

4) Reference Accuracy: +0.2% of full span.

c. Manufacturers: Johnson Controls and Setra.

6. Medium Differential Air Pressure Applications (5" to 21" w.c.):

a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:

1) Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.

2) Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.

3) Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).

b. Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

c. Manufacturers: Johnson Controls and Setra.

K. Flow Monitoring:

1. Air Flow Monitoring:

a. Outdoor Air Monitoring Systems:

1) General:

a) The outside air flow measuring system shall be capable of measuring outdoor air at low velocities.

2) Outdoor Air Flow/Temperature Measurement Devices:

a) Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

b) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.

c) Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

d) The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.

e) The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.

f) Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.

g) Devices using chip-in-glass or diode-case chip thermistors are not acceptable.

h) Devices using less than two thermistors in each sensor assembly are not acceptable.

i) Devices using platinum wire RTDs are not acceptable.

j) Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.

k) Pitot tubes and arrays are not acceptable.

l) Vortex shedding devices are not acceptable.

3) All Sensor Probes:

a) Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.

b) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).

c) Airflow accuracy shall be +/-2% of Reading over the entire operating airflow range.

(1) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.

d) Temperature accuracy shall be +/-0.15°F over the entire operating temperature range of -20°F to 160°F.

e) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).

f) Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.

g) Each sensor assembly shall not require matching to the transmitter in the field.

h) A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.

4) Duct And Plenum Probes:

a) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.

b) Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:

(1) Insertion mounted through the side or top of the duct

(2) Internally mounted inside the duct or plenum

(3) Standoff mounted inside the plenum

c) The number of sensor housings provided for each location shall be as follows:

| Duct or Plenum Area (sq.ft.) | Total # Sensors/Location |
|---|---|
| <2 | 4 |
| 2 to < 4 | 6 |
| 4 to < 8 | 8 |
| 8 to <16 | 12 |
| >=16 | 16 |

d) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5) Transmitters:

a) The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.

b) The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.

c) The transmitter shall have a power switch and operate on 24 VAC (isolation not required).

(1) The transmitter shall use a switching power supply fused and protected from transients and power surges.

(2) The transmitter shall use "watch-dog" circuitry to assure reset after power disruption, transients and brown-outs.

d) All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.

e) The operating temperature range for the transmitter shall be -20°F to 120°F. The transmitter shall be installed at a location that is protected from weather and water.

f) The transmitter shall be capable of communicating with the BMS using the following interface:

(1) Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire).

g) The transmitter shall be capable of accepting an infra-red interface card for downloading airflow and temperature data or uploading transmitter configuration data using a handheld PDA (Palm or Microsoft Windows Mobile operating systems).

(1) Provide PDA upload/download software.

(a) Download software shall be capable of displaying and saving individual sensor airflow rates, the average airflow rate, individual sensor temperatures and the average temperature received from the transmitter.

(b) Upload software shall be capable of displaying and saving all setup para-

meters that can be configured using the on-board pushbutton interface and LCD display.

(2) Provide a Microsoft Excel file capable of creating balance reports from PDA data files transferred to a Windows 98 or higher based PC.

(3) Provide a Microsoft Excel file to create configuration data files that can be transferred from a Windows 2000, Windows XP or higher based PC to a PDA for upload to one or more transmitters.

(4) The ATMD shall be UL listed as an entire assembly.

(5) The ATMD shall carry the CE Mark for European Union shipments.

(6) The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.

(7) A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

6) Installation:

a) Install airflow/temperature measurement devices in accordance with manufacturer's instructions at the locations indicated on the plans.

b) The mounting of the outdoor air probes shall be coordinated with the sheet metal contractor, in accordance with the manufacturer's recommendations.

c) A written report shall be submitted to the engineer confirming that the probes are installed in accordance with the manufacturer's recommendations.

d) Install electronic cables according to Division 26 requirements.

e) Install low-voltage power, signal and communication cable according to Division 26 requirements.

7) Adjusting:

a) Duct and plenum devices shall not be adjusted without approval from the engineer.

8) Manufacturers:

a) Subject to compliance with requirements of this Section, provide products that comply with this specification by one of the following vendors:

(1) EBTRON, Inc. Model GTx116-P (basis of design)

(2) Kurz Instraments

(3) Fluid Components International (FCI

b. Fan Inlet Air Flow Measuring Stations:

1) At the inlet of each fan and near the exit of the inlet sound trap, airflow sensors shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.

2) Each sensor shall be surface mount type. Unit shall be capable of monitoring and reporting the airflow and temperature at each fan inlet location through two or four sensing circuits. If a static pressure manifold is used, it shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm$ 20° in the approaching air stream.

3) Devices creating fan performance degradation, resulting in additional energy consumption, caused from pressure drop associated with probes or mounting apparatus in the center of the fan inlet are not allowed. The device shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Sensor circuit casings shall be constructed of U.L. 94 flame rated, high impact ABS and include a stainless steel thermistor cap that maintains the precise calibrated flow over the heated and ambient measurement points. Each sensor circuit shall consist of two ceramic base, glass encapsulated, thermistors for measuring ambient temperature and velocity. Circuit shall be designed for operation in a wide range of environments, including high humidity and rapid thermal cycling.

4) Manufacturers: Johnson Controls, Air Monitor Corp., Tek-Air Systems, Inc., or Dietrich Standard.

c. Duct Air Flow Measuring Stations (non-outdoor air applications):

1) Furnish and install an equalized air measuring probe system piped to a high performance pressure transducer or an electronic type airflow temperature measuring station.

2) Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.

3) Assembly shall be AMCA tested and capable of measuring a range from 70 to 5,000 FPM (22 to 1524 MPM).

4) Equalized air measuring assembly shall measure to ±3% average and consist of 6063T5 extruded aluminum step sensing blade(s) with anodized finish, plenum-rated polyethylene pressure tubing, brass barbed fittings, mounting hardware and a glass-on-silicone capacitance sensor pressure transducer capable of measuring up to six field-selectable pressure ranges up to 1 in. w.c.

5) The transducer shall be accurate to ±1% of full scale and be contained in a National Electrical Manufacturer's Association (NEMA) 4 (IP-65) enclosure. Transducer shall be factory mounted and piped to high and low pressure ports through fittings made of brass.

6) All sensor tubing shall terminate in solid brass barbed fittings.

7) Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.

8) Air straightener shall be provided for sizes over 17 square feet (1.6 sq meter).

9) Airflow measuring station assemblies shall be fabricated of galvanized steel or aluminum casing of appropriate thickness for slip fits or with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.

10) Equalized air measuring probe assemblies shall be, in all respects, equivalent to Johnson Controls® AD-1250 or AD-1251 airflow measuring systems.

11) Electronic air measuring station shall be capable of monitoring and reporting the airflow and temperature at each measuring location through one or more measuring probes containing multiple sensor points and a control transmitter that communicates with the BMS.

12) Probe(s) shall be constructed of an airfoil shaped aluminum extrusion containing the sensor circuit(s).

13) Each sensor circuit shall consist of coated thermistors, for temperature and velocity, mounted to a Printed Circuit Board (PCB).

14) Probe multiplexer circuit(s) shall include a microprocessor that collects data from each PCB and digitally communicates the average airflow and temperature of each probe to a microprocessor based control transmitter.

15) Multiplexer board shall be encased to prevent moisture damage.

16) Shielded CAT5e communications cable shall be Underwriters Laboratories Inc.® (UL) plenum-rated with RJ45 terminal connectors. Dust boot covers and gold-plated contacts shall link probes to electronic controller.

17) Control transmitter shall be capable of processing independent sensing points and shall operate on a fused 24 VAC supply.

18) Control transmitter shall feature a 16 x 2 character alphanumeric LCD screen, digital offset/gain adjustment, continuous performing sensor/transmitter diagnostics, and a visual alarm to detect malfunctions.

19) All electronic components of the assembly shall be Restriction of Hazardous Substances (RoHS) Directive compliant.

20) Installation Considerations:

a) The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .065" w.c. at 1000 feet per minute, or .23" w.c. at 2000 feet per minute. Each unit shall measure the airflow rate within an accuracy of plus 2% as determined by U.S. – GSA certification tests, and shall contain a minimum of one total pressure sensor per 36 square inches of unit measuring area.

b) Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

c) Where control dampers are shown as part of the airflow measuring station, parallel blade precision controlled volume dampers integral to the station and complete with actuator, and linkage shall be provided.

d) Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.

21) All air measuring devices shall be tested according to AMCA Standard 610

22) Manufacturers: Johnson Controls, Air Monitor Corp., Tek-Air, and Dietrich Standard.

d. Static Pressure Traverse Probe:

1) Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.

2) Manufacturers: Cleveland Controls

e. Shielded Static Air Probe:

1) A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.

2. Water Flow Monitoring:

a. Onicon Flow Measurement:

1) The hot water and chilled water flow measurement systems shall be a Onicon F-1210 Dual Turbine, or approved equal.

2) The flow measurement system shall run on a 115 VAC power source.

3) Accuracy shall be + 0.25% of actual value. Linearity shall be + 0.1% of actual value. Rangeability: 100 - 1.

4) Output shall be 4-20mA DC linear over calibrated range.

5) The flow measurement system shall be in accordance with the P&ID's.

b. Straight Run Requirements:

1) Manufacturer's recommendations shall be carefully adhered to with respect to straight run requirements to obtain specified accuracies.

2) Submit for approval, location of flow elements in piping clearly indicating upstream and downstream straight run dimensions.

c. Tagging:

1) Each flow element shall have a 1" x 2" stainless steel tag either permanently attached with screws or attached with a six inch chain.

2) The stainless steel tag shall have the tag number, design flow, and, when applicable, the differential pressure at design flow permanently engraved on its surface.

d. Manufacturers: Onicon.

3. Steam Flow Monitoring:

a. Stainless Steel Calibrated Orifice Plate rated for 300 psig with 4-20 mA transmitter with ±2% accuracy at full scale.

L. Freezestats:

1. Install freezestats for each hot water coil and provide protection for every square foot of coil surface area with one linear foot of element.

2. Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position. Provide manual reset.

3. Low limit freeze protection thermostats shall have 20' low point sensitive elements (not averaging type) installed to cover the entire coil face area. The elements shall be suspended at least 12" to 15" downstream of the preheater coil. These thermostats shall be 24 volt, two-position, manually reset type. Provide multiple freeze-stats to cover entire face of multi-coil banks. Every 20 square feet of coil requires one freeze-stat as minimum. Freezestats shall be hard wired.

M. Power Monitoring Devices:

1. Current Measurement (Amps):

a. Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.

b. Current Transformer – A split core current transformer shall be provided to monitor motor amps.

1) Operating frequency – 50 - 400 Hz.

2) Insulation – 0.6 Kv class 10Kv BIL.

3) UL recognized.

4) Five amp secondary.

5) Select current ration as appropriate for application.

6) Manufacturers: Veris Industries

c. Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

1) 6X input over amp rating for AC inrushes of up to 120 amps.

2) Manufactured to UL 1244.

3) Accuracy: +.5%, Ripple +1%.

4) Minimum load resistance 30kOhm.

5) Input 0-20 Amps.

6) Output 4-20 mA.

7) Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

8) Manufacturers: Veris Industries

N. Smoke Detectors:

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 26 for installation under Division 23. All wiring for air duct detectors shall be provided under Division 26, Fire Alarm System.

O. Status and Safety Switches:

1. General Requirements:

a. Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

2. Current Sensing Switches:

a. The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

b. Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

d. Manufacturers: Veris Industries.

3. Air Filter Status Switches:

a. Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.

b. A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

c. Provide appropriate scale range and differential adjustment for intended service.

d. Manufacturers: Johnson Controls, Cleveland Controls

4. Air Flow Switches:

a. Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

b. Manufacturers: Johnson Controls, Cleveland Controls

5. Air Pressure Safety Switches:

a. Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

b. Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

c. Manufacturers: Johnson Controls, Cleveland Controls.

6. Water Flow Switches:

a. Water flow switches shall be equal to the Johnson Controls P74.

7. Low Temperature Limit Switches:

a. The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

b. The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.

c. For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

d. The low temperature limit switch shall be equal to Johnson Controls A70.

8. Carbon Dioxide Sensors:

a. Sensors designed for indoor carbon dioxide levels in accordance with ASHRAE Standard 62.

b. 4 to 20 ma. linear output over range of 0 to 2000 ppm (0 to 2000 mg/kg) of carbon dioxide for interface to DDC control system.

c. For duct mounted sensors furnish airtight enclosure complete with sampling tube.

9. Oxygen Sensor and Transmitter: Single detectors, using solid-state zircon cell sensing, suitable over temperature range of minus 32 to 1100 degrees F (0 to 590 degrees C), calibrated for 0 to 5 percent, with continuous or averaged reading, 4 to 20 mA output, wall mounted.

P. Digital Energy Monitors:

1. Provide three phase digital watt-meters with pre-wired CTs. All watt-meter electronics shall be housed within the CTs. CTs shall include sizes capable of mounting directly on a power bus. Diagnostics visible to the installing electrician (without a operator tool) shall indicate: proper operation, mis-wiring or low power-factor, device malfunction, and over-load condition. The meters shall include the following:

a. The device shall be UL Listed, and shall comply with ANSI C12.1 accuracy specification. The minimum CT/meter combined accuracy shall be no greater than 1% of reading over the range of 5% to 100% of rated load. The meter shall not require calibration

b. The wattmeter shall directly connect to power from 208 through 480 with no potential transformer. In-line fuses for each voltage tap phase shall be included.

c. The wattmeter CTs shall be split-core and at minimum be sized to accommodate loads ranging from 100 to 2400 Amps. The CTs shall be volt-signal type, and shall not require shorting blocks.

d. The wattmeter shall reside directly on the Floor Level Network along with other FLN devices. Data transferred shall include:

1) kW & kWH

2) Consumption

3) Demand

4) Power Factor

5) Current

6) Voltage

7) Apparent Power

8) Reactive Power

e. Provide quantity of Digital Energy Monitors as required to meet the requirements specified herein.

Q. Occupancy Sensor:

1. The Dual Technology sensor shall be capable of detecting presence in the control area by detecting doppler shifts in transmitted ultrasound and passive infrared heat changes.

2. Sensors shall use patent pending ultrasonic diffusion technology that spreads coverage to a wider area.

3. Sensor shall utilize Dual Sensing Verification Principle for coordination between ultrasonic and PIR technologies. Detection verification of both technologies must occur in order to activate lighting systems. Upon verification, detection by either shall send "ON" signal.

4. Sensor shall have a retrigger feature in which detection by either technology shall retrigger the system on within 5 seconds of being switched off.

5. Sensors shall be ceiling mounted with a flat, unobtrusive appearance and provide 360° coverage.

6. Ultrasonic sensing shall be volumetric in coverage with a frequency of 40 KHz. It shall utilize Advanced Signal Processing that automatically adjusts the detection threshold dynamically to compensate for changing levels of activity and airflow throughout controlled space.

7. To avoid false "ON" activations and to provide immunity to RFI and EMI, Detection Signature Analysis shall be used to examine the frequency,

duration, and amplitude of a signal, to respond only to those signals caused by human motion.

8. The PIR technology shall utilize a temperature compensated, dual element sensor and a multi-element Fresnel lens. The lens shall be Poly IR4 material to offer superior performance in the infrared wavelengths and filter short wavelength IR, such as those emitted by the sun and other visible light sources. The lens shall have grooves facing in to avoid dust and residue build up which affects IR reception.

9. DT-300 and DT-305 sensors shall operate at 24 VDC/VAC and halfwave rectified and utilize a Watt Stopper power pack.

10. Sensors shall utilize SmartSet™ technology to optimize time delay and sensitivity settings to fit occupant usage patterns. The use of SmartSet shall be selectable with a DIP switch.

11. Sensors shall have a time delay that is adjusted automatically (with the SmartSet setting) or shall have a fixed time delay of 5 to 30 minutes, set by DIP switch.

12. Sensors shall feature a walk-through mode, where "ON" signal turns off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.

13. The DT-300 and DT-305 sensors shall have a manual on function that is facilitated by installing a momentary switch.

14. Sensors shall have eight occupancy logic options that give the ability to customize control to meet application needs.

15. The sensors shall feature terminal style wiring, which makes installation easier.

16. DT-300 sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.

17. Each sensing technology shall have an LED indicator that remains active at all times in order to verify detection within the area to be controlled. The LED can be disabled for applications that require less sensor visibility.

18. To ensure quality and reliability, sensor shall be manufactured by an ISO 9002 certified manufacturing facility and shall have a defect rate of less than 1/3 of 1%.

19. Sensors shall have standard 5 year warranty and shall be UL and CUL listed.

2.14 OUTPUT DEVICES

A. Actuators:

1. General Requirements:

a. Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.

2. Electronic Damper Actuators:

   a. Electronic damper actuators shall be direct shaft mount.

   b. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

   c. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

   d. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

   e. Manufacturers: Johnson Controls, Mamac.

3. Electronic Valve Actuators:

   a. Electronic valve actuators shall be manufactured by the valve manufacturer.

   b. Temperature rating: -22 to 140°.

   c. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

   d. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

e. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

f. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

g. Size for torque required for valve close-off at maximum pump differential pressure, regardless of water loop system pressure.

h. Manufacturers: Johnson Controls.

B. Control Dampers:

1. The BMS Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor or as specifically indicated on the Drawings.

2. All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

3. All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

4. Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48"x48" size shall not leak in excess of 8.0 cfm per square foot when closed against 4" w.g. static pressure when tested in accordance with AMCA Std. 500.

5. Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5" w.g., but no more than 4000 FPM or 6" w.g. Manufacturers: Johnson Controls VD-1250, VD1630, or VD-1330, Ruskin CD50 or CD60, and Vent Products 5650.

6. One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Manufacturers: Johnson Controls VD-1620, VD-1320, Ruskin CD36, and Vent Products 5800.

7. Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

C. Control Relays:

1. Control Pilot Relays:

a. Control pilot relays shall be of a modular plug-in design with retaining springs or clips.

b. Mounting Bases shall be snap-mount.

c. DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.

d. Contacts shall be rated for 10 amps at 120VAC.

e. Relays shall have an integral indicator light and check button.

f. Manufacturers: Johnson Controls, Lectro.

2. Lighting Control Relays:

a. Lighting control relays shall be latching with integral status contacts.

b. Contacts shall be rated for 20 amps at 277 VAC.

c. The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.

d. Lighting control relays shall be controlled by:

1) Pulsed Tri-state Output – Preferred method.

2) Pulsed Paired Binary Outputs.

3) A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the "dry-contact" type.

e. The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

D. Control Valves:

1. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed or flanged) shall conform to the piping specified elsewhere in this

Specification. Unless otherwise noted, minimum pressure rating shall be 150 psig.

2. Performance Requirements:

   a. Valves are to be sized and guaranteed to meet the requirements as specified and as indicated on the Drawings.

   b. Unless otherwise specified, the following performance requirements shall be used for valve sizing:

      1) All control valves shall have a manual override.

      2) Flow Rates:

         a) Normal flow rate: See equipment schedule on Drawings.

         b) Minimum flow rates: 20:1 turndown for heat transfer equipment; 5:1 turndown for pump discharge throttling and for pressure reducing stations.

         c) Maximum flow rate: To be considered only where specified or shown on the Drawings.

   c. Pressure Drops:

      1) The control valve operator shall be sized to shutoff against a differential pressure equal to the pump design head plus 30%.

      2) Flowing pressure drop at design conditions: use a maximum of 5 psi, unless otherwise noted.

   d. Cavitation:

      1) Valve selections shall be free of cavitation over the whole range of performance. Obtain relevant upstream pressure for each valve prior to valve selection, and include the documentation for the cavitation check in the shop drawing submittal.

      2) All valves will be checked for cavitation and noise during their shop drawing review. If any valve shows light incipient cavitation, it may be accepted, but only after consultation with the owner's engineer. Any valve which suffers critical or damaging cavitation shall be replaced by the contractor without extra charge.

   e. Ports and Trim:

      1) Control valves shall be single-seated and shall have equal percentage flow characteristics.

   f. Actuator for water control valves shall be electric/electronic type. Actuators for steam valves shall be pneumatic type.

g. Steam Valves:

1) Control valves shall be of linear flow characteristics for modulating service.

2) Sizing Criteria:

a) 15 psig or less; pressure drop equal to 2 - 3 psig

b) 16 to 50 psig; pressure drop equal to 4 - 5 psig

c) Over 50 psig; pressure drop equal to 5 psig

d) Steam valves shall fail normally open or closed, as scheduled on plans, or as follows:

(1) Heating coils in air handlers: normally open.

e) Steam to hot water heat exchanger: normally closed.

f) Other applications; as required by sequences of operation

3. Water control valves shall be modulating plug, globe or ball as required by the specific application and as noted herein. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving variable flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no greater than 5 PSI. Valves (3-way) serving constant flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

4. Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.

5. Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.

6. Butterfly valves shall be acceptable for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system, and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight, high performance type.

7. Specific Valve Requirements:

a. Hydronic Systems:

1) Rate for service pressure of 150 psig at 250 degrees F (860 kPa at 121 degrees C).

2) Replaceable plugs and seats of stainless steel.

3) Furnish two-way valves with equal percentage characteristics. Furnish three way valves with linear characteristics. Size two way valve actuators to close valves against pump shut off head.

b. Steam Systems:

1) Rate for service pressure of 150 psig at 250 degrees F (860 kPa at 121 degrees C).

2) Replaceable plugs and seats of stainless steel.

3) Furnish valves with modified linear characteristics.

c. Globe Pattern:

1) 2 inches (50 mm) and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with back seating capacity packable under pressure.

2) 2-1/2 inches (65 mm) and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.

d. Ball Valves:

1) Forged brass body, chrome plated brass ball and blowout proof stem and EPDM O-rings with minimum 600 psig (4135 kPa) rating.

2) Fluid Temperature Range: minus 20 to 250 degrees F (minus 29 to 121 degrees C).

3) Flow Characteristics: Furnish 2-way valves with equal percentage characteristics. Furnish 3-way valves with equal percentage characteristic through control port and linear characteristic through bypass port.

e. Butterfly Valves:

1) Service Pressure Rating: 150 psig at 250 degrees F (860 kPa at 121 degrees C).

2) Construction: Steel body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

3) Body Style: Wafer, or Lug.

4) Disc: Stainless steel.

5) Resilient replaceable seat for service to 250 degrees F (121 degrees C).

a) Size for 1 psig (7 kPa) maximum pressure drop at design flow rate.

6) Use only for open-close two-position operation. Provide bubble-tight shutoff.

f. Terminal Unit Control Valves:

1) Brass body, Class 250, nickel plated brass ball, with optimizer insert for modulating applications, blow out resistant stem, threaded ends.

2) Two or three way as indicated in schedule or on Drawings.

3) Integral actuator.

4) Spring return required for unit ventilator heating valves and other terminal equipment with outside air.

5) Furnish non-spring return valves with manual override capability built into actuator.

6) Minimum Fluid Temperature: 20 degrees F (minus 7 degrees C).

7) Maximum Operating Conditions: 250 degrees F (121 degrees C).

8) Sizing: 3 psig (21 kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.

9) Flow Characteristics: Furnish two-way and three-way valves with equal percentage characteristics.

g. Characterized Control Valves for all air handling unit chilled water and hot water control valves:

1) Factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of the piping system, unless otherwise indicated.

2) Pressure Independent Control Valves:

a) Manufacturers:

(1) Belimo Aircontrols (USA), Inc.

(2) Flow Control Industries.

b) The modulating control valves shall be pressure independent.

c) The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic. The flow shall not vary more than ± 5% due to system pressure fluctuations across the valve with a minimum of 5 PSID across the valve.

d) Forged brass body rated at no less than 400 PSI, chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and TEFZEL characterizing disc.

e) Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSID.

f) The control valve shall require no maintenance and shall not include replaceable cartridges.

g) All actuators shall be electronically programmed by use of a handheld programming device or external computer software. Programming using actuator mounted switches or multi-turn actuators are NOT acceptable. Actuators for 3-wire floating (tri-state) on 1/2 inch – 1 inch pressure independent control valves shall fail safe (HW valves shall fail open; CHW valves shall fail closed and have a mechanical device inserted between the valve and the actuator for the adjustment of flow. Actuators shall be provided with an auxiliary switch to prove valve position.

h) The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting base.

i) The control valve shall require no maintenance and shall not include replaceable cartridges.

j) The manufacture shall warrant all components for a period of 5 years from the date of acceptance, with the first two years unconditional.

k) The use of pressure independent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

8. Manufacturers: Johnson Controls, Belimo.

E. Electronic Signal Isolation Transducers:

1. A signal isolation transducer shall be provided whenever an analog output signal from the BMS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.

2. The signal isolation transducer shall provide ground plane isolation between systems.

3. Signals shall provide optical isolation between systems.

4. Manufacturers: Advanced Control Technologies.

2.15 MISCELLANEOUS DEVICES

A. Local Control Panels:

1. All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall be UL

inspected and listed as an assembly and carry a UL 508 label listing compliance and shall be NEMA 4X construction. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and flush latch operable by key.

2. In general, the control panels shall consist of the DDC controller(s), display module and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. The display module shall be flush mounted in the panel face unless otherwise noted.

3. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.

4. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

5. All wiring shall be neatly installed in plastic trays or tie-wrapped.

6. A 120 volt convenience outlet, fused on/off power switch, and required transformers shall be provided in each enclosure.

B. Power Supplies:

1. DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.

2. Input: 120 VAC +10%, 60Hz.

3. Output: 24 VDC.

4. Line Regulation: +0.05% for 10% line change.

5. Load Regulation: +0.05% for 50% load change.

6. Ripple and Noise: 1 mV rms, 5 mV peak to peak.

7. An appropriately sized fuse and fuse block shall be provided and located next to the power supply.

8. A power disconnect switch shall be provided next to the power supply.

C. Thermostats:

1. Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

D. Time Clocks:

1. Seven-day programming switch timer with synchronous timing motor and seven-day dial. Continuously charged Ni-cad battery driven for power failure with 8 hour carry over and multiple switch trippers to control systems for

minimum of two and maximum of eight signals each day with two normally open and two normally closed output switches.

2. Solid-state programmable time control with three (3) separate programs, 24-hour battery carry over duty cycling, 365 day calendar with 20 programmable holidays and choice of fail safe operation for each program and system fault alarm.

E. Alarm System:

1. Enclosure Construction: NEMA 250, Type 4.

2. Furnish alarm panel with individual indication, horn, silenced acknowledge switch, and test switch.

3. At alarm condition indication, light flashes and alarm sounds. Horn stops when acknowledge switch is pushed and system indicates alarm conditions by continuous light until trouble condition has cleared. Alarm sounds again when second alarm occurs before first one has cleared.

4. Furnish remote panels with duplicate functions of primary panel. Furnish alarm silence/acknowledge switch to acknowledge alarm from each panel.

5. Furnish dry contacts at main alarm panel for use with remote alarm monitoring system to indicate each alarm condition.

2.16 LABORATORY CONTROL SYSTEMS

A. Furnish and install a Laboratory Airflow Control System (LACS) in conjunction with the central Building Management System (BMS) to maintain laboratory room supply and exhaust airflows, room ventilation rates, room static pressurization, room ambient temperatures & humidity's and the laboratory exhaust system functionality as specified herein.

1. The LACS shall also ensure that all VAV fume hood average face velocities (100 FPM for standard fume hood, 120 FPM for Radioisotope Hoods) and minimum exhaust airflows are maintained as required and as indicated in the project plan schedules.

2. The LACS shall also ensure that all biological safety cabinets and other required exhaust airflows listed in the project plan schedules are maintained.

3. The LACS shall also provide the laboratory emergency control modes as detailed in this specification.

4. The LACS shall comply with the functional requirements of U.S. OSHA 29 CFR, (Canada Public Works MD 1580), NFPA 45, AIHA Z9.5, and all applicable Local and State (Provincial) codes

B. The LACS shall include all laboratory room supply and exhaust airflow terminals, tracking of supply, exhaust and fume hood boxes for each lab, reheat coils, reheat coil valves, air terminal actuators, instrumentation and the control units and associated interconnecting wiring and pneumatic tubing. Any and all associated components required to implement a fully functioning and integrated system as specified herein shall also be provided. System verification and other documentation

as specified under the commissioning requirements and commissioning plan section shall also be included.

C. All LACS data shall be capable of being accessed by authorized persons via the facility BMS network as well as via the Intranet using standard web browsers to obtain LACS data in graphical form as well as in specific user defined and configured LACS summary and status reports.

D. Total system shall be installed and commissioned by, or under the direct supervision of, factory trained and authorized field engineers.

E. Quality Assurance:

1. Supplier of this section's systems shall be regularly engaged in the production, assembly, and installation of laboratory and fume hood control systems and have a proven track record of a minimum of 10 years.

2. Supplier of this section's systems shall assume single source responsibility for the complete installation, calibration, and startup of the isolation room tracking systems. Systems shall be left in a completely automated, fully functioning mode of operation.

F. Manufacturers:

1. Base Bid: Laboratory Control Systems Inc. Envirotrak IV System.

G. General:

1. Laboratory Control system shall use closed loop control to continually monitor and adjust the supply and exhaust volumes. Open loop control systems that merely feedback an analog signal that measures a position of a mechanical device, or systems that can control by pressure only, are unacceptable and will not be considered. Open loop and closed loop are as defined by 1991 ASHRAE Application Manuals Chapter 41, page 41.1 .

H. System Design:

1. In all cases, systems shall fail-safe to a mode which achieves the maximum safety to personnel in the spaces served by the systems.

2. Room pressurization control will be accomplished by flow synchronization (airflow tracking) or by direct space pressure control, or by a combination of both. Unless specifically identified elsewhere, all systems on this project shall utilize flow synchronization as the mode of control. Air flows from the supply air and exhaust air will be measured, tracked and controlled to maintain a safe, comfortable, and energy efficient environment.

3. Fume hood face velocity control will be used to maintain a preset adjustable face velocity setpoint. Inputs to the controller shall include sash position or velocity sensor and fume hood exhaust air flow, from which the controller will calculate the hood face velocity. A high speed electronic, normally open, damper motor will modulate an exhaust valve as required to maintain the face velocity setpoint.

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

5. The laboratory controllers shall be integrated into the Building Management System (BMS).

I. Equipment:

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

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

3. Besides its programming flexibility, another key feature of this controller is that it has built-in hardware and software support for the 4 leading protocols in use among BMS companies today:

4. BACnet (ARC 156, MS/TP, and PTP), Modbus (RTU & ASCII), N2 Bus, and LonWorks (provide plug-on card used for LonWorks). It will also support BACnet/IP communications through an Ethernet plug-on card (this Ethernet card shall also be capable of serving up Web pages to a standard Internet Browser package). The point "mapping" to all of these protocols can be pre-setup at the factory, so that the protocol & baud rates desired can be easily field-selected or switched without the need for any additional downloads or technician assistance.

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

J. Controller:

1. Each laboratory shall be provided with a dedicated laboratory room controller with 20% spare I/O capacity.

2. Input/Output (I/O) Configuration:

a. Digital Outputs:

1) 6 relay outputs SPDT (contact ratings: 5A @ 25OVAC).

2) Removable Screw terminals.

3) Individual LED Indication of output status (color - "red')

b. Universal Inputs:

1) 12 total.

2) Input Signals Supported (jumper selectable):

a) Thermistor/Dry Contact.

b) 0-10 VDC (scalable in software for other ranges).

c) 0-20 mA (scalable in software for other ranges).

d) 1K Platinum RTD.

3) Removable screw terminals.

4) 12-Bit A/D.

5) Selectable +5V or +24V voltage source (240 mA max).

c. Universal Outputs:

1) 6 total.

2) Analog Output Signals Supported:

a) 0-10 V DC on all 6 outputs (scalable in software for other ranges).

b) 0-10 VDC or 0-20 mA on 2 of the outputs.

3) Digital Output Signals - Each of the 6 outputs can be individually configured as digital outputs. They have the signal capacity to drive an external voltage relay device.

4) Removable screw terminals

5) Individual LED Indication (red - vary in intensity based on output signal status)

3. Power Requirements:

a. External Power Source - 24 VAC ± 15 *%,* 50-60 Hz, 20 VA.

b. Removable screw terminal (2-position) for power connection.

c. LED Indication: Power (green), Run (green), and Error (red) LEDs

4. Communication Ports:

a. 4Ports:

1) Open Protocol Port #1 – BACnet (ARCNET; ARC 156).

2) Open Protocol Port #2a – Configurable for EIA-232 or EIA-485 (2 wire or 4 wire). Network protocol selectable for BACnet (MS/TP or PTP), MODBUS, N2, LONWorks SLTA, or modem.

3) Open Protocol Port#2b – Configurable for Lon Works plug-in or Ethernet (BACnet/IP capable of serving up custom web pages).

4) Rnet Port - for connection to keypad/displays and/or intelligent sensors. This port also acts as the local laptop access port.

5) I/O Expansion Port (CAN-bus).

b. Removable Screw terminals.

c. Transmit & Receive LEDs for each port.

d. Rotary Address Switches.

e. Protocol & Baud Rate selector DIP switch.

5. Size and Environmental Requirements:

a. Board Size (including metal cover): 11-3/4" wide x 5" high x 2" deep

b. Expander Board Size: 10-5/8" wide x 3" high x 2" deep (note: the expander boards can be mounted on top of the ENV IV controller to conserve panel space or they can be remotely mounted up to 500 feet away from the controller.)

c. Protection: Brushed aluminum, gull-wing metal.

d. Temperature Range: -40 to 150 deg. F, 10-95% RH non-condensing.

e. Agency Listings: UL, cUL, CE. FCC.

K. Room Alarm Module:

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

1. Alarm Silence and/or override function keys.

2. Red and Green L.E.D. Indicators for status display.

3. Digital Liquid Crystal Display (LCD) Capable of Displaying the Following:

a. Environmental Control:

1) Air Flow: CFM or L/S

2) Pressurization: Differential Flow - CFM or L/S
Differential Pressure - H20 or Pa

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

L. Fume Hood Alarm Module:

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

1. Alarm Silence and/or override function keys.

2. Red and Green L.E.D. Indicators for status display.

3. Digital Liquid Crystal Display (LCD) Capable of Displaying the Following:

   a. Face velocity: FPM or M/S.

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

M. Sash Position Sensors:

1. Vertical:

   a. Sash Position Sensor shall equal to Laboratory Control Systems Inc. Model VSPS consisting of a precision optical encoder coupled to a spring return cable assembly. The sensor shall be 0.1% resolution and accuracy combined. The sensor shall be mounted in a concealed location and coordinated with the fume hood manufacturer.

2. Horizontal:

   a. Sash Position Sensor shall equal to LCS Model ALPS consisting of a precision resistive switch array that can be field installed into hoods without the need for pre-measurement and custom manufacturing. Sensors shall connect directly to laboratory controller without the need of any outside power source or interface box.

3. Coordinate installation of sash positioning of Fume Hood Manufacture's Factory.

N. Face Velocity Sensors:

1. Face Velocity Sensors shall consist of electronic velocity sensor mounted in a PVC shroud assembly. The sensor shall be hot-wire anemometer consisting of platinum elements in a glass encased assembly. The sensor shall be temperature compensated and produce a linear output voltage equivalent to 0-200FPM. The sensor shall be mounted in accordance with the manufacturer's recommendations and shall be coordinated with the fume hood manufacturer. The sensor shall provide an accuracy of not less than +/-2% and shall have the capability to be field-calibrated in the installed condition to provide for maximum installed accuracy and performance.

O. Room Temperature Sensor:

1. Equal to Laboratory Control Systems Inc. Model RS.

2. The RS Series Intelligent Sensors are room temperature sensors designed for use with the Envirotrak IV controller. Each sensor features a precision 10K ohm thermistor and communications port.

3. The communication port shall provide access to the entire network, not only the connected controller. Systems requiring additional hardware, routers or network devices to provide this function shall include a specific list of additional equipment necessary and include the cost of necessary equipment and any additional installation and wiring costs.

4. The RS-Pro also features the addition of LCS display and function buttons.

5. Specifications:

   a. Sensing Element: 10K ohm precision thermistor. Standard accuracy +/- 0.35°F. Less than +/-0.18°F drift over a 10 year period.

   b. Recommended Wire: Two pair twisted unshielded cable- 18 AWG recommended.

   c. Communication: 115kbaud Rnet.

   d. Local Access Port: 5 pin port for commissioning and maintenance.

   e. Mounting: Standard 2x4" electrical box.

   f. Overall Dimensions: 2 3/4"w x 4 3/4"h x 5/8"D.

P. Duct Temperature Sensor:

Equal to Laboratory Control Systems Inc. Model DTS RTD sensor for installation in air ducts. Two-wire interface with Envirotrak controller. Features include:

1. Type: Resistance temperature detector (RTD).

2. RTD material: Thin Film Platinum.

3. Nominal resistance: 1000 ohms +/- .1% @ 0°c
   Alpha .00385/ohm/ohm/°C

4. Temperature range: -40 to 250°F (-40to 121°C).

5. Maximum Error: 1.6°F (1.0°C) Over 290°F (161°C) Spa.

6. Recommended current: 1.0 mA

7. Maximum current: 3.0 mA

Q. Low Differential Pressure Transmitter:

Furnish for each air flow or differential pressure measurement point a low differential pressure transmitter incorporating the following functions and features:

1. Pressure Range:

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

3. Bi-Directional: +/-0.1 through +/-0.5" W.C. - Selected according to required operating range.

4. Accuracy: 0.4% F.S.O.

5. Stability: <0.5% F.S./Y.

6. Response Time: 250 ms.

7. Overpressure Rating: 15 psi Proof Pressure, 25psi Burst Pressure.

8. Power Supply: 12-36vdc.

9. Output Signal: 4-20mA.

10. Pressure Connections: ¼" Brass barbed fittings.

11. Electrical Connections: Euro style pluggable terminal block accepts 12-26 gauge wire.

12. Enclosure: NEMA Type 1 Fire Retardant ABS (Meets UL 94-5VA).

13. LED visual indicator standard.

14. Mounting: Threaded fastener and 35mm DIN rail mount standard.

R. Process Chilled Water Detection/Alarm System:

1. Equal to Model ILP, Intelligent Leak Protection module.

2. Furnish and install on each fume hood served by process chilled water. The ILP shall be seamlessly integrated into the laboratory control system and provide alarm functions via the network.

S. E/P Transducers:

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

1. Minimum Specifications:

a. Ambient Operating Limit:

1) Temperature: 41F to 122°F (5 to 50°C).

b. Power Supply: None, loop powered.

1) Input Signal: 0-10 vdc.

2) Input resistance: 1000 ohms minimum.

3) Output: .05-19 psi, linear to input, direct acting.

c. Main Air Pressure: 18-25 psig ( 126 to 175 kPa).

d. Maximum Safe Air Pressure: 25psi (175 kPa).

e. Air Consumption: 45 scim (12.3 mL/s)maximum.

f. Air Capacity: 1600 scim (437 mL/s) maximum.

1) Linearity: 5% maximum of output span between 3-15 psig.

2) Hysteresis: 0.5 psig typical.

3) Dimensions: 1.42"W x 1.26" H x 4.17"D.

4) Mounting: Surface mounted.

g. Air Connections: barbed fittings for 5/32" or ¼" O.D. tubing.

h. Electrical Connections: Screw terminals.

i. Calibration: Factory calibrated.

T. Actuators:

1. Electronic actuators shall be fast acting, either fail-safe type or fail-in-place, as required by the application. Fail-safe actuators shall incorporate super capacitor technology and be field selectable for fail-safe position, i.e. open or closed on loss of power.

2. Spring return electric actuators are not acceptable. The actuators shall be rated for a minimum of 35 in. lbs. of torque and have a rotation time of 1 second or less for 90° travel.

U. Air Flow Sensors:

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

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

V. Duct Velocity Transmitter Specifications:

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

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

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

4. The DVT shall be furnished with an integral differential pressure transmitter suitable for output to a Building Management System for control or

monitoring purposes. The transmitter shall incorporate the following features and functions:

a. Pressure Range:

1) Unidirectional: 0-0.1 through 0-5.0"W.C. - Selected according to required operating range.

2) Accuracy: 0.8% F.S.O. (Optional 0.4% available).

3) Stability: <0.5% F.S./Y.

4) Response Time: 250 ms.

5) Overpressure Rating: 15 psi Proof Pressure, 25psi Burst Pressure.

6) Power Supply: 12-36vdc.

7) Output Signal: 4-20mA.

8) Pressure Connections: ¼" Brass barbed fittings.

9) Electrical Connections: Euro style pluggable terminal block accepts 12-26 gauge wire.

10) Enclosure: NEMA Type 1 Fire Retardant ABS (Meets UL 94-5VA).

11) LED visual indicator standard.

12) Mounting: Threaded fastener and 35mm DIN rail mount standard.

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

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

W. Room Static Pressure Sensor:

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

2. The Room Static Transmitter shall be furnished with a differential pressure transmitter suitable for output to a Building Management System for control or monitoring purposes. The transmitter shall incorporate the following features and functions.

a. Pressure Range:

1) Unidirectional: 0-0.1 through 0-5.0"W.C. - Selected according to required operating range.

2) Bi-Directional: +/-0.1 through +/-0.5" W.C. - Selected according to required operating range

b. Accuracy: 0.8% F.S.O. (Optional 0.4% available)

c. Stability: <0.5% F.S./Y.

d. Response Time: 250 ms.

e. Overpressure Rating: 15 psi Proof Pressure, 25psi Burst Pressure.

f. Power Supply: 12-36vdc.

g. Output Signal: 4-20mA.

h. Pressure Connections: ¼" Brass barbed fittings.

i. Electrical Connections: Euro style pluggable terminal block accepts 12-26 gauge wire.

j. Enclosure: NEMA Type 1 Fire Retardant ABS (Meets UL 94-5VA).

k. LED visual indicator standard.

l. Mounting: Threaded fastener and 35mm DIN rail mount standard.

X. Laboratory VAV Air Terminals - Single Blade Damper:

1. VAV air terminals shall have a single blade damper for airflow modulation and shall provide adequate operational maximum to minimum airflow turndown ratios to provide the full range of minimum to maximum airflows listed in the project airflow control schedules. Terminal airflow shall be pressure independently controlled using actual airflow measurement feedback as an integral part of the control process. Air terminal dampers shall be capable of achieving maximum to minimum airflow and vice-versa within 1 second. Minimum airflow sensor measurement accuracy shall be +/- 5% of actual airflow and shall have a repeatability within +/- 0.15% over the entire airflow range of each air terminal. Airflow measurement accuracy and response time substantiation by a qualified independent test agency shall be included with the submittal. All single blade damper air terminals shall have a maximum pressure drop of 0.30" or less at their maximum rated airflow.

2. Due to laboratory occupant health and safety concerns and to ensure compliance with the airflow control performance and reliability requirements of this specification, the LACS shall provide and install an independent airflow measuring station at each room supply, each room general exhaust and at each fume hood exhaust air terminal. The airflow measurement signals from these airflow measurement stations shall be made available to the central Building Management System (BMS). The room supply and room general exhaust airflow measurement stations shall be comprised of an averaging type of airflow sensor. The fume hood exhaust airflow measurement stations shall also be comprised of an averaging type of sensor such as an orifice ring which is not subject to clogging by an accumulation of particulate, chemical deposits or is likely to catch debris such as tissues. All airflow measuring stations shall include the necessary signal conditioning/ transmitter instrumentation to provide an output of 4-20 mA that is proporional to the airflow velocity pressure. Airflow transmitter instrumentation shall have an accuracy of at least +/- 0.5% over the full transmitter range. Airflow transmitter ranges shall not exceed 0 to 1.00 Inches W.C.

3. Room supply air terminals shall be industrial grade and constructed of 22 gauge galvanized steel with mechanically locked and gasketed seams and shall meet the mechanical standards of and be in compliance with UL 181 and UL 723, NFPA 90A, ESTM E84 and bacteria standard ASTM C665. Air terminal casings shall have 3/4" thick foil lined fiber guard insulation with all ends sealed with galvanized metal caps and edge angles. Damper shafts solid ½" diameter zinc-plated steel with self-lubricating polyethylene bushings and with external indication of the damper position. Damper blades shall be 22 gauge steel with a polyurethane foam gasket to enable tight shutoff for smoke control applications. Air terminal leakage shall not exceed 1% of the design airflow @ 3 inches W.C. positive static pressure and shall be capable of tight shut-off to accommodate smoke control routines that call for a total shut off of room supply airflow. Supply air terminals shall be provided with an averaging pitot tube array type of airflow sensor located upstream from all other air terminal components. Hot water reheat coils shall be comprised of copper tubing of 0.017" wall thickness and have heavy gauge sine wave coil fins for efficient heat transfer, rated for a minimum of 250 psig.

4. Room general exhaust air terminals including damper blades shall be industrial grade and constructed of 22 gauge galvanized steel. Damper shafts shall be solid ½" diameter stainless steel with self-lubricating Teflon® bushings and with external indication of the damper position. Terminal air leakage shall not exceed 1% of design airflow @ 3 inches W.C. positive static pressure. Room general exhaust air terminals shall be provided with an orifice ring type of airflow sensor located upstream of the damper.

5. All fume hood exhaust terminals shall be constructed of 316L stainless steel coated with Teflon. Damper shafts shall be ½" diameter, solid stainless steel with self-lubricating Teflon® bushings and with external indication of the damper position. Fume hood exhaust terminals shall be provided with a stainless steel orifice ring type of airflow sensor located upstream of the damper. Airflow sensing techniques that are likely to become inoperative due to accumulation of particulate or chemical deposits or which can catch debris and obstruct exhaust airflow shall not be acceptable for fume hood exhaust applications.

6. Certified discharge and radiated sound power level data shall be provided for each different size and type of air terminal as part of the submittal documentation. Sound power data shall be obtained via the ARI 880-98 Standard for Air Terminals and ANSI/ASHRAE 130-1995 Standard Methods of Testing for Rating Ducted Air Terminal Units. All sound data shall be obtained by a qualified, accredited and ARI approved testing laboratory.

7. Each device must be field calibrated to accurately reflect construction and last minute design changes.

8. Laboratory VAV air terminals shall have all controls supplied by controls system manufacturer and factory mounted.

2.17 ATC INSTRUMENT AIR SYSTEM

A. General:

1. The instrument compressed air supply for instrument and control air users shall be provided from a duplex instrument air compressor and dryer system.

2. The duplex instrument compressed air system shall supply clean, dry, oil free, uninterrupted compressed air to all instrumentation and control air users, and shall conform to Instrument Society of America Standard ISA-S7.3.

3. The electric feed for the compressors shall be from the emergency power system.

B. Instrument Air Compressor:

1. Furnish and install two (one operating and one standby) electric motor driven, high pressure, reciprocating air compressors with no greater speed than 500 RPM capable of supplying compressed air at 100 psig under maximum CFM and operating not more than 1/3 of the time. Each compressor unit shall be complete with starter package and all auxiliary equipment, including safety valves, belt guards, pressure gauges and pressure switches.

2. The reciprocating air compressors shall be Ingersoll-Rand Type 30 series or approved equal.

3. Rotary screw air compressors may be quoted as an alternate to the reciprocating type. Ingersoll-Rand SSR-1000 or approved equal.

4. Detailed calculations of operating time and number of starts per hour for each compressor shall be documented and submitted for approval. The compressor motor shall be sized as required to serve building's needs. Minimum size for each compressor motor shall be 5 hp.

5. The Duplex compressors, mounted on 120 gal. receiver tank, shall be installed on a 6" high concrete inertia base and supported on vibration eliminators provided by this Division.

   a. The spring supported concrete inertia foundation for the compressor shall be poured within structural perimeter frame (reinforced as necessary). The structural perimeter frame shall be equipped with height saving brackets and stable bare spring isolators. The mountings shall provide minimum static deflection of 1". The structural perimeter frame, mounting templates, height saving brackets and spring system shall be provided as an assembly under this Division. The structural frame shall include top and bottom reinforcing steel for concrete.

   b. Mounting assemblies for compressors shall be one of the following, or approval equal:

      1) Type KSL - Mason Industries, Inc.

      2) Type ASSB - Vibration Mountings & Controls.

      3) Type SN-OSK - Vibration Eliminator Co.

6. The compressor manufacturer shall furnish the compressed air system complete with a prewired compressor control panel including a NEMA 1 enclosure with key lock, hinged front panel.

   a. The panel shall house two combination motor starters/disconnect switches each provided with a control power transformer fused on

both the primary and secondary sides. Control circuit voltage shall be 120 VAC, single phase, 60 Hz. Each starter shall have three thermal overload relays and at least one normally open spare auxiliary contact for status indication to be inputted into the DDC System.

b. The control panel shall have for each starter; disconnect switch, a "HAND-OFF-AUTO" selector switch, a pilot light to indicate motor running, and a thermal overload reset button mounted on its face.

c. The panel shall be furnished with a Lead-Lag alternator, which shall automatically alternate compressors as required.

d. Internal control wiring terminal blocks shall be provided for all external wiring connections.

e. External pressure or pneumatic tubing connections shall be terminated in compression type, brass bulkhead fittings.

C. Desiccant Air Dryer and Refrigerant Type Air Dryer:

1. Furnish and install a refrigerant and a desiccant air dryer that shall dry saturated instrument air entering at 100 PSIG to a final dewpoint of minus 40°F.

2. The total air side pressure drop shall not exceed five (5) PSI.

3. The dryer control package shall be fully automatic and operate on a standalone basis.

4. The dryer shall be provided with the following instrumentation:

a. Locally mounted chamber pressure gages.

b. Purge flow indicator.

c. Locally mounted moisture indicator.

d. Alarm contacts and signal light to be activated if switching takes longer than fifteen (15) seconds. Alarm shall be wired into the DDC system under this Division.

5. Power supply to the desiccant dryer and 15 amp local disconnect switch shall be installed under this Division.

6. The dryer shall be manufactured by Pall Trinity, Ingersoll-Rand, Hankison or approved equal.

D. Filters:

1. Furnish and install pre-filters to complete with automatic drain valve to remove contaminants of ten (10) micron size and larger. Pall Trinity, Ingersoll-Rand or approved equal.

2. Furnish and install as shown on the Drawings after-filters to remove contaminants 0.9 micron size and larger. Pall Trinity, Ingersoll-Rand or approved equal.

3. Filters shall be provided with differential pressure gages to indicate the need for filter cleaning or replacement. Dwyer, Orange Research or approved equal.

E. Oil Separator:

1. Furnish and install as shown on the Drawings an oil separator complete with automatic drain valve to provide oil free compressed air. The separator shall have a filtration efficiency of 99.9% at 0.5 microns.

2. Deltech or approved equal.

F. Pressure Reducing Stations:

1. Furnish and install as shown on the Drawings each pressure reducing stations which shall include two pressure reducing valves, each with overpressure relief valve, piped in parallel (one operating and one valved off for standby service).

G. Valved Bypasses:

1. Furnish and install valved bypasses around air filters, oil separator and air dryers to allow for servicing without shutdown.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Division 01 - Administrative Requirements: Coordination and project conditions.

B. Verify conditioned power supply is available to control units and to operator workstation.

C. Verify field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.02 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration. Provide metal channel support system for all wall and floor-mounted devices.

B. Install software in control units and in operator workstation. Implement features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.

C. Install with 120 volts alternating current, 15 amp dedicated emergency power circuit to each programmable control unit.

D. Install conduit and electrical wiring in accordance with Section 26 05 03.

E. Install electrical material and installation in accordance with appropriate requirements of Division 26.

F. Install all devices, sensors, etc. in sheet metal enclosures to prevent dust, dirt and water damage. Provide outdoor rated enclosures for devices exposed to weather.

G. Graphic Displays:

1. Provide a color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

2. User shall access the various system schematics via a graphical penetration scheme and/or menu selection. .

H. Actuation/Control Type:

1. Primary Equipment:

a. Controls shall be provided by equipment manufacturer as specified herein.

b. All damper and water valve actuation shall be electric.

c. All steam valves serving comfort heating and domestic hot water heating shall be pneumatic. Provide air compressor system and pneumatic tubing.

2. Air Handling Equipment:

a. All air handers shall be controlled with a HVAC-DDC Controller.

b. All damper and valve actuation shall be electric.

3. Terminal Equipment:

a. Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.

b. All Terminal Units shall be controlled with HVAC-DDC Controller.

## 3.03 MANUFACTURER'S FIELD SERVICES

A. Division 01 - Quality Requirements: Manufacturers' field services.

B. Start and commission systems. Allow adequate time for start-up and commissioning prior to placing control systems in permanent operation.

C. Furnish service technician employed by system installer to instruct Owner's representative in operation of systems plant and equipment for a 3-day period.

## 3.04 SYSTEM START-UP

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

B. All dampers, damper operators, flow sensors, etc., shall be checked for proper operation and field calibrated where required. Alarm systems and fail-safe modes shall be checked for each and every device.

C. Each tracking system shall be calibrated and tuned to provide fail-safe, efficient operation. Flow transducers shall be calibrated for zero and span, the control loop shall be for each mode of proportional, integral and derivative control. All dampers, damper operators, flow sensors, etc., shall be checked for proper operation. Alarm systems and fail-safe modes shall be checked for each and every device.

D. The Laboratory Control System supplier shall work closely with the balancing contractor to ensure proper air distribution in the HVAC system. The balancing contractor shall coordinate the work of the hood and tracking systems supplier with the hood certification testing and the HVAC balancing. It is imperative that the methods of testing air flow at the hoods are known and understood by all parties involved. Where there is a conflict as to proper methods to use for balancing, the Engineer shall have the final say.

E. The Balancing Contractor shall be responsible for providing CFM versus signal data to the laboratory fume hood control system supplier, who will then generate CFM versus signal charts for each box. This data shall be provided to the Owner as a part of the Operation and Maintenance Manuals.

3.05 COMMISSIONING, TESTING AND ACCEPTANCE

A. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets which shall be submitted prior to acceptance testing. Commissioning work which requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the Owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the Owner and construction manager are present throughout the commissioning procedure.

1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:

a. Sensor accuracy at 10, 50 and 90% of range.

b. Sensor range.

c. Verify analog limit and binary alarm reporting.

d. Point value reporting.

e. Binary alarm and switch settings.

f. Actuator ranges.

g. Fail safe operation on loss of control signal, electric power, network communications.

B. After control devices have been commissioned (i.e. calibrated, tested and signed off), each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the Owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy's. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

C. After all BMS programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to:

1. Data communication, both normal and failure modes.
2. Fully loaded system response time.
3. Impact of component failures on system performance and system operation.
4. Time/Date changes.
5. End of month/ end of year operation.
6. Season changeover.
7. Global application programs and point sharing.
8. System backup and reloading.
9. System status displays.
10. Diagnostic functions.
11. Power failure routines.
12. Battery backup.
13. Smoke Control, stair pressurization, stair, vents, in concert with Fire Alarm System testing.
14. Testing of all electrical and HVAC systems with other division of work.

D. Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy's and the system performance does not degrade over time.

E. Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate all system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

F. The contractor shall supply all instruments for testing and turn over same to the Owner after acceptance testing.

1. All test instruments shall be submitted for approval.

a. Test Instrument Accuracy:

| | |
|---|---|
| Temperature: | 1/4F or 1/2% full scale, whichever is less. |
| Pressure: | High Pressure (psi): 1/2 psi or 1/2% full scale, whichever is less. |
| Low Pressure: (in w.c.) | 1/2% of full scale |
| Humidity: | 2% RH |
| Electrical: | 1/4% full scale |

G. After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the Owner may request that performance tests be repeated.

3.06 DEMONSTRATION AND TRAINING

A. Division 01 - Execution and Closeout Requirements: Requirements for demonstration and training.

B. Furnish basic operator training for 16 persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 40 hours instructor time. Furnish training on site.

C. Demonstrate complete and operating system to Owner.

3.07 ELECTRICAL WIRING AND MATERIALS

A. Install, connect and wire the items included under this Section and all other Sections of HVAC work. This work includes providing required conduit, wire, fittings, transformers, etc. and related wiring accessories. All conduit and wiring shall be installed in accordance with Division 26 Specifications. Contractor is responsible to provide all wiring for a complete system.

B. Provide conduit and wiring between thermostats, aquastats and unit heater motors, all control and alarm wiring for all control and alarm devices for all Sections of Specifications.

C. Provide 120 volt, single phase, 60 hertz emergency power to every B.M.S. DDC Controller panel, HVAC/Mechanical Equipment Controller, PC console, power supply, transformer, annunciator, modems, printers and to other devices as required. It is the intent that the entire building management system except terminal equipment shall be operative under emergency power conditions in the building.

D. Provide status function conduit and wiring for equipment covered under this Section.

E. Provide conduit and wiring between the B.M.S. panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring in conduit.

F. Provide conduit and control wiring for devices specified in this Section.

G. Provide conduit and signal wiring between motor starters/disconnect switches and high and/or low temperature relay contacts and remote relays in B.M.S. panels located in the vicinity of motor control centers.

H. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and B.M.S. panels, as shown on the drawings or as specified.

I. All wiring to be compliant to local building code and the NEC.

J. Provide all conduit wiring for split systems, chillers, AC units, etc. as required for a complete and operational system.

K. Provide electrical wall box and conduits for all wall mounted devices.

L. Power source will be provided by Division 26 in the select locations on each floor for VAV boxes., etc., and at panels. HVAC contractor shall extend this wiring as required and provide all 120 volt to 24 volt wiring, conduits, transformers and wire each VAV box, controllers, panels, devices etc.

M. Class 2 Wiring:

1. All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.

    a. Conduit is not required for Class 2 plenum rated wiring in concealed accessible ceiling locations. Class 2 plenum rated wiring not installed in conduit shall be supported every 5' from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.

2. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

3. Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

N. BMS Line Voltage Power Source:

1. 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 26. Contractor shall extend wiring in conduit to BMS controllers, devices.

2. Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

O. BMS Raceway

1. All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".

2. Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Architect.

3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

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

P. Penetrations:

1. Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.

2. All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

3. All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.

4. Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

Q. Reference Division 26 Specifications and drawings for conduit, wiring and accessories requirements.

3.08 CONTROL AIR PIPING SYSTEM

A. Instrument air piping construction shall be suitable for a working pressure of 125 PSIG.

B. Instrument air piping headers & branches, piping sizes 2" and smaller

1. Piping shall be Type "L" hard drawn copper tubing ASTM-B-88-66A.

2. Fittings shall be wrought sweat fittings, applied by 95% tin, 5% antimony solder.

3. Valves shall be 200 lb. brass or bronze, unless otherwise specified on the Instrument Installation Details.

4. Minimum size for tubing shall be 1/2".

C. Instrument Air Tubing (other than headers and branches) and Accessories:

1. Copper tubing shall be type "L" hard drawn copper with compression type fittings.

a. Non-metallic tubing shall be flame retardant polyethylene and be number coded by manufacturer.

b. Fittings for non-metallic tubing shall be brass barb type.

c. Non-metallic tubing shall be installed in conduit.

d. Conduit used for protection of non-metallic tubing (air tubing) shall be terminated with insulated plastic bushings to prevent damage to tubing.

D. Tubing buried in walls and concrete shall be hard or soft copper tubing, or polyethylene tubing in rigid steel conduit.

E. Tubing inside panels may be polyethylene.

F. Pressure Reducing Stations:

1. Each pressure reducing station shall include two pressure reducing valves piped in parallel each with double block valves to allow one to be operating and one to be valved off for standby service.

G. Provide tubing for all pneumatically controlled HVAC devices and domestic hot water heating control valves.

3.09 INSTALLATION PRACTICES

A. BMS Identification Standards:

1. Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

a. Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

B. BMS Panel Installation:

1. The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.

2. The BMS contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.

C. Input Devices:

1. All Input devices shall be installed per the manufacturer's recommendation.

2. Locate components of the BMS in accessible local control panels wherever possible.

D. HVAC Input Devices - General:

1. All Input devices shall be installed per the manufacturer recommendation

2. Locate components of the BMS in accessible local control panels wherever possible.

3. The mechanical contractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

4. Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

5. Outside Air Sensors:

   a. Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.

   b. Sensors shall be installed with a rain proof, perforated cover.

6. Water Differential Pressure Sensors:

   a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.

   b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.

   c. The transmitters shall be installed in an accessible location wherever possible.

7. Medium to High Differential Water Pressure Applications (Over 21" w.c.):

   a. Air bleed units, bypass valves and compression fittings shall be provided.

8. Building Differential Air Pressure Applications (-1" to +1" w.c.):

   a. Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.

   b. The interior tip shall be inconspicuous and located as shown on the drawings.

9. Air Flow Measuring Stations:

   a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.

   b. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

   c. Contractor shall provide straight run of duct at inlet and outlet of stations as required for proper operation and as recommended by station manufacturer. Contractor shall submit scaled plans locating all stations with related ducts, AHU, fans, systems.

10. Duct Temperature Sensors:

    a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

    b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

c. For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

d. The sensor shall be mounted to suitable supports using factory approved element holders.

11. Space Sensors:

a. Shall be mounted per ADA requirements.

b. Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

12. Low Temperature Limit Switches:

a. Install on the discharge side of the first water or steam coil in the air stream.

b. Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.

c. For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

13. Air Differential Pressure Status Switches:

a. Install with static pressure tips, tubing, fittings, and air filter.

14. Water Differential Pressure Status Switches:

a. Install with shut off valves for isolation.

E. HVAC Output Devices:

1. All output devices shall be installed per the manufacturers recommendation. The mechanical contractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

2. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

3. Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

4. Control Valves: Shall be sized for proper flow control with equal percentage valve plugs.

5. Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer.

Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems.

3.10 LACS INSTALLATION

A. The LACS supplier shall install all control system equipment including controllers, sensors, damper actuators, reheat valves, fume hood sash sensors and fume hood operator display panels. This contractor shall install and terminate all low voltage control system wiring including wiring between each controller and between each controller and all control and sensing devices. This contractor shall also provide 24 VAC power where required by the control system and associated control devices.

B. The electrical contractor shall provide 120 volt power in the spaces for connection to the laboratory control system equipment. This contractor shall provide all transformers.

C. The mechanical contractor shall install all supply air terminals, reheat coils, exhaust air terminals, air valves and interconnecting ductwork associated with the laboratory ventilation system.

D. The Laboratory Control System manufacturer shall provide detailed control schematics and prepare field installation drawings for the ATC Contractor to install control wiring and tubing. The temperature control contractor shall provide a source of clean, dry, control grade 20 psig air as required.

3.11 LACS SYSTEM STARTUP

A. System startup shall be provided by factory certified and trained employees of the LACS manufacturer. Start up shall include the following tasks:

1. Determine when the HVAC equipment and each room is ready for ventilation system operational testing.

2. Set up all laboratory room and fume hood controllers and verify that all controlled parameters are being maintained at the required setpoint and that all associated operational aspects including measurement accuracies, alarm criteria, high-low limits, time delays, etc. are functioning in accord with the specified performance. The Testing Adjusting and Balancing (TAB) agent shall verify that all airflows are within the specified requirements and any departure from the specified performance shall be corrected and verified by the LACS to ensure all aspects of the control system are in full conformance with these specifications. The setup and verification process shall cover:

3. Fume hood face velocity and/or fume hood exhaust airflow rate control.

4. Room supply and exhaust airflows and the room ventilation rate control

5. Room static pressurization control and associated operational criteria.

6. Room ambient temperature control.

7. Room emergency control sequences.

8. Laboratory facility centralized exhaust system static pressure and associated exhaust system functionality.

B. All operational aspects of the LACS performance shall be formally recorded when verified and a copy of the recorded data shall be provided to the owner as part of the as-built documentation.

3.12 LACS SYSTEM DEMONSTRATION

A. The LACS supplier shall provide a functional demonstration on the LACS operation to owner designated representatives as well as other interested participants which may include the architect, engineer, as well as the general and mechanical contractors. This demonstration shall include any LACS control sequences selected by the owners representatives and may cover several laboratory rooms. Demonstration items that may be included (but not limited to) shall include fume hood and room airflow control, room pressurization control, exhaust system functionality, emergency functions and associated local monitoring provisions as well as required BMS monitoring and alarm reporting. The day for this demonstration shall be established by the owner's representatives in conjunction with the other participants.

3.13 LACS TRAINING

A. The laboratory ventilation control system contractor shall provide on-site instruction for up to six (6) owner designated personnel covering all aspects of the operation and use of the LACS including operator interface, control parameter setpoint adjustment, alarm limit and time delay adjustments, point trending, automatic startup, shutdown and changeover scheduling as well as the manipulation and utilization of all associated LACS monitoring and control functions. The training shall be augmented an operational manual for each attendee and shall also include the recommended procedures to verify the proper functioning of the LACS. Instructors shall be highly qualified factory trained personnel who reside at the local branch office of the LACS supplier and who are thoroughly familiar with all aspects of the overall subject matter and this specific facility's LACS. All training shall be provided on weekdays during the normal daytime working hours of the facility operations personnel.

B. Training shall consist of not less than 40 hours for designated personnel and shall include:

1. A thorough walk-through of the facility to identify LACS controls and controlled equipment.

2. Explanations of the LACS system, its operation and user interaction.

3. Explanation of laboratory room and fume hood control sequences.

4. Explanation of adjustment, inspection and test procedures.

C. Additional specialized operational training courses shall be made available to facility personnel covering the LACS and its components.

3.14 LACS INSPECTION, TESTING AND PREVENTIVE MAINTENANCE

A. To ensure system operational reliability, control systems that do not incorporate independent airflow measurement as required for true closed loop control shall include a two (2) year inspection, testing and preventive maintenance program on the overall LACS and its components after the initial warranty period has expired. This additional inspection, testing and preventive maintenance program shall be at

no additional cost to the owner and shall require the LACS supplier to include two thorough annual inspections of all airflow control devices, actuators and associated internal and external linkages. As a part of this program all airflow control device linkages shall be cleaned to avoid fouling and to ensure proper continued operation. Any airflow control device and/or linkage that cannot be restored to normal to its initial non-contaminated condition shall be replaced at no cost to the owner. The owner shall have the option of including designated facility personnel to accompany the supplier's personnel who are performing these procedures in order to ensure that no control system devices are overlooked and to acquire first-hand knowledge on how to perform the annual inspection, testing and preventive maintenance procedures.

B. Systems that incorporate true closed loop control by independent airflow measurement shall offer an annual inspection, testing and preventative maintenance program as an option to the owner.

3.15 LACS BUILDING MANAGEMENTSYSTEM INTERFACE

A. The following laboratory ventilation and environmental information shall be provided to the BMS:

1. Fume hood average face velocity (fpm) or (m/s) and high / low alarm.

2. Fume hood open face area (sq. ft.) or (sq. m).

3. Fume hood exhaust airflow (cfm) or (l/s) and high / low alarm.

4. Laboratory room supply airflow (cfm) or (l/s) and high / low alarm.

5. Laboratory room general exhaust airflow (cfm) or (l/s) and high / low alarm.

6. Laboratory supply air temperature (0F) or (0C).

7. Laboratory room ambient temperature (0F) or (0C) and high / low alarm.

8. Laboratory room differential airflow (cfm) or (l/s).

9. Exhaust system static pressure (In W.C.) or (Pa) and high / low alarm.

10. Exhaust system fan status, damper position, and associated alarm parameters.

11. Exhaust system stack velocity (fpm) or (m/s).

12. Laboratory room differential pressure (inches H20).

13. Information may be communicated by means of protocol translators or by seamless LAN connections. As an option the LACS supplier may provide the information by individual direct connections (hard wired inputs). If the direct connection approach is used the LACS supplier shall be responsible for all interconnecting wiring and any additional BMS and LACS system control panels that may be required to accept these inputs. If the communications approach is used the LACS supplier shall be responsible for all network wiring and any protocol translators required by the BMS and LACS.

14. The LACS system shall accept the following control inputs from the BMS:

a. Laboratory room airflow tracking offset setpoint adjustment.

b. Laboratory room ambient temperature setpoint adjustment.

c. Occupied/Unoccupied state of the laboratory room for room control mode changeover.

END OF SECTION