SECTION 23 09 00 (15900)
HVAC CONTROLS AND INSTRUMENTATION

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PART 1 - GENERAL

1.01 Work Included:

A. General - Building Management System (BMS) Contractor shall provide and install:

1. A fully integrated Building Automation System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

2. Complete temperature control system to be DDC with electric actuation as specified herein.

3. All wiring, conduit, panels, and accessories for a complete operational system.

4. BMS Contractor shall be responsible for all electrical work associated with the BMS.

    a. Perform all wiring in accordance with all local and national codes.

    b. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 16 specifications, NEC and local building code.

    c. Provide extension of 120 volt, 20 amp circuits and circuit breakers from Emergency power panels for all BMS equipment power. Provide and install UPS Power supply for all BMS system panels and terminal equipment controllers.

    d. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.

    e. All low voltage electrical control wiring throughout the building whether in exposed areas shall be run in conduit in accordance with the division 16 specifications, local building code and the NEC.

    f. Provide all miscellaneous field device mounting and interconnecting wiring for all mechanical systems including fuel oil system, emergency generators, chillers, water treatment, AC units, condensing units, expansion tanks, VFD, unit heaters, filtration systems, terminal units, fan coil units, electric heaters, chiller control system.

g. All systems requiring interlock wiring shall be hardwired interlocked and shall not rely on the BMS to operate (e.g. emergency generator to fuel oil pump interlock, emergency generator damper interlock, etc.) Interlock wiring shall be run in separate conduits from BMS associated wiring.

5. All wells for water monitoring devices, flow switches and alarms, as required.

    a. All installation kits for turbine flow meters, allow service and removal under pressure.

6. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. To accomplish this effectively, system shall be capable of utilizing standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols.

    a. System shall be capable of high speed Ethernet communication using TCP/IP protocol.

    b. System shall be capable of BACnet communication according to ANSI/ASHRAE 135-2004.

    c. The system shall be capable to integrate a wide variety of third-party devices and legacy systems.

    d. The intent is to either use the Operator Workstation provided under this contract to communicate with control systems provided by other vendors or to allow information about the system provided in this contract to be sent to another workstation. This allows the user to have a single seat from which to perform daily operation.

    e. All systems (i.e. UPS System, PDUs and Static Transfer, ATS Switches, Computer Room Air Conditioning, Emergency Generators, Lighting Control System, Security and Access Control, Closed Circuit TV and Fire Alarm System) integrated to Building Automation System that utilize BACnet communication protocol shall provide hardwired, normally-closed general alarm signals to Apogee system panel.

7. Provide hardware, software, and wiring to provide communication interfaces with each of the systems listed below.

    a. UPS System
    b. PDUs and Static Transfer
    c. ATS Switches
    d. Computer Room Air Conditioning (CRAC)
    e. Emergency Generators

f. Lighting Control System
g. Security and Access Control
h. Closed Circuit TV
i. Fire Alarm System
j. Hot Water Heat Exchangers

8. Provide system graphics for each controlled device and/or integrated systems as required by the owner. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

9. Primary DDC panels as follows:

   a. Minimum one (1) BMS system Primary DDC panel per floor installed in the Tele/Data room. The application specific controllers installed for the terminal units on a floor will be connected to the BMS panel on the same floor.

   b. Minimum one (1) BMS system Primary DDC panel per each major mechanical system:

      1) Air Handling Unit and associated Exhaust Fan
      2) Hot Water heat Exchangers and associated pumps
      3) Chillers and associated pumps
      4) Boilers and associated pumps
      5) Cooling Towers associated pumps
      6) Emergency Generator
      7) Fuel Oil System

   c. It shall be acceptable to combine up to three (3) of the following mechanical equipment into one (1) Primary DDC panel:

      1) Exhaust Fans
      2) Standalone Supply Fans
      3) Package AC Units

   d. It is acceptable to wire normally-closed general alarm of the following systems into any of the Primary DDC panels:

      1) Miscellaneous alarm monitoring (i.e. ATS, leak, temperature, light …etc.)
      2) Miscellaneous equipment (i.e. Unit Heater, Domestic Water Heater, Standalone Dampers …etc.)

e. Motors in motor control centers shall be controlled from the DDC controller associated with HVAC system. It shall not be acceptable to control all motors in a MCC from one DDC controller dedicated to the MCC. The intent of this specification is that the loss of any one DDC controller shall not affect the operation of other HVAC systems, only for the points connected to the DDC controller.

10. Stand-alone Application Specific Controllers (ASCs) for terminal equipment (CAV, FP VAV, and VAV units, and fan coil units). Provide UPS Power supply for all terminal equipment.

B. General product description

1. The installation of the control system shall be performed under the direct supervision of the BMS Contractor with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer. The BMS Contractor shall certify in writing, that the shop drawings have been prepared according to the equipment manufacturer's guidelines.

2. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.

3. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.

5. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

6. DDC Controllers shall be able to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust or control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (E.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priority levels for every point shall be fully programmable and adjustable.

7. Spare Points. All DDC controllers shall be installed with 25% spare points (of each type) and 25% spare memory capacity for connection of floor work.

1.02 Products Furnished but Not Installed Under This Section

A. Hydronic Piping:

1. Control Valves
2. Temperature Sensor Wells and Sockets
3. Flow Switches
4. Flow Meters

B. Refrigerant Piping:

1. Pressure and Temperature Sensor Wells and Sockets

C. Duct-work Accessories:

1. Dampers
2. Air-flow Stations
3. Terminal Unit Controls

1.03 Products Installed but Not Furnished Under This Section

A. Refrigeration Equipment:

1. Refrigerant Leak Detection System

B. Rooftop Air Handling Equipment:

1. Thermostats
2. Duct Static Pressure Sensors

1.04 Products Integrated To but Not Furnished or Installed Under This Section

A. Heat Generation Equipment:

1. Boiler Controls

B. Refrigeration Equipment:

1. Chiller Controls

C. Rooftop Air-Handling Equipment:

1. Discharge Air Temperature Control
2. Economizer Control
3. Volume Control

D. Unit Ventilators and Fan Coil Units:

1. Set Point Reset
2. Day/ Night Indexing

E. VAV Terminal Units:

1. Cross-Flow Velocity Sensor

F. Variable Frequency Drives

G. Lighting Control

H. Access/Security

I. Fire/Life Safety – Alarm, Trouble and Supervisory Signals

J. Power/Energy Monitoring

1.05 Related Sections

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Section 01 00 00 - General and Special Requirements
2. Section 01 33 00 - Submittal Requirements

3. Section 27 05 26 - Commissioning of HVAC
4. Section 05 45 19 – Commissioning of Integrated Automation
5. Section 28 13 00 - Security Access
6. Section 28 20 00 - Security Surveillance
7. Section 23 31 03 - Detection and Alarm (Fire and Smoke Alarm Systems)
8. Section 01 60 00 - Materials and Equipment
9. Section 21 05 00 – Common Work Results for Fire Suppression
10. Section 22 05 00 – Common Work Results for Plumbing
11. Section 23 05 00 – Common Work Results for HVAC
12. Section 23 82 00 - Heat-Generation Equipment
13. Section 23 60 00 - Refrigeration Equipment
14. Section 23 50 00 - Central Heating Equipment
15. Section 23 60 00 - Central Cooling Equipment
16. Section 23 70 00 - Central HVAC Equipment
17. Section 23 80 00 - Decentralized HVAC Equipment
18. Section 23 30 00 - HVAC Air Distribution
19. Section 23 05 93 - Testing, Adjusting, and Balancing for HVAC
20. Section 26 05 00 - Common Work Results for Electrical
21. Section 26 30 00- Facility Electrical Power Generating and Storing Equipment
22. Section 26 20 00 - Low-Voltage Electrical Transmission
23. Section 26 50 00 - Lighting

1.06 Approved Control System Contractors and Managers

A. The following are the approved Control System Contractors and Manufacturers:

1. Siemens Industry, Inc. – APOGEE System

1.07 Quality Assurance

A. The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel. BMS contractor shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. The BMS contractor shall provide full time, on site, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the BMS. The Bidder shall be regularly engaged in the installation and maintenance of BMS systems and shall have a minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.

B. The BMS contractor shall maintain a service organization consisting of factory trained service personnel and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

C. 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.

D. All BAS 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.

E. The BAS peer-to-peer network controllers and local user display shall also comply with the European Electromagnetic Compatibility (EMC) Framework, and bear the C-Tic Mark to show compliance. 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. DDC peer-to-peer controllers shall be compliant with the European EMC Directive, Standards EN 50081-2 and EN 50082-2, at the Industrial Levels. Additionally the equipment shall be compliant with the European LVD Directive and bear the CE mark in order to show compliance to both directives.

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

H. All wireless devices shall conform to:

    1. The requirements of Title 47 of the Code of Federal Regulations, FCC Part 15, governing radio frequency intentional radiating devices and be issued a FCC user identification and be so labeled. CE Directive 1999/5/EC (Radio Equipment and Telecommunications Terminal Equipment and the Mutual Recognition of their Conformity)

I. The manufacturer of the building automation 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.

J. 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. 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.

1.08 Codes and Standards

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

1. National Electric Code (NEC)
2. Uniform Building Code (UBC)

    a. Section 608, Shutoff for Smoke Control
    b. Section 403.3, Smoke Detection Group B, Office Buildings and Group R, Division 1 Occupancies
    c. Section 710.5, Wiring in Plenums
    d. Section 713.10, Smoke Dampers
    e. Section 1106, Refrigeration Machinery Rooms
    f. Section 1107, Refrigeration Machinery Room Ventilation
    g. Section 1108, Refrigeration Machinery Room Equipment and Controls
    h. Section 1120, Detection and Alarm Systems

3. Uniform Mechanical Code (UMC)
4. ANSI/ASHRAE Standard 135- 2004, BACnet--A Data Communication Protocol for Building Automation and Control Networks
5. [Local] Building Code

1.09 System Performance

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Multiple Alarm Annunciations.

1.10 Submittals

A. Product Submittal Requirements. Meet requirements of Section 01330 on Shop Drawings, Product Data, and Samples. Provide six copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2004 (or newer) compatible files on optical disk (file format: .dwg, .dxf, .vsd, or comparable) or hard copies on 11" x 17" prints of each drawing. When manufacturer's cut sheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work.

B. Provide submittals within 4 weeks of contract award

C. Submittal data shall consist of the following:

1. Direct Digital Control System Hardware:

a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

b. Manufacturer's description and technical data, such as product specification sheets, installation and maintenance instructions for items listed below and for relevant items not listed below:

1) Direct Digital Controllers (controller panels)
2) Transducers and transmitters
3) Sensors (including accuracy data)
4) Valves
5) Dampers
6) Relays and Switches
7) Control Panels
8) Power Supplies
9) Operator Interface Equipment
10) Uninterrupted Power Supply (UPS)

c. Wiring diagrams and layouts for each control panel. Show all termination numbers.

d. Floor plan schematic diagrams indicating control panel and space temperature sensor locations.

2. Central System Hardware and Software:

a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.

b. Manufacturer's description and technical data such as product specifications for items listed below and for relevant items furnished under this contract not listed below:

1) Central Processing Unit (CPU)
2) Monitors
3) Keyboards
4) Power Supply
5) Battery Backup
6) Interface Equipment Between CPU and Control Panels
7) Operating System Software
8) Operator Interface Software
9) Color Graphic Software
10) Third-Party Software

c. Schematic diagrams of all control, communication, and power wiring for central system installation. Show interface wiring to control system.

d. Provide sample color graphics on 11" x 17" prints for each typical system indicating conceptual layout of pictures and data for each graphic. List of color graphics to be provided showing or explaining which other graphics can be directly accessed.

e. Provide a list of BMS point names. BMS point nomenclature shall follow the format shown on Part 4: "Abbreviations & Nomenclature." of this guideline.

3. Controlled Systems:

a. Riser diagrams showing control network layout, communication protocol, and wire types.

b. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.

c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic use the same name.

d. Instrumentation list for each controlled system. List control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.

e. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system.

f. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.

4. Description of process, report formats and checklists to be used in Part 3: "Control System Demonstration and Acceptance."

5. Contractor shall submit documentation in the following phased delivery schedule:

a. Valve and damper schedules

b. Point Naming Convention – see Part 4: "Abbreviations & Nomenclature." of this guideline.

c. Sample Graphics

d. System schematics, including:

1) System Riser Diagrams
2) Sequence of Operations
3) Mechanical Control Schematics
4) Electrical Wiring Diagrams
5) Control Panel Layouts
6) Product Specification Sheets

e. As-Built drawings

D. Project Record Documents: Submit three copies of record (as-built) documents upon completion of installation. Submittal shall consist of:

1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD 2004 (or newer) compatible files on optical media and as 11" x 17" prints.

2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Part 3: "Control System Demonstration and Acceptance."

3. Certification of pressure test required in Part 3: "Control Air Tubing."

4. Operation and Maintenance (O & M) Manual.

    a. As-built versions of the submittal product data.

    b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.

    c. Operator's Manual with procedures for operating control systems, logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.

    d. Terminal equipment application specific controller installation and startup manuals.

    e. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

    f. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.

    g. Documentation of all programs created using custom programming language, including set points, tuning parameters, and object database.

    h. Graphic files, programs, and database on magnetic or optical media.

    i. List of recommended spare parts with part numbers and suppliers.

j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.

k. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

l. Licenses, guarantees, and warranty documents for equipment and systems.

E. Training Materials. Provide course outline and manuals at least six weeks before training.

1.11 Warranty

A. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Failures on control systems that include all computer equipment, transmission equipment and all sensors and control devices during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

C. If Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.

D. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with the above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

E. Exception:

1. Contractor shall not be required to warrant reused devices, except those that have been rebuilt or repaired. Installation labor and materials shall be warranted.

Demonstrate operable condition of reused devices at time of Engineer's acceptance.

2. Contractor shall not be required to warrant systems, equipment and devices or software if the damages and/or failures were caused by lack of training, unauthorized use, negligence or deliberate action of other parties, or job site conditions.

1.12 Ownership of Proprietary Material

A. Project specific software and documentation shall become Owner's property. This includes, but not limited to:

1. Graphics

2. Record drawings

3. Database

4. Application programming code

B. Documentation

1. General

a. Submit two (2) draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and submit four (4) interim final copies.

b. Submit four (4) copies of owner's manuals upon completion of project.

c. Submit two (2) electronic copies of complete as-built documentation on CD ROM. All drawings shall be in standard AutoCad 2004 format, other documentation shall be in standard MS Office format.

d. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above for "as built" manuals.

e. Assemble owner's manuals into multi-volume sets as necessary and required by the owner.

f. Protect each volume with a heavy duty binder. Volumes to have plastic printed dividers between major sections and have oversized binders to accommodate up to ½ inch thick set of additional information.

g. Each binder to be printed with project name and volume title on front cover and binder.

h. On the first page of each manual identify with project name, manual title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.

C. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:

1. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross reference the system point names.

2. Description of manual override operation of all control points in system.

3. BMS system manufacturers complete operating manuals.

D. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:

1. Complete as-built installation drawings for each building system.

2. Overall system electrical power supply schematic indicating source of electrical power for each system component. Indicate all battery backup provisions.

3. Photographs and/or drawings showing installation details and locations of equipment.

4. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.

5. Parts list with manufacturer's catalog numbers and ordering information.

6. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.

7. Manufacturer's operation, set-up, maintenance and catalog literature for each piece of equipment.

8. Maintenance and repair instructions.

9. Recommended spare parts.

E. Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum include the following:

1. Complete programming manuals, and reference guides.

2. Details of any custom software packages and compilers supplied with system.

3. Information and access required for independent programming of system.

1.13 Technical Proposal

A. Technical proposals shall be prepared in accordance with these specifications. Six (6) copies of the proposal shall be submitted with the bid. Proposals that are unbound, loose, and loose in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:

1. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.)

2. Information on training program to demonstrate specification compliance.

3. System Configuration as Proposed:

a. Describe system architecture including a schematic layout with location and type (model number) of all control panels.

b. Describe system operation, functions and control techniques.

c. Modularity.

d. Migration strategies to protect owner's investment in BMS system.

4. Technical data to support the information on the hardware and software proposed for this solution including any integrated systems and/or solutions.

5. Detailed description of all operating, command, application and energy management software provided for this project.

6. A signed certificate stating the Contractor "has read the performance and functional requirements, understands them and his technical proposal will comply with all parts of the specification."

7. Line by line specification concordance statement.

8. Other requirements for inclusion in the technical proposal are located throughout this specification.

B. Submit technical proposals with pricing in accordance with “Instructions to Bidders”.

C. Failure to submit technical proposal containing the information outlined above will result in rejection of bidder’s proposal.

PART 2 – PRODUCTS

2.01 Materials

A. All products used in this project installation shall be new and currently manufactured and shall have been applied in similar installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.02 Communication

A. The design of the BMS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet based primary network for all operator workstations, servers, and primary DDC controllers along with secondary Floor Level Networks (FLN) for terminal equipment application specific controllers.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

C. Operator Workstation:

1. A workstation, printer and Voice over IP (VOIP) phone shall be installed in the BMS Room. The computer shall be configured through ITS department before connecting to the SOM BMS virtual local area network (VLAN). The BMS computer, printer and desk phone hardware requirements shall include the following:

a. Computer:

1) Apple 13” Mac Book Pro or comparable
2) 1.7Ghz dual-core Intel Core with 4MB shared L3 cache
3) 256GB Flash Storage
4) 8GB
5) External Monitor Adapter
6) Ethernet Adapter
7) Mac Book Pro Security Lock Kit
8) Mac Book Pro compatible USB wired keyboard and mouse
9) Mac Book Pro docking station
10) 24” or larger monitor

b. Printer:

1) Apple compatible HP Laser Printer or comparable

c. Desk Phone:

1) ITS Standard issue VOIP phone or comparable

2. All color graphic operator workstations shall reside on the Ethernet network and access to client-server configuration via Windows Remote Desktop Protocol (RDP).

3. The servers will act as the central database for system graphics and databases to provide consistency throughout all system workstations.

4. The network shall allow concurrent use of multiple BMS software site licenses.

5. Provide two (2) identical servers and a shared hard disk drive array. The second “back-up” server shall function as a hot standby back-up and automatically and immediately take over as the system server on a failure of the primary server. Each server shall be an enterprise level fault tolerant server with redundant processors. Servers shall be located on different floors to maximize redundancy. Server consoles shall not be used as operator workstations.

D. Management Level Network Communication (MLN)

1. All PCs shall simultaneously direct connect to the Ethernet Management Level Network without the use of an interposing device.

2. Operator Workstation shall be capable of simultaneous direct connection and communication with BACnet/IP and TCP/IP corporate level networks without the use of interposing devices.

3. The Primary Network shall not impose a maximum constraint on the number of operator workstations.

4. Any controller residing on the primary network shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.

5. Any PC on the Primary Network shall have transparent communication with controllers on the building level networks connected via Ethernet.

6. Any break in Ethernet communication from the server to the controllers on the Primary Network shall result in a notification at the server.

7. The standard client and server workstations on the Primary Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.

8. System software applications will run as a service to allow communication with Primary Network Controllers without the need for user log in. Closing the application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.

9. Access to the system database shall be available from any standard workstation on the Primary Network. Client access to client-server workstation configurations over the Internet network shall be available via Web browser interface.

10. Thin Client access to client-server workstation configurations via Windows Terminal Services shall provide multiple, independent sessions of the workstations software. Terminal Services clients shall have full functionality, without the need to install the workstation software on the local hard drive.

E. Primary Network - Panel to Panel Communication:

1. All Building Controllers shall directly reside on the primary Ethernet network such that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.

2. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.

3. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

4. The primary network shall use TCP/IP over Ethernet. All devices must:

    a. Auto-sense 10/100 Mbps networks.

    b. Receive an IP Address from a Dynamic Host Configuration Protocol (DHCP) Server or be configured with a Fixed IP Address.

    c. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.

    d. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.

5. The primary network shall provide the following minimum performance:

    a. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building controllers, and other alarm printers within 15 seconds.

    b. Message and alarm buffering to prevent information from being lost.

    c. Error detection, correction, and re-transmission to guarantee data integrity.

    d. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.

    e. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building controller

to access, edit, modify, add, delete, back up, restore all system point database and all programs.

f. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (E.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

g. Devices containing custom programming must reside on the Primary Network

F. Secondary Network – Application Specific Controller Communication:

1. Communication over the secondary network shall be the manufacturer's standard protocol.

2. This level communication shall support a family of application specific controllers for terminal equipment.

3. The Application Specific Controllers shall communicate bi-directionally with the primary network through Building Controllers for transmission of global data.

4. A maximum of 30 terminal equipment controllers may be configured on individual secondary network trunks to insure adequate global data and alarm response times.

G. Internet Based Communication:

1. Terminal Services Operator Interface

a. Client access to client-server workstation configurations over low-bandwidth network technologies shall be available optionally via Windows Terminal Services or Web browser interface. Remote client access via Windows Terminal Services shall provide multiple, independent sessions of the workstations software – Terminal Services clients shall have workstation software access, without the need to install the workstation software on the local hard drive]

H. Remote Notification Paging System:

1. Workstations shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition. Xxx.

2. There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.

3. On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.

4. Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.

5. System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.

6. Message detail shall be configurable on a per user basis.

7. During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.

8. Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.

9. Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.

I. Operator Interface Software:

1. Basic Interface Description

a. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between Ethernet-connected building level networks.

b. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.

c. The navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded hyperlinks to open graphics, documents, drawings, etc.

d. Selection of applications within the operator interface software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.

e. The graphical toolbar menu shall have the option of adding additional user definable buttons that can launch local or network programs, files, folders on Internet/Intranet addresses external to the BMS software.

f. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run on a Windows XP, 2000, or comparable 32 bit operating system. System database parameters shall be stored within an object-oriented database. Standard Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information

g. The software shall provide, as a minimum, the following functionality:

    1) Real-time graphical viewing and control of the BMS environment

    2) Reporting

    3) Scheduling and override of building operations

    4) Collection and analysis of historical data

    5) Point database editing, storage and downloading of controller databases.

6) Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.

7) Alarm reporting, routing, messaging, and acknowledgment

8) "Collapsible tree," dynamic system architecture diagram application:

    a) Showing the real-time status and definition details of all workstations and devices on a management level network

    b) Showing the real-time status, definition details and locations of all Building Controllers at the Primary Network.

    c) Showing the definition details of all application specific controllers

9) Definition and construction of dynamic color graphic displays.

10) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.

11) On-screen access to User Documentation, via online help or PDF-format electronic file.

12) Automatic database backup at the operator interface for database changes initiated at Building Controllers.

13) Display dynamic trend data graphical plot.

    a) Must be able to run multiple plots simultaneously

    b) Each plot must be capable of supporting 10 pts./plot minimum

    c) Must be able to command points directly off dynamic trend plot application.

    d) Must be able to plot both real-time and historical trend data

14) Program editing

15) Report output shall have the option to be sent to an email address or group of email addresses.

16) Transfer trend data to 3rd party spreadsheet software

a) Scheduling reports

b) Operator Activity Log

c) Open communications via OPC Server

d) Open communications via BACnet Client & Server

h. Enhanced Functionality:

1) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):

a) Dynamic color graphics application

b) Alarm management application

c) Scheduling application

d) Dynamic trend graph data plotter application

e) Dynamic system architecture diagram application

f) Control Program and Point database editing applications

g) Reporting applications

2) Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

i. Security: Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control,

display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application. And each BMS workstation user account shall use a Windows Operating System user account as a foundation.

j. The operator interface software shall also include an application to track the actions of each individual operator, such as alarm acknowledgement, point commanding, schedule overriding, database editing, and logon/logoff. The application shall list each of the actions in a tabular format, and shall have sorting capabilities based on parameters such as ascending or descending time of the action, or name of the object on which the action was performed. The application shall also allow querying based on object name, operator, action, or time range.

k. Dynamic Color Graphics application shall include the following:

    1) Must include graphic editing and modifying capabilities

    2) A library of standard control application graphics and symbols must be included

    3) Must be able to command points directly off graphics application

    4) Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks

    5) Navigation through various graphic screens shall be optionally achieved through a hierarchical “tree” structure

    6) Graphics viewing shall include zoom capabilities

    7) Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.

    8) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other

workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

l. Reports shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers, file or email address. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1) A general listing of all or selected points in the network

2) List of all points currently in alarm

3) List of all points currently in override status

4) List of all disabled points

5) List of all points currently locked out

6) List of user accounts and access levels

7) List all weekly schedules and events

8) List of holiday programming

9) List of control limits and dead bands

10) Custom reports from 3rd party software

11) System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points

12) List of programs

13) List of point definitions

14) List of logical point groups

15) List of alarm strategy definitions

16) List of Building Control panels

17) Point totalization report

18) Point Trend data listings

19) Initial Values report

20) User activity report

m. Scheduling and override

1) Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation and in the Building Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:

a) Weekly schedules

b) Zone schedules

c) Event schedules – an event consists of logical combinations of equipment and/or zones

d) Report schedules

e) Ability to schedule for a minimum of up to ten (10) years in advance.

2) Additionally, the scheduling application shall:

a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)

b) Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)

c) Provide searching capabilities of schedules based on name – with wildcarding options

n. Collection and Analysis of Historical Data

1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an

extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.

2) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. BMS contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. BMS contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.

3) Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of ten points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of ten (10) dynamic graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point. Operator shall be able to zoom in on a specific time range within a plot. The dynamic trend plotting application shall support the following types of graphs, with option to graph in 3D: line graph, area graph, curve graph, area-curve graph, step graph, and scatter graph. Each graph may be customized by the user, for graph type, graph text, titles, line styles and weight, colors, and configurable x- and y-axes.

4) Provide additional functionality that allows the user to display trend data for points from a graphic, alarm status screen, or a displayed point log report.

o. Dynamic Color Graphic Displays

1) Capability to create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including, but not limited to, air handling units, chilled water systems, hot water boiler systems, and room level terminal units.

2) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.

3) Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.

a) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the operator interface software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed.

b) Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.

c) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.

d) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.

e) State text for digital points can be user-defined up to eight characters.

f) Provide the user the ability to display trend data from the graphic screen through right click feature selection.

4) Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.

5) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

6) The Windows environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

7) Off the shelf graphic software shall be provided to allow the user to add, modify or delete system graphic background displays.

8) A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.

9) The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic

display of a selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.

10) The graphic application shall provide a tool be able to change full or partial point names on a graphic.

p. System Configuration & Definition

1) A "Collapsible tree," dynamic system architecture diagram/display application of the site-specific BMS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, Building Controllers, as well as 3rd-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics connections to Building Controllers.

2) Network wide control strategies shall not be restricted to a single Building Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

3) Provide automatic backup and restore of all Building controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Building Controller. Changes made at the user-interface of Building Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

4) System configuration, programming, editing, graphics generation shall be performed on-line.

5) Point database configuration shall be available to the user within a dedicated point database editor application included in the operator interface software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database.

6) The point editor shall have the capability to assign "informational text" to points as necessary to provide critical information about the equipment.

7) The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the Building Controllers.

8) The operator interface software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.

9) Control program configuration shall be available to the user within a dedicated control program editor application included in the operator interface software. The editor shall allow for creation, modification and deletion of control programs. The editor shall include a programming assistance feature that interactively guides the user through parameters required to generate a control program. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the Building Controllers. The editor shall provide the option for editing the control programs in an online or offline mode, and also the ability to selectively enable or disable the live program execution within the Building Controllers. Additional compiler checks shall be built into the program editor which assists in the verification of valid GOTO statements. The additional compiler check shall also verify if each point in the program was defined in another panel.

q. Alarm Management

1) Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.

2) Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time &

date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.

3) Alarm Display shall have the ability to list & sort the alarms based on alarm status, point name, ascending or descending alarm time.

4) Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.

5) Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm.

6) Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs. The system shall have the ability to modify the priority text based on operator preference.

7) Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BMS system management.

r. Remote notification of messages

1) Operator Interface software shall be configured to send out messages to numeric pagers, alphanumeric pagers, phones (via text to speech technology), SMS (Simple Messaging Service, text messaging) Devices, and email accounts based on a point's alarm condition.

2) There shall be no limit to the number of points that can be configured for remote notification of alarm conditions and no limit on the number of remote devices which can receive messages from the system.

3) On a per point basis, system shall be configurable to send messages to an individual or group and shall be configurable to send different messages to different remote devices based on alarm message priority level.

4) Remote devices may be scheduled as to when they receive messages from the system to account for operators' work schedules.

5) System must be configurable to send messages to an escalation list so that if the first device does not respond, the message is sent on to the next device after a configurable time has elapsed.

6) Message detail shall be configurable on a per user basis.

7) During a "flood" of alarms, remote notification messages shall have the ability to optimize several alarms into an individual remote notification message.

8) Workstation shall have the ability to send manual messages allowing an operator to type in a message to be sent immediately.

9) Workstation shall have a feature to send a heartbeat message to periodically notify users that they have communication with the system.

2.03 Building Controller Software

A. General

1. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.

2. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.

3. All points, panels and programs shall be identified by a 30 character name. All points shall also be identified by a 16 character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.

4. All digital points shall have a user defined two-state status indication with 8 characters minimum (e.g. Summer, Enabled, Disabled, Abnormal).

5. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

6. The Building Controllers shall have the ability to perform the following pre tested control algorithms:

    a. Two position control

    b. Proportional control

    c. Proportional plus integral control

    d. Proportional, integral, plus derivative control

    e. Automatic tuning of control loops

    f. Model-Free Adaptive Control

7. Each controller shall be provided with an interactive HELP function to assist operators using POTs and remote connected operators.

8. Building Controllers shall not be susceptible to Microsoft Windows operating systems based viruses.

B. System Security

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.

3. User Log On / Log Off attempts shall be recorded.

4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

5. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

C. User Defined Control Applications

1. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

2. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.

3. Any process shall be able to issue commands to points in any and all other controllers in the system.

4. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

5. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

6. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

D. Alarm Management

1. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

2. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.

3. An Alarm "shelving" feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).

4. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

5. Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.

6. All alarm or point change reports shall include the point's user defined language description and the time and date of occurrence.

7. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, Building Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each Building Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

8. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.

9. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

    a. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

10. Operator-selected alarms shall be capable of initiating a call to a remote operator device.

E. Scheduling

1. Provide a comprehensive menu driven program to automatically start and stop designated object or group of objects in the system according to a stored time.

2. Schedules shall reside in the building controller and shall not rely on external processing or network.

3. It shall be possible to define a group of objects as a custom event (i.e. meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.

4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.

5. The operator shall be able to define the following information:

    a. Time, day

    b. Commands such as on, off, auto, etc.

    c. Time delays between successive commands.

    d. There shall be provisions for manual overriding of each schedule by an authorized operator.

6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:

    a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.

    b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

    c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.

F. Peak Demand Limiting (PDL):

1. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.

2. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.

3. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.

4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.

5. Ability to initialize and restart the meter area directly from the workstation.

G. Temperature-compensated duty cycling.

1. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.

2. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

H. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

I. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

J. Enthalpy switchover (economizer). The Building Controller Software (BCS) shall control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the BCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.

K. Loop Control. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and weighting parameters shall be user-selectable.

L. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

M. Staggered Start

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.

2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

N. Totalization

1. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.

2. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

3. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

O. Data Collection

1. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.

2. Building Controllers shall store point history data for selected analog and digital inputs and outputs:

   a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.

3. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either

user-defined interval, manual command or when the trend buffers are full. All trend data shall be available for use in 3rd party personal computer applications.

4. Loop Tuning. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a <monthly, seasonal, quarterly, annual> period.

    a. For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).

    b. For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.

        1) In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.

        2) Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

2.04 Building Controllers

A. Building Controllers shall be 32 bit, multi-tasking, multi-user, real-time 48 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

B. Each Building Controller shall support a minimum of 3 directly connected Secondary Networks.

C. Each Building Controller shall have sufficient memory, a minimum of 72 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for

points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.

D. Building Controller shall have an integral real-time clock.

E. Each Building Controller shall support firmware upgrades without the need to change hardware.

F. Each Building Controller shall support:

1. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.

G. Spare Point Capacity.

1. Each Building Controller shall have a minimum of 10 percent spare point capacity.

2. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.

3. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:

a. Expansion modules
b. Sensor/actuator
c. Field wiring/tubing.

H. Serial Communication. Building Controllers shall provide at least two EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.

I. Manual Override. The operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, integral hand/off/auto operator override switches for all digital control type points and gradual switches for all analog control type points. These override switches shall be operable whether the panel processor is operational or not. Each Building Controller shall monitor and alarm the hand, off and auto positions of integral HOA switches.

J. I/O Status and Indication. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.

K. Self Diagnostics. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

L. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 hours.

M. Environment.

1. Controller hardware shall be suitable for the anticipated ambient conditions.

2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

N. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

    a. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft.).

2. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:

    a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V

    b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact

c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power

d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

3. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:

a. IEEE Standard 587 1980

b. UL 864 Supply Line Transients

c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

O. Minimum Approved Building Controllers.

1. BMS Contractors shall furnish Building Controllers as listed below. Providing an approved controller does not release the contractor from meeting all performance, software and hardware specifications for Building Controllers and system operations.

2. Siemens Building Technologies Inc. - Apogee Programmable Controller – PX Compact Series (PXC36-PEF.A) – 36 point, Ethernet/IP or RS-485 ALN, Island Bus, P1 FLN with FLN license installed.

3. Johnson Controls Inc., Metasys Extended Architecture- (with NAE-55 and DX-9100s mounted in a common enclosure for each DDC panel).

4. Honeywell, EBI Automation System (with ILON 1000 and XL5000 in a common enclosure for each DDC panel).

2.05 Application Specific Controllers (ASC)

A. General

1. Provide for control of each piece of equipment , including, but not limited to the following:

a. Variable Air Volume (VAV) boxes

b. Constant Air Volume (CAV) boxes

c. Reheat Coils (RH)

d. Fan Coil Units (FCU)

e. Fan Powered Boxes (FPB)

f. Unit Conditioners

g. Heat Pumps

h. Unit Ventilators

i. Room Pressurization

j. Supplemental AC units

k. Digital Energy Monitors

2. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.

3. The use of Secondary Network controllers with custom program applications to control AHU's, water systems, etc. is not acceptable.

4. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

5. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.

6. Discharge Air Temperature Sensors. Each controller performing space temperature control shall be provided with a temperature sensor installed on the supply duct between the terminal box and room supply air diffuser.

7. Space Temperature Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor.

a. Wired Sensor specifications. The sensor may be either RTD or thermistor type providing the following.

1)	Accuracy:	+ .5 F
2)	Operating Range:	35 to 115 F
3)	Set Point Adjustment Range:	55 to 95 F
4)	Calibration Adjustments:	None required
5)	Installation:	Up to 100 ft. from controller
6)	Auxiliary Communications Port:	as required
7)	Local LCD Temperature Display:	as required
8)	Set Point Adjustment Dial	as required
9)	Occupancy Override Switch	as required

b. Set Point Modes:

1) Independent Heating, Cooling

2) Night Setback-Heating

3) Night Setback-Cooling

c. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

d. LCD Display. Interactive, two- line liquid crystal display shall allow the operator to query and modify operating parameters of the local room terminal unit from the room sensor. The display shall indicate the space temperature and associated ASC point when not being used to query or modify operating parameters.

e. Set Point Adjustment Dial. The set point adjustment dial shall allow for modification of the temperature by the building operators. Set point adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

f. Override Switch. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

8. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

9. Control Algorithms. The controller shall receive its real-time data from the Building Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

10. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

11. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.

    a. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary

b. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

c. Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

12. Memory.

a. Provide each ASC with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.

b. Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation.

13. Power Supply. Main 120 VAC circuit to ASCs shall be powered from Emergency/UPS power. The ASCs shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:

a. The existing line voltage power trunk and installing separate isolation transformers for each controller

b. Dedicated line voltage power source and isolation transformers at a central location and installing 24VAC power trunk to supply multiple ASCs in the area.

14. Environment. The controllers shall function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

15. Immunity to noise. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft.).

16. Manufacturer Installed Controls.

    a. BMS manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.

    b. Cost of factory mounting shall be borne by equipment manufacturer.

    c. For VAV terminals, equipment manufacturer shall provide and install flow-cross sensor, 24 Vac transformer, controls enclosure, fan relay, SCR and factory install, wire and tube ASC controller and actuator.

    d. Fan powered VAV terminals shall be equipped with a fan speed controller and relay to change summer and winter speed set point.

B. Controllers for VAV terminals.

1. All VAV terminal control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. ASC's that require factory application changes are not acceptable. The VAV terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:

    a. VAV cooling only

    b. VAV with hot water or electric reheat

    c. Fan-powered VAV

    d. Fan-powered VAV with hot water or electric reheat

2. The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual air flow. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of +5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled and maintained to within +5% of Set point at the specified parameters. The BMS contractor shall provide the velocity sensor if required to meet the specified functionality.

C. Controllers for CV terminals.

1. Constant volume ASCs shall meet all requirements of paragraphs as previously specified for VAV terminals. The controllers shall have a minimum and

maximum flow set point, which shall be selected based on interior ventilation requirements. Under normal conditions, the set point shall be set to minimum set point. When the floor area requires additional ventilation (high CO2 level, manual command, etc.) the set point shall be set to maximum set point.

D. Controllers for Fan Powered Boxes (FPB) terminals.

1. FPB ASCs shall monitor the primary air and return air flows with separate flow sensors and sum the flows to read total air flow.

2. The ASC shall have the capability to control the speed of the fan speed through the BMS system.

3. Each controller performing space heating control shall incorporate an algorithm allowing for modulation of a hot water reheat valve or cycling up to three (3) stages of electric reheat via an SCR to satisfy space heating requirements. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space cooling requirements. This algorithm shall function to signal the respective Building Controller to perform the required discharge temperature reset in order to maintain space temperature cooling set point.

E. Controllers for Supplemental AC Units.

1. Supplemental AC unit ASCs shall meet all requirements of paragraphs as previously specified for VAV terminal ASCs except for velocity/cfm control.

F. Digital Energy Monitors:

1. Provide three phase digital Watt-meters with pre-wired current transmitters. (CT) 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 an operator tool) shall indicate: proper operation, defective wiring or low power-factor, device malfunction, and over-load condition. The meters shall include the following:

2. 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

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

a. The Watt-meter 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.

b. The Watt-meter shall reside directly on the Secondary Network along with other Secondary Network 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

2.06 Input/output Interface:

A. Hardwired inputs and outputs may tie into the system through building or application specific controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

E. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.

F. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

H. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

I. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.07 Power Supplies and Line Filtering

A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.

1. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

2. Line voltage units shall be UL recognized and CSA approved.

C. Power line filtering.

1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:

    a. Dielectric strength of 1000 volts minimum

    b. Response time of 10 nanoseconds or less

    c. Transverse mode noise attenuation of 65 dB or greater

    d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.08 Auxiliary Control Devices

A. General

1. Specified in this section are the following hard wired input/output devices connected to the Building Controller or ASC.

    a. Automatic Dampers
    b. Fire/Smoke Dampers
    c. Electric Damper Actuators
    d. Pneumatic Damper/valve Actuators
    e. Motorized Isolation Valves
    f. Ball Valves
    g. Automatic Control Valves
    h. Airflow Measuring Stations
    i. Binary Temperature Devices
    j. Temperature Sensors
    k. Dew Point/Humidity Sensors
    l. Pressure Sensors
    m. Water Differential Pressure Sensors
    n. Differential Pressure Switches
    o. Analog Water Level Sensors
    p. Water Leak Detection Systems
    q. Audio/Visual Alarm Units
    r. Fuel Oil Meters
    s. Water BTU Meters
    t. Vortex Shedding Flow Meters
    u. Indoor Air Quality (CO2/VOC) Space Sensors
    v. Relays
    w. Override Timers
    x. Current Transformers
    y. Voltage Transmitters

z. Voltage Transformers
aa. Power Monitors
bb. Current Switches
cc. Pressure Electric Switches
dd. Electro-pneumatic Transducers
ee. Local Control panels
ff. Local User Display

2. Specified in this section are the following devices connected to the BMS using secondary network communication.

a. Water BTU Meters
b. Variable Frequency Drives (VFD)
c. Indoor Air Quality (CO2/VOC) Space Sensors
d. Power Monitors

B. Automatic Dampers

1. Dampers shall have 13 gauge galvanized frames of not less than 3" in width and blades of 14 gauge, equivalent thickness, galvanized steel roll formed airfoil type for low pressure drop and low noise generation and shall be adequately braced to from a rigid assembly where required in galvanized duct work. Dampers shall have blades not more 8" wide. Linkage and hardware shall be zinc plated steel and shall be concealed out of airstream within the damper frame. Damper blades and rods shall be installed in horizontal position.

2. In copper, aluminum and stainless steel duct work, damper material shall match the duct work material.

3. All dampers shall be of the proportioning or opposed blade type, and shall be motor operated. Dampers shall have continuous elastomer or stainless steel stops to avoid leakage. Bearings shall be corrosion resistant oil tight stainless steel sleeve type. All dampers shall be provided with continuous 3/16" x ½" closed cell neoprene gasket around perimeter of the frame and at interlocking blade edges to form an air tight seal. Blade seals shall be suitable for -76° F to 350°F mechanically locked into blade edge. Adhesive of clip on type are not acceptable. Axles shall be square or hexagonal positively locked into damper blade. Linkage shall be concealed out of airstream within the damper blade.

4. All dampers shall be constructed to provide a maximum leakage of 3-1/2%, with an approach velocity of 1500 fpm when closed against a pressure of 4 inches of water. Submit leakage and flow characteristic data for all dampers.

5. All outside air dampers, with the exception of the emergency generator dampers, shall automatically close in the event of a loss of power. Dampers on emergency generators shall automatically open on a loss of power.

6. All smoke dampers shall be constructed in accordance with UL standard 555S.

7. Dampers shall be Ruskin Model CD60, Imperial Model 800 or approved equal.

C. Fire/Smoke Dampers

1. Dampers shown on drawings designated as "F/SM" shall comply with the following. They shall have a U.L. label. Dampers shall be pneumatically operated combination fire and smoke Ruskin, Imperial or approved equal, provided with factory installed U.L. rated full sleeves. Provide air foil or "V" blade damper blades supported with shafts and stainless steel bearings to allow daily operation. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems when closed shall be the equivalent of a 1-1/2 hour fire damper. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G. Damper actuators shall be provided with position indicator switches to enable remote status of open or closed positions (only those dampers designated in the electrical trade plans and specifications will be provided with position switches and will be wired for remote status and remote open/closed operation, but all dampers will be provided with position indicators for possible future use). Note that dampers which are controlled from a central fire command station shall be provided with a 212□F heat sensor with normally closed contacts (manual reset) to close and lock damper if open. Additionally, dampers shall be factory equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250□F to 350□F, depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station. Dampers which are not controlled from a central fire command station shall have a fusible link which melts on heat causing damper to close and lock in a closed position. The following will be accepted in lieu of the two fire stats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150□F or less.

2. Dampers shown on drawings designated "SM" shall comply in all respects to F/S damper description including position indicating switches except they shall not be provided with a heat sensor or fusible link.

D. Electric Damper Actuators

1. Manufacturers

    a. Belimo
    b. Siemens

2. Electric Actuators

    a. Entire actuator shall be UL or CSA approved by a Nationally Recognized Testing Laboratory.

    b. Enclosure shall meet NEMA 4N weatherproof requirements for outdoor application

    c. Dampers: The actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The clamp shall be steel of a V-belt design with associated V-shaped, toothed cradle attaching to the shaft for maximum strength and eliminating slippage via cold weld attachment. Single bolt or set screw type fasteners are not acceptable. Aluminum clamps are unacceptable.

    d. Valves: Actuators shall be specifically designed for integral mounting to valves without external couplings.

    e. Actuator shall have microprocessor based motor controller providing electronic cut off at full open so that no noise can be generated while holding open. Holding noise level shall be inaudible.

    f. Noise from actuator while it is moving shall be inaudible through a tee-bar ceiling.

    g. Actuators shall provide protection against actuator burnout using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation or use of magnetic clutches are not acceptable.

    h. Modulating Actuators:
        1) General: Actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. Actuators shall have positive positioning circuit so that controlled device is at same position for a given signal regardless of operating differential pressure. Actuators that internally use a

floating actuator with an analog signal converter are not acceptable.

2) Optional for VAV box dampers only: Actuators may be floating type if either:
   a) Feedback from the actuator is provided as an analog input; or
   b) For VAV boxes NOT serving areas occupied 24 hours per day, damper position is estimated by timing pulse-open and pulse-closed commands with auto-zeroing whenever zone is in Unoccupied mode and damper is driven full closed.

i. Where indicated on Drawings or Points List, actuators shall include
   1) 2 to 10 VDC position feedback signal
   2) Limit (end) position switches

j. All 24 VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC. Actuators operating on 120 VAC power shall not require more than 11 VA.

k. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

l. Actuators shall be provided with a conduit fitting at a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

m. Where fail-open or fail-closed position is required an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe are not acceptable. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.

n. Actuators shall be capable of being mechanically and electrically paralleled to increase torque where required.

o. All non-spring return actuators shall have an external gear release to allow manual position of the damper when the actuator is not powered. Spring return actuators with more than 60 inch-pound torque capacity shall have a manual crank for this purpose.

p. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed.

q. Actuators shall clearly indicate position of damper valve.

3. Electric Actuators for Large Butterfly Valves

a. Entire actuator shall be UL or CSA approved by a National Recognized Testing Laboratory.

b. The valve actuator shall consist of a capacitor-type reversible electric motor, gear train, limit switches and terminal block, all contained in a die cast aluminum enclosure.

c. Enclosure shall meet NEMA 4X weatherproof requirements for outdoor applications

d. Output shaft shall be electroless nickel plated to prevent corrosion.

e. Actuator shall have a motor rated for minimum 75% duty cycle. Duty cycle shall be defined as running time divided by installed time at maximum torque.

f. Actuator shall be suitable for operation in ambient temperature ranging from -22° F to +150° F (-30° C to +65° C)

g. A pre-wired cable shall bring wiring outside enclosure to avoid necessity of opening cover.

h. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.

i. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator. When in manual operation electrical power to the actuator will be permanently interrupted.

j. The hand wheel will not rotate while the actuator is electrically driven.

k. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.

l. Provide limit (end) position switches where indicated on schematics.

4. Normal Position: Except as specified otherwise therein, the requirement for spring return actuators and the normal positions of control devices shall be as

indicated in table below. For actuators indicated as Spring Return Required in the table, normal position refers to the position with zero control signal and with no power to the actuator. For actuators not indicated as Spring Return Required in the table, non-spring style actuators are acceptable and normal position refers to the position with zero control signal.

Device	Normal Position	Spring Return Required
Outside air damper	CLOSED	Yes
Return air damper	OPEN	Yes
Exhaust relief air damper	CLOSED	Yes
Domestic hot water generator	CLOSED	Yes
AHU heating coil valves	CLOSED	Yes
AHU cooling coil valves	OPEN	Yes
Equipment isolation valves	OPEN	
Hot water reheat coil valves	CLOSED	Yes
Fan-coil HW and CHW valves	CLOSED / OPEN	Yes
CRAC CHW valves	OPEN	Yes
VAV box dampers	OPEN	Yes

5. Valve Actuator Selection
    a. Modulating actuators for valves shall have minimum range ability of 50 to 1.

    b. Water
        1) 2-way and two position valves
            a) Tight closing against 125% of system pump shut-off head
            b) Modulating duty against 90% of system pump shut-off head.

        2) 3-way shall have close-off against twice the full open differential pressure for which they are sized.

6. Damper Actuator Selection
    a. Actuators shall be direct coupled. For multiple sections, provide one actuator for each section; linking or jack-shafting damper sections shall not be allowed.

    b. Provide sufficient torque as velocity, static, or side seals require per damper manufacturer's recommendations and the following:
        1) Torque shall be a minimum 5 inch-pounds per square foot for opposed blade dampers and 7 inch-pounds per square foot for parallel blade dampers.

2) The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating.

E. Pneumatic damper/valve actuators

1. Pneumatic actuators shall be piston-rolling diaphragm type or diaphragm type with easily replaceable, beaded, molded neoprene diaphragm.

2. Actuator housings may be molded or die-cast zinc or aluminum.

3. Actuator size and spring ranges selected shall be suitable for intended application.

4. Rate pneumatic actuators for a minimum 140 kPa (20 psig).

5. Damper actuators shall be selected in accordance with manufacturer's recommendations to provide sufficient close-off force to effectively seal damper and to provide smooth modulating control under design flow and pressure conditions. Furnish a separate actuator for each damper section.

6. Valve actuators shall provide tight close off at design system pressure and shall provide smooth modulation at design flow and pressure conditions.

7. On sequencing applications, valve and damper actuators shall be sized for a maximum of 14 kPa (2 psi) shift in nominal spring range. Spring ranges shall be selected to prevent overlap or positive positioners shall be provided.

8. Positive positioners to have the following performance characteristics:

    a. Linearity: ±10% of output signal span
    b. Hysteresis: 3% of the span
    c. Response: 1/4 psig input change
    d. Maximum pilot signal pressure: 140 kPa (20 psig)
    e. Maximum control air supply pressure: 420 kPa (60 psig)

9. Positive positioners shall be provided on actuators for inlet vane control and on any other actuators where required to provide smooth modulation or proper sequencing.

10. Positive positioners shall be high-capacity force balance relay type with suitable mounting provisions and position feedback linkage tailored for particular actuator.

11. Positive positioners shall use full control air pressure at any point in stem travel to initiate stem movement or to maintain stem position. Positioners shall operate on a 20 to 100 kPa (3 to 15 psig) input signal unless otherwise required to satisfy the control sequences of operation.

12. All actuators shall be designed and manufactured using ISO900registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-93

F. Motorized isolation valves

1. Butterfly Valves.

a. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein. All butterfly valves shall have body ratings in accordance with the piping specifications. Valves shall be high performance, fully lugged with carbon steel body ANSI 150/300. Valves shall be rated for bubble tight dead end closure, with 316 stainless steel disc, stainless steel shaft and reinforced Teflon seat and seals.

b. Motorized valves located outdoors or in areas subject to outdoor air conditions provide fail in place, electric operators with water proof enclosure, crankcase heater, and open and closed position limit switches. Valve and all accessories shall be constructed for outdoor use. All electrical devices shall be weather proof and NEMA 4 rated.

c. All valves shall be provided with external position indicators and a speed control device to prevent rapid closure.

d. All valves shall be provided with manual override hand wheels for operating the valve.

e. The valves shall be line size as shown on plans.

f. Motorized isolation valves shall be Jamesbury 815/830L, Fisher, DeZurik Model HP II or Bray.

G. Ball Valves

1. Furnish automatic full port ball valves for isolation requirements on line sizes up to 2’as shown on the drawings or required herein. All ball valves shall have ANSI 250 body rating. Valves shall bronze body and stainless steel trim.

2. Valves shall close against a differential pressure equal to the design pump head pressure plus 10%.

3. The valves shall fail to their safe position upon power loss as specified in the sequence of operation.

4. All valves shall be provided with manual override.

5. Provide valve position indicator end switches with the actuator.

6. The valves shall be line size as shown on plans.

7. Motorized isolation valves shall be Neptronic, Dezurik or Siemens.

H. Automatic Control Valves

1. General:

a. Control valves shall be two-way or three-way type single seated globe type for two-position or modulating service as shown. Valves shall meet ANSI Class IV leakage rating.

b. Body pressure rating and connection type construction shall conform to pipe, fitting and valve schedules. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided.

c. Valve operators shall be of pneumatic or electric type.

d. The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of power failure.

e. Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.

f. Furnish differential pressure control valves for all water systems as shown on plans and/or specified in the sequence of operations.

g. Provide valves 2" and smaller with screwed end bronze bodies and stainless steel trim. Provide valves 2-1/2" and larger with flanged ends, cast iron body and stainless steel trim.

h. For modulating service that require large valve size (above 6”), such as cooling tower temperature bypass, chiller head pressure ,etc. where proper control with globe type control valve cannot be achieved or the application is not economical butterfly or v-port ball valves are allowed.

2. Water Valves:

    a. Control valves shall be of equal percentage flow characteristics for modulating service.

    b. Sizing Criteria:

3. Steam Valves:

    a. Control valves shall be of linear flow characteristics for modulating service.

    b. Sizing Criteria:

I. Air Flow Measuring Stations

1. Fan Inlet Type:

    a. Provide where indicated on the plans, airflow measuring stations of fan inlet type. Airflow traverse probes shall be suitable for mounting in the inlet bell(s) of the indicated fan.

    b. Probes shall be provided with the appropriate end support brackets for mounting in the inlet bell(s). Where fans are of dual inlet type, two sets of inlet probes must be provided.

    c. Fan inlet probes shall be provided with the fittings to allow for the connection of control tubing to the probe assemblies.

    d. Probes shall be capable of operating with an accuracy of 3% of actual volume over the fan operating range.

    e. The installation of the air flow measuring stations shall be coordinated with sheet metal contractor to ensure actual accuracy and accessibility for maintenance.

    f. Fan inlet probes shall be Tek-Air T-FP7000.

2. Duct Mounted Type:

    a. Provide where indicated on the plans, airflow traverse probes of the insertion type, capable of continuously measuring air volume in the duct served.

b. Probes shall utilize multiple total and suction pressure measurement points, located along the length of the probe surface in accordance with ASHRAE recommendations for duct traversing.

c. The probes shall provide measurement accuracy within ± 2% of actual velocity when used with the appropriate conversion formula.

d. Probes shall be of cylindrical cross section and shall indicate no more than a ± 3% percent deviation from the centerline velocity at a yaw angles up to 30 degrees.

e. Probes shall be constructed of extruded aluminum, unless dictated otherwise by service requirements. Probes over sixteen inches long shall be supported on the insertion end.

f. Probe quantities for each location shall be sufficient to meet ASHRAE recommendations.

g. The pressure drop created by the traverse probes shall not be greater ten percent of the velocity pressure at the maximum design flow.

h. The probes shall not amplify sound levels in the duct. The manufacturer shall provide submittal data indicating the developed differential pressure and pressure loss at the minimum and maximum design air flows for each duct location.

i. Traverse probes shall be Tek-Air model T-FP5000.

J. Binary temperature devices

1. Line-voltage space thermostat:

a. Line-voltage thermostats shall be bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating. The thermostat cover shall provide exposed set point adjustment knob. The thermostat shall operate within the 55°F to 85°F setpoint range, with 2°F maximum differential.

2. Low-temperature safety thermostat:

a. Low-limit air stream thermostats shall be UL listed, vapor pressure type, with a sensing element of 20 ft. minimum length. Element shall respond

to the lowest temperature sensed by any 1 ft. section. The low-limit thermostat shall be automatic reset, SPDT type.

3. Aquastat:

   a. Strap-on type thermostats shall be provided for low or high temperature limit service on hot water or steam condensate pipes. The thermostats shall be UL listed, with a liquid-filled bulb type sensing element and capillary tubing. The thermostat shall operate within the 20°F to 120°F, or 100°F to 240°F, setpoint range, with an adjustable 6°F differential.

   b. The low-limit thermostat shall be automatic reset, snap acting SPDT type with concealed set point adjustment.

K. Temperature sensors.

1. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensors shall use platinum RTD elements only, nickel or silicon is not acceptable. All control signals shall be via a 4-20 mA loop.

2. Room Temperature:

a.	Temperature monitoring range	+40/+90 F (+40/120 F for high temp alarms)
b.	Output signal	4-20 mA
c.	Installation adjustments	none required
d.	Calibration adjustments	zero & span
e.	Factory calibration point	70 deg F
f.	Accuracy at calibration point	+0.5 F

3. Liquid Immersion Temperature

a.	Temperature monitoring range	+20/+120 F or +70/+220 F
b.	Output signal	4-20 mA
c.	Installation adjustment	none required
d.	Calibration adjustments	zero & span
e.	Factory calibration point	70 deg F
f.	Accuracy at calibration point	+0.5 F

4. Duct (Single Point) Temperature

a.	Temperature monitoring range	+20/+120 F
b.	Output signal	4-20 mA

c.	Installation adjustments	none required
d.	Calibration adjustments	zero & span
e.	Factory calibration point	70 deg F
f.	Accuracy at calibration point	+0.5 F

5. Duct (Averaging) Temperature

a.	Temperature monitoring range	+20/+120 F
b.	Output signal	4 - 20 mA
c.	Installation adjustments	none required
d.	Calibration adjustments	zero & span
e.	Factory calibration point	70 deg F
f.	Accuracy at calibration point	+0.5 F

6. Outside Air Temperature

a.	Temperature monitoring range	-50/+122
b.	Output signal	4-20 mA
c.	Installation adjustments	none required
d.	Calibration adjustments	zero & span
e.	Factory calibration point	70 deg F
f.	Accuracy at calibration point	+0.5 F

L. Dew point/humidity sensors

1. Outside Air Dew Point Temperature

a.	Dew point monitoring range	-40/+115 F DP, 12% to 99% RH
b.	Output signal	4-20 mA
c.	Calibration adjustments	zero & span
d.	Factory calibration point	70 F
e.	Accuracy at calibration point	+2.0 Fdp

2. Room/duct Relative Humidity

a.	Sensor Humidity range	0 to 100%
b.	Operating temperature	15 F to +170 F
c.	Accuracy	+2% RH
d.	Sensing element	Capacitive sensor
e.	Output signal	4-20 mA DC
f.	Installation adjustments	zero & span
g.	Operating temperature	15 F to +170 F
h.	Voltage requirement	12-36 VDC

M. Pressure sensors

1. Air Static Pressure Sensor

a.	Duct Static range	-.5 to + 7.5"wg
b.	Accuracy	+ .05" w.g.
c.	Output signal	4 - 20 mA

N. Water differential pressure sensor

1. Transducer shall have linear output signal. Zero and span shall be field adjustable.

2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.

3. Water pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.

4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and three valve manifold.

5. Provide industrial grade differential pressure sensors for all differential pressure bypass valves. Sensor shall be factory calibrated for operating range and rated for system pressure. Provide manufacturers standard 316 stainless steel, 3 valve manifold and pressure gauges for supply and return pressures. Output shall be 4-20 ma. Sensor shall be Rosemount 1151DP, with 316 stainless steel or approved equal.

O. Differential pressure switches

1. Water Differential Pressure Switch

   a. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum), NEMA 1 enclosure, with scale range and differential suitable for intended application or as shown.

   b. The differential switches shall meet the following requirements:

1)	Range	8 to 70 psi
2)	Differential	3 psi
3)	Maximum differential pressure	200 psi
4)	Maximum pressure	325 psi

2. Air Differential Pressure Switch

    a. Differential pressure switches shall be diaphragm type, with die-cast aluminum housing and adjustable set point. Switch rating shall be a minimum 5 amps at 120 VAC. Switches shall be SPDT and be used for fan status as specified in the point schedule. Switch pressure range shall be suited for application. (E.g. filter 0-2.0", fan status 0-5.0", etc.)

P. Analog water level sensors

1. Furnish and install full height, analog level sensors for each location as specified. Sensor shall provide 4-20ma signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required. Sensor shall be Drexel Brook or equal.

Q. Water leak detection system

1. General:

    a. Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cables length, sound an alarm and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide preconnectorized sensing cable and components. The system shall be UL listed and FM approved.

    b. The system shall be as manufactured by Raychem Corporation or equal.

    c. Locating leak detection panel (TTB-FA)

    d. The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 mA signal to the BMS and displaying the distance from the start of the sensing cable to the start of

the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.

e. The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

f. The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

g. The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.

h. The alarm module shall be powered by Emergency power.

i. The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

2. Single point leak detector

a. The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall remain activated until the cable is dry and the module is reset.

b. The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

c. The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

d. The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow).

e. The alarm module shall be powered by Emergency power.

f. The module shall be mounted in a field equipment cabinet.

3. Water sensing cable

    a. The water sensing cable (TT-1000) shall detect the presence of water and pinpoint its location. The cable shall consist of four wires: Two sensor wires, a continuity wire and a return wire. All four wires shall be coated and insulated with a fluoropolymer and wound helically around a flouropolymer core. The cable shall have a breaking strength, including connectors, of at least 70 pounds, per ASTM D-638. The cable shall have an abrasion resistance of >65 cycles, per UL 719.

    b. The sensing cable shall offer distributed sensing with the ability to detect the location of water at any point along the length of the cable. The cable shall be flexible, and carry less than 24VDC under normal conditions.

    c. The system shall not alarm when in contact with any metallic equipment such as drip pans, floor tile supports, conduit, etc.

    d. The cable shall be available in modular, preconnectorized lengths of 5, 10, 15, 25 and 50 feet. Field splicing shall not be acceptable.

    e. The cable shall be UL 910 rated and plenum rated per NEC 725-2(b).

    f. Provide two sets of test instrumentation to owner.

4. Jumper cable

    a. Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum rated and jacketed with fluoropolymer materials, per NEC 725-2(b). The jumper cable shall consist of four different colors (Y, B, R, and G), insulated 18 AWG wires and shall be available in preconnectorized lengths of 5, 10, 15, 25 and 50 feet.

5. Accessories

    a. Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.

6. Graphic display map

    a. Provide a graphic display map for each room served. The map shall be a 1/8 in = 1.0 ft. scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual

cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.

b. A dynamic graphic display, equivalent to the aforementioned map, shall be duplicated on the BMS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.

7. Performance

a. A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.

b. The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.

c. The cable shall be capable of being cleaned with a clean dry cloth, in place.

d. The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping or mechanical action shall be required.

8. Installation

a. All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.

b. The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and retested, at no additional cost.

c. The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

9. Warranty

a. All equipment shall be warranted to the same extent as the BMS system, or per the manufacturer's warranty, whichever is greater.

R. Water BTU meters

1. Provide insertion type water flow meters designed to mount through a fully open 1 inch full bore ball valve supplied by flow meter manufacturer. Meter flow range shall be 2-40 feet/second for liquid service. Meter linearity shall be +/-1% for a 10:1 range. Repeatability shall be .10%. All wetted parts shall be constructed of stainless steel, bearings shall be tungsten carbide. Housing and flange shall be carbon steel. Housing pressure rating shall be 350 psig. A D.C. powered transmitter shall be mounted on the flow meter. Flow transmitter output shall be 4-20 mA linear with flow. Transmitter input shall be from magnetic pickup. Transmitter accuracy shall be .25% of span. The water flow meter shall be Onicon F 1220 or equal.

2. Provide supply and return temperature sensors for "Delta-T" calculation of BTU consumption. Monitor total accumulated BTUs, current BTUs, monthly total BTUs, and yearly total BTUs for each location specified or shown.

3. Provide isolation valve kit to allow removal and servicing of meter while system is operating.

4. All devices associated with the BTU meters serving the chilled water and ice storage system shall be suitable for the extreme environmental conditions. The devices shall properly operate with the specified accuracy and shall not be affected by the media, or by the environment that includes but not limited to low temperatures (10 Deg F), temperature fluctuations and condensation. Control panel enclosures and electronics shall meet the aforementioned requirements or located strategically to ensure proper operation.

S. Vortex shedding flow meters

1. Provide vortex shedding flow meter for steam metering locations. Meter shall be pressure and temperature compensated, rated for service conditions and is manufactured by Endress and Hauser model FTV 1810 or approved equal. Provide remote readout of pressure, flow, MLb/Hr and total MLb.

2. Coordinate location to provide proper straight run of pipe, pipe size, etc.

3. Power 24VDC power supply as required from Emergency source.

4. BMS system shall monitor Mlb/Hr, Mlb total, pressure and temperature values.

T. Indoor air quality (Co2/vVOC) sensors

1. Provide indoor air quality sensors to monitor Carbon Dioxide (CO2) and Volatile Organic Compound (VOC) levels.

2. The sensors shall be of microprocessor-based photo acoustic type with heated stannic dioxide semiconductor.

3. The CO2 sensors shall have no more than 1% drift during the first year of operation and minimal drift thereafter so that no calibration will be required.

4. The units shall be wall or duct mounted type as indicated on plans and in the sequence of operation.

5. Wall mounted sensors shall be provided with white plastic cover, without LED indicators.

6. Duct mounted sensors shall be provided with LED indicators in a dust proof plastic housing with transparent cover.

7. The VOC sensor shall have automatic self calibrating capability to ensure accuracy.

8. The sensor shall meet the following requirements:

a.	Operating voltage:	24 VAC +/- 20%
b.	Frequency:	50/60 Hz
c.	Power consumption:	max. 6 VA
d.	CO2 measuring range:	0 – 2000 ppm
e.	Tolerance:	+/- 100 ppm
f.	Output:	0 – 10 VAC
g.	Calibration:	none required
h.	VOC measurement range:	0 – 10 V VOC
i.	Permissible air velocity in duct:	<26.2 Ft/s.

9. The sensors shall be model:

    a. Siemens QPA63 Series.
    b. MSA AirOX

U. Relays

1. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on

plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

V. Override timers

1. Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

2. Current transmitters.

3. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.

4. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.

5. Unit shall be split-core type for clamp-on installation on existing wiring.

W. Current transformers

1. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.

2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale outputs.

3. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.

X. Voltage transmitters

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.

2. Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1% full-scale accuracy with 500 ohm maximum burden.

3. Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

Y. Voltage transformers

1. AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection.

2. Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ±0.5% accuracy at 24 VAC and a 5 VA load.

3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.

Z. Power monitors

1. Power monitors shall be the three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers, and UL Listed split-core current transformers.

2. They shall provide a selectable rate pulse output for kWh reading and a 4 to 20 mA output for kW reading. They shall operate with 5 A current inputs with a maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

AA. Current switches

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

BB. Pressure-electric (pe) switches

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale set point range of 14-125 kPa (2-18 psig) minimum, UL listed.

2. Provide one or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.

3. Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.

4. Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

CC. Electro-pneumatic (e/p) transducers

1. Electronic/pneumatic transducer shall provide a proportional 20 to 100 kPa (3 to 15 psig) output signal from either a 4 to 20 mA or 0 to 10 VDC analog controls input.

2. E/P transducer shall be equipped with the following features:

3. Separate span and zero adjustments

4. Manual output adjustments

5. Pressure gauge assembly. Feedback loop control

6. Air consumption of 0.05 L/s (0.1 scfm) at mid-range

DD. Local control panels

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable sub panels. A single key shall be common to all field panels and sub panels.

2. Interconnections between internal and face mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

EE. Local user display

1. Where specified in the sequence of operation or points list, the controllers on the peer to peer building level network shall have a display and keypad for local interface. A keypad shall be provided for interrogating and commanding points in the controller.

2. The display shall use the same security password and access rights for points in the display as is used in the associated controller.

3. The LCD display shall be a minimum of a 2 line 40 character display.

4. The LCD display shall include the full point name, value (numeric, digital or state text), point priority and alarm status on one screen.

5. The LCD shall dynamically update the value, priority, and alarm status for the point being displayed.

6. The display shall be mounted either on the door of the enclosure or remote from the controller.

2.09 Communication and Control Wiring

A. General:

1. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.

2. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

B. Wire Sizing and Insulation

1. Wiring shall comply with minimum wire size and insulation based on services listed below:

	Service	Minimum Gage/Type	Insulation Class
a.			
b.	AC 24V Power	12 Ga Solid	600 Volt
c.	DC 24V Power	10 Ga Solid	600 Volt
d.	Class 1	14 Ga Stranded	600 Volt
e.	Class 2	18 Ga Stranded	300 Volt
f.	Class 3	18 Ga Stranded	300 Volt

2. Provide plenum-rated cable when open cable is permitted in supply or return air plenum where allowed per execution specifications defined in Paragraph 3.07

C. Power Wiring:

1. 115V power circuit wiring above 100 feet distance shall use minimum 10 gage.

2. 24V control power wiring above 200 feet distance shall use minimum 12 gage.

D. Control Wiring:

1. Digital input/output wiring shall use Class 2 blue jacketed, twisted pair, and insulated.

2. Analog inputs shall use Class 2 twisted shielded pair, insulated and blue-jacketed and require a grounded shield.

3. Actuators with tri-state control shall use 3 conductor with same characteristics

E. Communication Wiring

1. Ethernet Cable shall be minimum CAT5

2. Secondary level network shall be 24 gage orange-jacketed, TSP, low capacitance cable.

F. Approved Cable Manufacturers:

1. Wiring from the following manufacturers which meet the above criteria shall be acceptable:

a. Anixter
b. Belden

2.10 Fiber Optic Cable System

A. Fiber Optic cable: Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. The sheath shall be UL Listed OFNP in accordance with NEC Article 770. The optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm for us in 10/100 MB fiber optic networks.

B. Connectors: All optical fibers shall be field-terminated with ST type connectors. Connectors shall have hot melt and polish or epoxy and polish type connectors. No Mechanical crimp type permitted.

C. Outdoor/underground installation of Fiber Optic cable shall be gel coated and rated for outdoor/underground installation.

D. Four strands is the minimum required for each run, two for the link and two as spares.

E. 1 GB Ethernet networks shall be single mode fiber for lengths over 275m. Single mode Ethernet requires two strands of 9 um cable.

2.11 Compressed Air Supply

A. General:

1. Provide a compressed air supply system including duplex type air compressor set, air tanks and pneumatic air distribution system including tubing and pressure reducing stations.

B. Air Compressor:

1. Provide a duplex type air compressor set complete with motors, V-belt drives, OSHA belt guards, pressure switches, ASME safety relief valve, pressure gauge, intake filter silencers, starters, electric alternator, and all other items and accessories.

2. The two compressors shall be mounted on ASME National Board receiving tank. The entire unit shall be factory piped and wired.

3. Each compressor shall be single stage, one or two cylinders, air cooled, with drop forged steel crankshaft supported on both ends by means of ball, roller or sleeve main bearings. Lubrication shall be of the constant level splash type, or of the pressure type, to assure adequate supply of oil to all working parts. Compressor shall be provided with oil proof piston rings.

4. The compressor shall meet the following minimum requirements:

a.	Working pressure:	70-90 PSI
b.	System air pressure:	80 PSI
c.	Maximum oil carryover:	4 ppm
d.	Maximum run time:	33%
e.	Maximum Starts per hour:	six (6)
f.	Motor speed:	450 RPM
g.	Motor voltage:	230 VAC/3 Phase

5. Compressor shall be sized as necessary to supply all pneumatics associated with the building automation system as well as the main air for all other HVAC equipment and devices as required.

6. The compressor assembly shall be mounted on vibration isolation pads.

C. Motor Starter / Alternator

1. Each compressor motor shall be provided with a magnetic starter with dedicated local disconnect and three overload relays.

2. Provide factory-installed duplex starter/automatic alternator package with separate motor feeds, arranged for automatic start of standby compressor.

D. Air Tank

1. Provide ASME receiver tank, sized according to runtime and start per hour requirements.

2. The air tank shall be painted with a prime and finish coat of paint in accordance with the manufacturers standard practice.

3. Air tank shall be provided with a drain opening at the bottom, which shall be piped near the floor drain.

4. Provide electric solenoid type (normally closed) automatic receiver tank drain valve with built-in timers for operating frequency and duration.

E. Refrigerated Air Dryer:

1. Provide continuously operating, hermetic compressor refrigerated type air dryer, UL Listed, sized for maximum dew point of -9.5°C (15°F) with 38°C (100°F) saturated inlet air at 550 kPa (80 psig) at maximum rated flow.

2. Dryer package shall include operating/failure status indication, manual bypass service valve, inlet and outlet pressure gauges, and automatic condensate drain trap with manual override.

F. Regenerative Desiccant Compressed Air Dryer:

1. Unit shall be wall-mounted, complete with two drying towers containing desiccant beds sized to ensure that air velocity across the desiccant bed is not greater than 0.3 m/s (60 fpm) at 700 kPa (100 psig). Bed shall be sized so that the effects of desiccant aging during the first year are negated. Each tower shall be furnished with fill and drain ports to facilitate desiccant replacement.

2. Unit shall be complete with On/Off switch, solid-state timer, control valves, and check valves. Purge air shall be exhausted through mufflers to reduce noise levels.

3. Unit shall have a 3 psi maximum pressure drop and provide dry air with a -40°C (-40°F) dew point.

4. Unit shall be sized to match required air consumption, 2.5 L/s (5 cfm) minimum.

G. Filter and PRV Station:

1. Provide aerosol coalescing type auto-drain, submicron air filter assembly with replaceable element, and 98% efficient for solids 0.3 micron and larger, with 99% efficient oil removal at rated capacity. Furnish with manual filter bypass and shutoff valves, upstream and downstream pressure gauges, and one spare filter element.

2. Provide relieving type pressure-reducing valves suitable for temperature control service sized for rated system capacity, with the following:

    a. ASME-rated safety relief valve on low-pressure side, factory set at 25 psig maximum

    b. Control pressure gauge on inlet and outlet

    c. Valved bypass

    d. Particle filter

H. Tubing.

1. Copper. Provide ACR hard-drawn seamless copper tubing.

2. Polyethylene. Provide type FR plenum rated polyethylene tubing. Tubing shall be rated for a maximum operating pressure of 200 kPa (30 psi) at 80°C (175°F), with an ambient operating temperature range of -13°C (-10°F) to 65°C (150°F). Plastic tubing shall have the burning characteristics of linear low-density polyethylene tubing, shall be self-extinguishing when tested in accordance with ASTM D 635, shall have UL 94 V-2 flammability classification and shall withstand stress cracking when tested in accordance with ASTM D 1693. Plastic-tubing bundles shall be provided with Mylar barrier and flame-retardant polyethylene jacket.

PART 3 – EXECUTION

3.01 Examination:

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others.

3.02 Protection

A. The contractor shall protect all work and material from damage by its employees and/or subcontractors and shall be liable for all damage thus caused.

B. The contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted.

3.03 Coordination

A. Site

1. The project coordination between trades is the responsibility of the prime contractor who is the one tier higher contractual partner such as mechanical contractor, general contractor, construction manager, owner or owner's representative as applicable.

2. The controls contractor shall follow prime contractor's job schedule and coordinate all project related activities through the prime contractor except otherwise agreed or in minor job site issues. Reasonable judgment shall be applied.

3. Where the work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment.

4. If the contractor deviates from the job schedule and installs work without coordinating with other trades, so as to cause interference with work of other trades, the contractor shall make the necessary changes to correct the condition without extra charge.

5. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals.

1. Refer to the "Submittals" article in Part 1 of this specification for requirements.

C. Test and Balance

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours. [ID: 136

3. In addition, the contractor shall provide a qualified technician for duration of 8 hours to assist in the test and balance process.

4. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

D. Life Safety

1. Duct smoke detectors required for air handler shutdown are supplied under Division 16 of this specification. The contractor shall interlock smoke detectors to air handlers for shutdown as described in Part 3, "Sequences of Operation."

2. Smoke dampers and actuators required for duct smoke isolation are provided under a Section of Division 15. The contractor shall interlock these dampers to the air handlers as described in Part 3, "Sequences of Operation."

3. Fire/smoke dampers and actuators required for fire rated walls are provided under another Section of Division 15. Control of these dampers shall be by Division 16.

4. The Main Fire Alarm Control Panel shall provide Alarm, Trouble and Supervisory signals to the BMS for monitoring and secondary email notification to SOM E&M personnel.

E. Coordination with controls specified in other sections or divisions.

1. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

a. All communication media and equipment shall be provided as specified in Part 2, "Communication" of this specification.

b. Each supplier of controls product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this section.

c. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.

d. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.

e. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.04 General Workmanship

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.05 Field Quality Control

A. Contractor shall have a 6 Sigma certified quality manager on staff to inspect the project execution and to enforce quality standards.

B. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

C. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

D. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

3.06 Existing Equipment

A. Unless otherwise directed, the contractor is not responsible for the repairs or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

3.07 Wiring

A. All control and interlock wiring shall comply with national and local electrical codes and Division 16 of this specification. Where the requirements of this section differ from those in Division 16, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved conduit according to NEC and Division 16 requirements.

C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.

E. All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage— shall be installed in conduit.

F. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).

G. Do not install wiring in conduit containing tubing.

H. Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft.) intervals.

I. Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical conduits, piping, or ceiling suspension systems.

J. All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.

K. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

L. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers or interposing relays.

M. All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points

N. All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.

O. Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.

P. Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

Q. Include one pull string in each conduit 3/4 in. or larger.

R. Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.

S. Conceal all conduits, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

T. Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.

U. Adhere to this specification's Division 16 requirements where conduit crosses building expansion joints.

V. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

W. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft.) in length and shall be supported at each end. Flexible metal conduit less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

X. Conduit must be adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.08 Communication Wiring

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.

C. Do not install communication wiring in raceway and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following the cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to the manufacturer's instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.09 Fiber Optic Cable System

A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

C. All terminations need to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

3.10 Installation Of Sensors

A. General:

1. Install sensors in accordance with the manufacturer's recommendations.

2. Mount sensors rigidly and adequately for the environment within which the sensor operates.

3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

5. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type.

6. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the full face of the coil.

7. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

8. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

B. Room Instrument Mounting

1. Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 53 inches above the finished floor unless otherwise shown.

C. Instrumentation Installed in Piping Systems

1. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermo wells.

2. Gauges in piping systems subject to pulsation shall have snubbers.

3. Gauges for steam service shall have pigtail fittings with isolation valve.

D. Duct Smoke Detectors

1. Duct smoke detectors will be provided by the Fire Alarm System Contractor in supply and return air ducts in accordance with Division 16

2. Contractor shall connect the DDC System to the auxiliary contacts provided on the Smoke Detector as required for system safeties and to provide alarms to the DDC system.

E. Occupancy Sensors

1. A sufficient quantity of occupancy sensors shall be provided to provide complete coverage of the area (room or space).

2. Occupancy sensors shall be installed in accordance with NFPA 70 requirements and the manufacturer's instructions.

3. Occupancy sensors shall not be located within 1.8 m (6 feet) of HVAC outlets or heating ducts.

4. PIR and dual-technology PIR/ultrasonic sensors shall not be installed where they can "see" beyond any doorway.

5. Ultrasonic sensors shall not be installed in spaces containing ceiling fans.

6. Sensors shall detect motion to within 0.6 m (2 feet) of all room entrances and shall not trigger due to motion outside the room.

7. The off-delay timer shall be set to 15 minutes unless otherwise shown.

8. All sensor adjustments shall be made prior to beneficial occupancy, but after installation of furniture systems, shelving, partitions, etc.

9. Each controlled area shall have one hundred percent coverage capable of detecting small hand-motion movements, accommodating all occupancy habits of single or multiple occupants at any location within the controlled room.

F. Temperature Limit Switch

1. A temperature limit switch (Low Temperature Detector) shall be provided to sense the temperature.

2. A sufficient number of temperature limit switches shall be installed to provide complete coverage of the duct section.

3. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily.

4. The temperature limit switch sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.

5. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m^2 (1 ft. of sensing element for each 1 ft^2) of coil area.

G. Averaging Temperature Sensing Elements

1. Sensing elements shall be installed in a serpentine pattern.

2. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

H. Air Flow Measuring Stations (AFMS)

1. Outside Air AFMSs shall be located downstream from the Outside Air filters.

2. Pitot tube type AFMS shall not be used if the expected velocity measurement is below 3.5 m/s (700 fpm) [or for outside airflow measurements].

I. Differential air static pressure.

1. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.

2. Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.

3. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.

4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

5. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork.

6. Mount transducers in a location accessible for service without use of ladders or special equipment.

J. Water Differential pressure sensors

1. Differential pressure sensors shall be installed with valved taps into the piping to ensure serviceability without draining the system

2. Sensors shall be mounted with bleed valves

3. After sensor installation any air shall be eliminated using the bleed valves to ensure reading accuracy

4. The sensors shall be located to ensure accessibility

K. Relative Humidity Sensors

1. Relative humidity sensors in supply air ducts shall be installed at least 3m (10 feet) downstream of humidity injection elements.

L. Flowmeters

1. The minimum straight unobstructed piping for the flow meter installation shall be at least 10 pipe diameters upstream and at least 5 pipe diameters downstream and/or in accordance with the manufacturer's installation instructions.

M. Flow Switch

1. Use correct paddle for pipe diameter.

2. Adjust flow switch in accordance with manufacturer's instructions.

3.11 Flow Switch Installation

A. Use correct paddle for pipe diameter.

B. Adjust flow switch in accordance with manufacturer's instructions.

3.12 Actuators

A. Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

3. Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

1. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.

2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.13 Warning labels and identification tags

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the DDC system.

1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows: "C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing."

B. Permanent warning labels shall be affixed to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.

1. Labels shall use white lettering (12-point type or larger) on a red background.

2. Warning labels shall read as follows: "C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing."

C. Equipment and Device labeling:

1. Labels and tags shall be keyed to the unique identifiers shown on the As-Built drawings.

2. All Enclosures and DDC Hardware shall be labeled.

3. All sensors and actuators not in occupied areas shall be tagged.

4. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.

5. Duct static pressure taps shall be tagged at the location of the pressure tap.

6. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire.

7. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to the enclosure or DDC Hardware.

8. Labels inside protective enclosures may be attached using adhesive, but shall not be hand written.

9. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

10. Identify room sensors relating to terminal box or valves with nameplates.

11. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

D. Identification of Tubing and Wiring

1. All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

3. All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

3.14 Identification Of Hardware And Wiring

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

B. All pneumatic tubing shall be labeled at each end within 5 cm (2 in.) of termination with a descriptive identifier.

C. Permanently label or code each point of field terminal strips to show the instrument or item served.

D. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

E. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

F. Identify room sensors relating to terminal box or valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

H. Identifiers shall match record documents.

3.15 Programming

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free within the primary controller for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Point Naming standard shall be

agreed upon between owner and BAS contractor. Refer to Submittals section in the General Section.

C. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. The contractor also shall provide all other system programming necessary for the operation of the system, but not specified in this document. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation and be of different font and color in text editor. Use the appropriate technique based on one of the following programming types:

    a. Text-based:

        1) Must provide actions for all possible situations
        2) Must be modular and structured
        3) Must be commented
        4) Must provide line by line programing and compilation wizard to allow for ease of editing.

    b. Graphic-based:

        1) Must provide actions for all possible situations
        2) Must provide programing and compilation wizard to allow for ease of editing.
        3) Must be documented

D. Operator Interface

1. Standard graphics—Provide graphics for all mechanical systems and floor plans of the building. This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.

2. Show terminal equipment information on a “graphic” summary table. Provide dynamic information for each point shown.

3. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface

database, and any third-party software installation and integration required for successful operation of the operator interface.

4. Contractor shall provide necessary programming to create all reports referred to in Part 2 Operator Interface Software

3.16 Control system checkout and testing

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 that shall be submitted prior to acceptance testing. Commissioning work that 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.

B. Phase I – Field I/O Calibration and Commissioning

1. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off 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 and positioner spring ranges if pneumatic actuation is utilized.
g. Fail safe operation on loss of control signal, pneumatic air, electric power, network communications, etc.

C. Phase II – System Commissioning

1. 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. 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 re-tested.

D. Phase III - Integrated System Program Commissioning

1. Tests shall include, but not be limited to:

    a. Data communication, both normal and failure modes.
    b. Fully loaded system response time.
    c. Impact of component failures on system performance and system operation.
    d. Time/Date changes.
    e. End of month/ end of year operation.
    f. Season changeover.
    g. Global application programs and point sharing.
    h. System backup and reloading.
    i. System status displays.
    j. Diagnostic functions.
    k. Power failure routines.
    l. Battery backup.
    m. Smoke Control, vents, in concert with Fire Alarm System testing.
    n. Testing of all electrical and HVAC systems with other division of work.
    o. Year 2000 compliance test.

2. Sub Systems shall also be tested and commissioned.

    a. Compressed Air System

        1) Test all high pressure piping (80 PSI) at 100 PSI sustained for 24 hours. Pressure loss shall not exceed 10 PSI at the end of the 24-hour test period.

        2) Test all low-pressure piping (25 PSI and below) at 30 PSI sustained for 24 hours. Pressure loss shall not exceed 3 PSI at the end of the 24-hour period.

3. 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 and the system performance does not degrade over time.

4. Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate 100 percent of the system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

5. The B.M.S. contractor shall supply all instruments for testing. Instruments shall be turned over to the owner after acceptance testing.

6. All test instruments shall be submitted for approval prior to their use in commissioning.

    a. Test Instrument Accuracy:
        1) Temperature: 1/4F or 1/2% full scale, whichever is less.
        2) Pressure: High Pressure (PSI): ½ PSI or 1/2% full scale, whichever is less.
        3) Low Pressure: 1/2% of full scale (in w.c.)
        4) Humidity: 2% RH
        5) Electrical: 1/4% full scale

7. 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.

3.17 Control system demonstration and acceptance

A. Demonstration

1. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests.

2. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The engineer will be present to observe and review these tests. The engineer shall be notified at least 10 days in advance of the start of the testing procedures.

3. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.

4. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied,

unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.

5. As each control input and output is checked, a log shall be completed showing the date, technician's initials, and any corrective action taken or needed.

6. Demonstrate compliance with Part 1, "System Performance."

7. Demonstrate compliance with sequences of operation through all modes of operation.

8. Demonstrate complete operation of operator interface.

9. Additionally, the following items shall be demonstrated:

    a. DDC control loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC control loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.

    b. Demand limiting. The contractor shall supply a trend data output showing the action of the demand-limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.

    c. Optimum start/stop. The contractor shall supply a trend data output showing the capability of the algorithm. The change-of value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.

    d. Interface to the building fire alarm system.

    e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and

have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and electronic formats.

10. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

B. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.18 Cleaning

A. The contractor shall clean up all debris resulting from their activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.19 Training

A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed. Factory employed/certified instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

B. Provide (40) hours of site specific training for Owner's operating personnel. Training shall include:

1. Day-to-day Operators:

a. Proficiently operate the system

b. Understand control system architecture and configuration

c. Understand DDC system components

d. Understand system operation, including DDC system control and optimizing routines (algorithms)

e. Operate the workstation and peripherals

f. Log on and off the system

g. Access graphics, point reports, and logs

h. Adjust and change system set points, time schedules, and holiday schedules

i. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals

j. Understand system drawings and Operation and Maintenance manual

k. Understand the job layout and location of control components

l. Access data from DDC controllers and ASCs

m. Operate portable operator's terminals

2. Advanced Operators:

a. Make and change graphics on the workstation

b. Create, delete, and modify alarms, including annunciation and routing of these

c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals

d. Create, delete, and modify reports

e. Add, remove, and modify system's physical points

f. Create, modify, and delete programming

g. Add panels when required

h. Add operator interface stations

i. Create, delete, and modify system displays, both graphical and others

j. Perform DDC system field checkout procedures

k. Perform DDC controller unit operation and maintenance procedures

l. Perform workstation and peripheral operation and maintenance procedures

m. Perform DDC system diagnostic procedures

n. Configure hardware including PC boards, switches, communication, and I/O points

o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware

p. Adjust, calibrate, and replace system components

3. System Managers/Administrators:

a. Maintain software and prepare backups

b. Interface with job-specific, third-party operator software

c. Add new users and understand password security procedure

C. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If such training is required by the Owner, it will be contracted at a later date. Provide description in the Technical Proposal of available local and factory customer training.

D. Provide course outline and materials in accordance with the "Submittals" article in Part 1 of this specification. The instructor(s) shall provide one copy of training material per student.

E. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

PART 4 – ABBREVIATIONS, NOMENCLATURES & DIAGRAMS

4.1 Building Equipment Abbreviations

A. The equipment abbreviations listed below shall be used on BMS point nomenclature. Deviation from these abbreviations may be made at the discretion of the Facilities Project Manager with Prior approval from the Director of Facilities Operations.

ACU	Air Conditioning Unit
AHU	Air Handling Unit
ATS	Automatic Transfer Switch
BLR	Boiler
BSC/BSH	Bio-Safety Cabinet/Bio-Safety Hood
CHLR	Chiller
CHWS	Chilled Water System
CO2	CO2 Sensor/Transmitter
ACOMP	Air Compressor
CRYO	Cryo Storage Unit
CT	Cooling Tower
CAV	Constant Air Volume Terminal Box
DRUM	Chemical Waste Container
EF	Exhaust Fan
EAV	Exhaust Air Volume Terminal Box
EVCP	Evacuation Control Panel
FACP	Fire Alarm Control Panel
FH	Fume hood
FRZ	Freezer
GEN	Generator
H2	Hydrogen Sensor/Transmitter
HRS	Heat Recovery System
HWS	Hot Water System
HXS	Heat Exchanger System
INC	Incubator
KEG	Chemical Supply Container
LEL	Low Explosion Limit
LYO	Lyophilize Unit
N2	Nitrogen Sensor/Transmitter
O2	Oxygen Sensor/Transmitter
PHM	PH Meter

PMP	Pump
RDWS	RO/DI Water System
REF	Refrigerator
RF	Return Fan
RTU	Rooftop Unit
SF	Supply Fan
SOLS	Solvent Supply
SOLW	Solvent Waste
STC	Stability Chamber
UPS	Uninterruptable Power Supply
VBE	Ventilated Balance Enclosure
VCUM	Vacuum System
VFD	Variable Frequency Drive
VAV	Variable Air Volume Terminal Box

4.2 Database Input/Output/Virtual Point Abbreviations

A. In addition to the equipment abbreviations, the system points (controlled and monitored) abbreviations listed below shall be used to complete the BMS point nomenclature. Deviation from these abbreviations may be made at the discretion of the Facilities Project Manager with Prior approval from the Director of Facilities Operations.

AIRV	Air Volume
BSPT	Building Static Pressure Transmitter
BYPVLV	Bypass Valve
CCVLV	Cooling Coil Valve
COMD	Command
COOL	Cool Mode
DATT	Discharge Air Temperature Transmitter
DAY	Day Mode
DMND	Demand
DMPR	Damper
DOM	Domestic
DPT	Differential Pressure Transmitter
EADSPT	Exhaust Air Duct Static Pressure Transmitter
EATT	Exhaust Air Temperature Transmitter
ENA	Enable/Disable
FBAK	Feedback
FILT	Filter
FNL	Final
FT	Flow Transmitter
HCVLV	Heating Coil Valve
HEAT	Heat Mode
HI	High
HRTT	Heat Recovery Temperature Transmitter
IND	Industrial
L	Level
LAG	Lag
LEAD	Lead
LO	Low
LOAD	Load
MATT	Mixed Air Temperature Transmitter
MED	Medium
NGT	Night Mode
OATT	Outside Air Temperature Transmitter
ODP	Operator Display Panel
POS	Position
PRE	Before

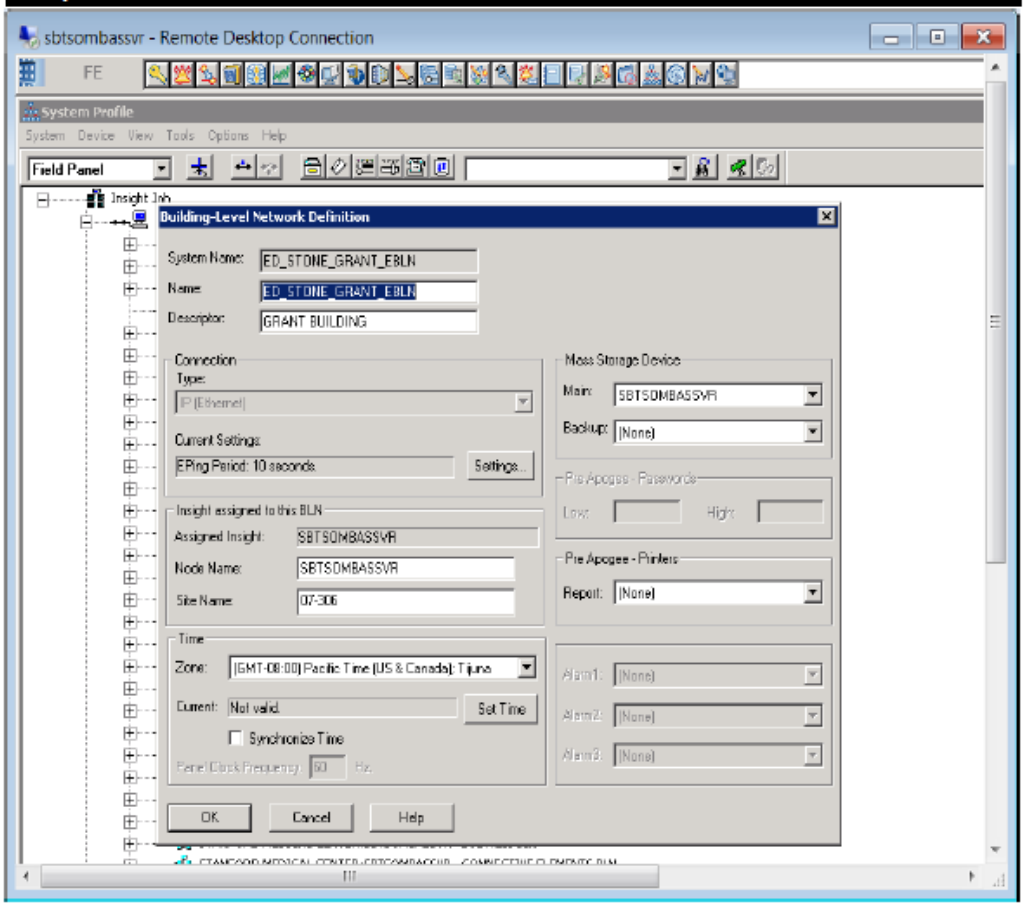
PRF	Proof
PT	Pressure Transmitter
RATT	Return Air Temperature Transmitter
RMTT	Room Temperature Transmitter
RWFT	Return Water Flow Transmitter
RWTT	Return Water Temperature Transmitter
SADSPT	Supply Air Duct Static Pressure Transmitter
SASDD	Supply Air Smoke Duct Detector
SATT	Supply Air Temperature Transmitter
SPD	Speed
SSTP	Start/Stop
STAGE	Cooling/Heating Stages
STAT	Status
STPT	Setpoint
SWFT	Supply Water Flow Transmitter
SWTT	Supply Water Temperature Transmitter
TT	Temperature Transmitter
THRSx	Time Delay in Hours, “x” – quantity of THRS point
TMINx	Time Delay in Minutes, “x” – quantity if TMIN point
TSECx	Time Delay in Seconds, “x” – quantity of TSEC point
VLV	Valve

4.3 Database Network Nomenclature

A. Building Level Network (BLN)

System Name:	Stanford defined
Name:	Same as System Name
Descriptor:	Building Name or Address
Connection:	IP (Ethernet)
Current Settings:	Default (Eping Period: 10 seconds)
Assigned Insight:	SBTSOMBASSVR
Node Name:	SBTSOMBASSVR
Site Name:	Stanford Zone-Building Asset ID
Time Zone:	(GMT-08:00) Pacific Time (US & Canada); Tijuana
Synchronize Time:	Checked
Mass Storage Device (Main):	SBTSOMBASSVR
Mass Storage Device (Backup):	None
PreApogee Printer Report:	None

Example:



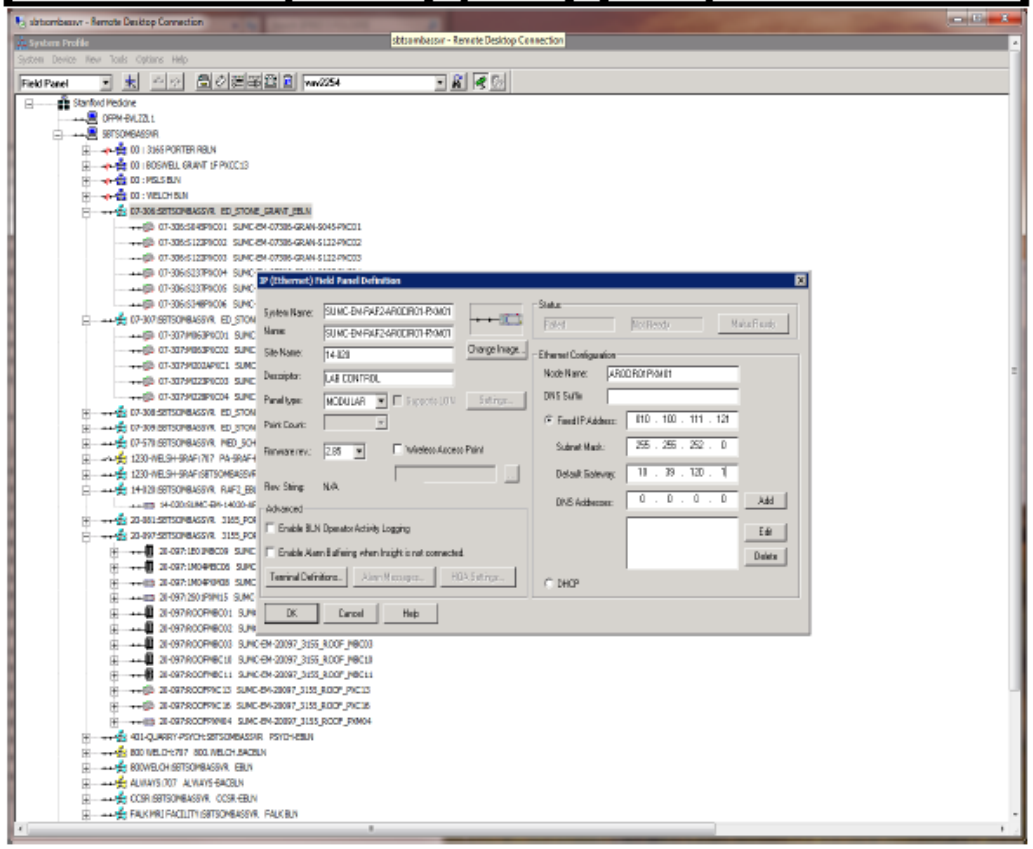
4.4 Database Controller Nomenclature

A. Primary DDC Controllers (i.e. AHU, EF, CT, CHWS, HWS)

Format:	
IRT Tag + Building Physical Address + Panel Location + CMI + CT + CC	
IRT Tag:	Stanford IRT Required Prefix
Building Address:	On-Campus First 4-letter or Acronym (i.e. LKSC, BECK for Beckman / Off-Campus Physical Building Address (.i.e 3155 Porter will be"3155") - Adjustable
Panel/System Location:	Physical Control Panel Location (i.e. "ROOF", "YARD", Corridor "AR0CIR01") - Adjustable
Controller Type:	Controller Type (i.e. M-Modular, C-Compact)
Control Panel Count:	Control Panel Count (1-999 per floor) - Adjustable

Example:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
S	U	M	C	-	E	M	-	3	1	5	5	-	1	M	1	-	P	X	C	0	1							
IRT Tag								Building Physical Address				Hyphen	Panel Location - Room #			Hyphen	Controller Type			Control Panel Count							



B. Secondary Floor Level Network (FLN) Controllers (i.e. CAV, VAV, EAV)

Format:	
Building Physical Address + Room T-stat Location + System Number + Box Type + Box ID	
Building Address:	On-Campus First 4-letter or Acronym (i.e. LKSC, BECK for Beckman / Off-Campus Physical Building Address (.i.e 3155 Porter will be"3155") - Adjustable
Room T-stat Location:	Room number of the T-stat location - Adjustable
System ID:	i.e. for AHU01 this field shall be "01", EF003 this field shall be "03"
Box Type:	i.e. VAV (VV), CAV(CV), EAV(EV)
Box ID:	Terminal Box ID from Mechanical Drawing CAV/VAV/EV Terminal Box Schedule - Adjustable

Example:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
3	1	5	5	.	M	1	0	2	2	X	.	0	1	V	V	V	A	V	0	1	-	1	0	2	2			
Building Physical Address				Period	Room T-stat Location						Period	AHU or EF Number		VAV/CAV/EAV Type		Terminal Box ID												

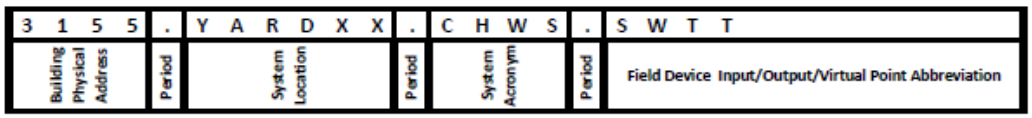
Example above represents the variable air volume terminal box id vav01-1022 that serves and room thermostat in room M1022X of building 3155 Porter Drive. AHU01 serves this terminal box.

4.5 Database Point Nomenclature

A. Main Equipment (i.e. AHU, EF, CT, CHWS, HWS)

Format:	
Building Physical Address + System Location + System ID + Field I/O Abbreviation	
Building Address:	On-Campus First 4-letter or Acronym (i.e. LKSC, BECK for Beckman / Off-Campus Physical Building Address (.i.e 3155 Porter will be"3155") - Adjustable
Panel/System Location:	Physical Control Panel Location (i.e. "ROOF", "YARD", Mezzanine "MEZZ") - Adjustable
System Acronym:	See acronym list
Field Device Abbreviation:	i.e. Supply Water Temp (SWT), Supply Air Temp (SAT)

Example:

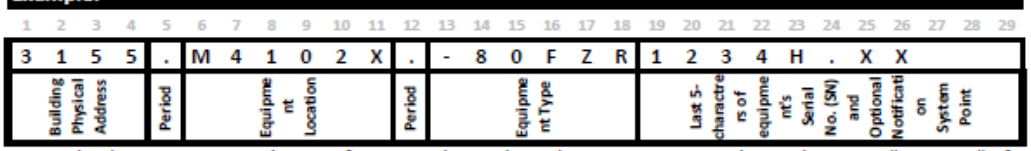


Example above represents the supply water temperature transmitter for the chilled water system located in the yard "XX" of building 3155 Porter Drive.

B. Miscellaneous Equipment Alarms (i.e. freezers, integrated devices)

Format:	
Building Physical Address + Equipment Location + -80FRZ + Equipment Serial No.+Notification	
Building Address	Physical Building Address or Building Name's first 4 characters or Acronym (Adjustable)
Equipment Location	Room number - Adjustable
Equipment Type	i.e. "-80FRZ", -20FRZ, "CRYO"
Equipment SN#	Last 5-characters of equipment's serial number
Notification (option)	i.e. 1A,1B,1C - first level alarm recipients; 2A,2B,2C - 2nd level alarm receipient and so forth.

Example:



Example above represents the -80c freezer with serial number xxxxxxxx1234H located in room "M4102X" of building 3155 Porter Drive.

4.6 Ethernet Network Connection Request Form

Stanford University
School Medicine - Office of Facilities Planning & Management
NETWORK CONNECTION REQUEST FORM

Building	Room No	TSO ID *(ITS Provided)*	Device Name *(OFPM provided)*	MAC Address	IPAddress (*IRT provided*)

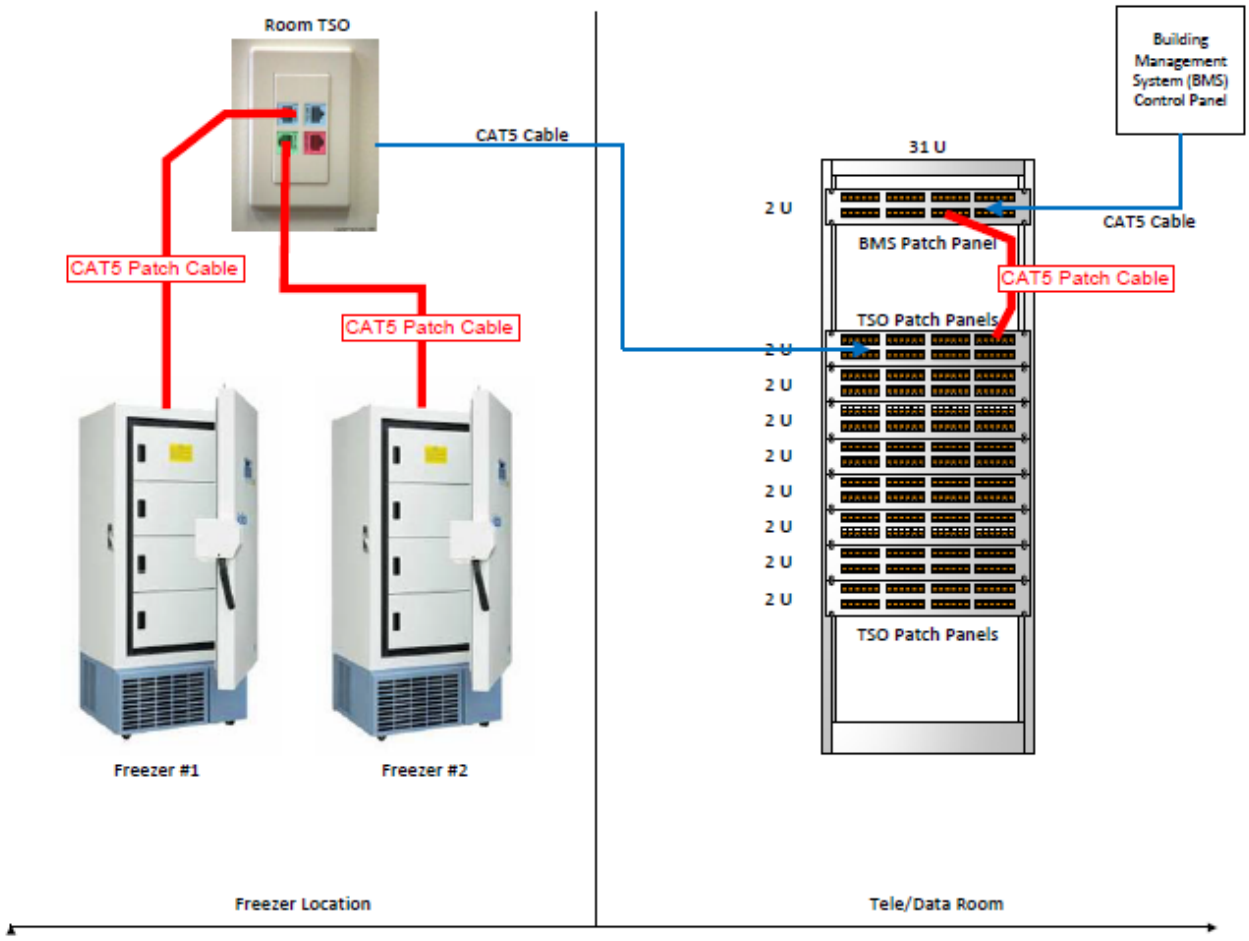
REQUESTOR'S CONTACT INFO

Name: _____

Mobile No: _____

Email: _____

4.7 Laboratory Equipment Alarm Monitoring Layout



PART 5 – REVISION HISTORY

Date:	Description:
12/15/2013	Addition of the following sections: - Table of Contents - Part 2.02 Section C: Operator Workstation - Part 4: BMS Abbreviations, Nomenclature & Diagrams - Part 5: Revision History

END OF SECTION