SAN JOSE/EVERGREEN COMMUNITY COLLEGE DISTRICT
San Jose, California

PROJECT MANUAL
Volume III
Bid Document G2010.0119
GE HVAC Upgrades Phase I, #31304-19
San Jose City Community College

Architect:
Salas O'Brien

Bids will be opened at 3:00 p.m., May 5, 2015, in the DISTRICT OFFICES MULTI-
PURPOSE ROOM, 40 South Market St, San Jose, CA 95113
PERFORMANCE SPECIFICATION

DIRECT DIGITAL CONTROLS (DDC) SYSTEM REPLACEMENT

2100 MOORPARK AVE, SAN JOSE, CA

PREPARED BY:

SALAS O'BRIEN ENGINEERS, INC.

FOR:

SAN JOSÉ-EVERGREEN COMMUNITY COLLEGE DISTRICT

FEBRUARY 19, 2015
PERFORMANCE SPECIFICATION – SUMMARY

1.0 GENERAL

This project is to upgrade the existing Building Automation System (BAS). This upgrade shall consist up replacing the first generation JCI Metasys System to the open protocol, Tridium based system. The new system shall not be proprietary. Additionally, existing JCI network controllers will be replaced with Johnson Controls FX70 controllers over several potential construction phases. All controllers shall have BACnet communication protocol. The software upgrade for the new system will occur during June through August of 2015, within an occupied and fully functioning campus. As such, all work will have to be phased such that disturbances are scheduled and minimized and comfort is maintained during normal working hours.

The existing BAS server has years of developed text screens, graphics, drawings, help files, and programmed sequences. The existing workstation shall stay functional throughout the construction of the new system until it is signed off and accepted. The new BAS shall provide the same text screens, graphics and programming sequences including text screen and graphic screens, drawings, the links between each of them, the data, and help files. Equipment, relays, panel designations etc. are labeled consistently on text and graphic screens, folders etc, and these are consistent with the field panel and field equipment labels. Before each system is switched over to the new BAS system, all labeling shall be complete and consistent with existing labeling.

A new server, Dell PowerEdge R630, or District approved equal, shall be installed in the Campus's MDF room, located in General Education Room 108. All existing network controllers shall continue to operate from the existing server and JCI Metasys System. However, as existing controllers are replaced, all the new FX controllers shall be integrated into the new server and Tridium system. Section 2.0 details the existing network controllers, which will be replaced as part of the base bid and add/alternates for this project.

Web servers shall be provided and installed so that all controls installed for this project are accessible from anywhere on SJCC's secure network with only an IP address by an unlimited number of users. No additional costs for licensing agreements or access software will be allowed. At the completion of the DDC system upgrade, the system shall have the latest software upgrade available. A minimum of three (3) handheld control devices, approved by the District, shall be provided to facilitate control of setpoints, sequences, etc while in the field. These devices shall remotely connect to the new BAS.

2.0 PERFORMANCE REQUIREMENTS

The controls contractor is required to provide all of the following:

2.1.1 Attendance at Pre-Bid meeting and separate Proposal Review Presentation meeting.
2.1.2 Existing Points List – This will be the final existing points list before commencing work.
2.1.3 Existing Sequences. The design builder will work with the District building specialists to reverse engineer the existing sequences, and document them.
2.1.4 Existing graphics, text screens and folder hierarchy screens associated with the existing controls. All programming or text that resides on the existing system. These shall form a part of the submittal of existing information that the contractor shall be responsible for. These shall be incorporated into the new front end program/graphic/text/hierarchy in its entirety unless permission by the District is given to remove/replace or otherwise modify specific information.
2.1.5 Existing HVAC Schematics for review and approval by the District prior to any reprogramming.
2.1.6 Point to Point wiring.
2.1.7 LAN TOPOLOGY/System Architecture drawings.
2.1.8 Submittals.
2.1.9 Customer Training in house for 6 District employees, in four hour increments per day maximum.
2.1.10 O & M Manuals & Record Drawings (record drawings to include mechanical floor plans with device locations shown). Mechanical floor plans will be provided by AT&T on an ACAD background.
2.1.11 Warranty.

The following is a very general description of the network control modules that are on the existing BAS and will be on the new BAS. This is meant as a general guide and not in any way limited to this. All existing points lists, sequence of operation (SOO) and graphics shall be transferred to the new Tridium system. It is the responsibility of the controls contractor to coordinate with the District to obtain the points lists, SOO and graphics.

### 3.0 BAS REPLACEMENT PHASES

<table>
<thead>
<tr>
<th>Type of Device</th>
<th>Building</th>
<th>Replacement Phase</th>
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<tbody>
<tr>
<td>NCM</td>
<td>Chiller Room</td>
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<tr>
<td>NCM</td>
<td>Library Learning Resource Center (LLRC)</td>
<td>Base Bid</td>
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<td>NCM</td>
<td>Technology Center</td>
<td>Base Bid</td>
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<tr>
<td>NAE</td>
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<td>Student Center (2 devices)</td>
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<td>NAE</td>
<td>Science Building</td>
<td>Add/Alternate #3</td>
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<td>NAE</td>
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<td>NAE</td>
<td>Cosmetology &amp; Reprographics Building</td>
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<td>Multi-Disciplinary and Arts (MDA) Building</td>
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<tr>
<td>NAE</td>
<td>Theatre</td>
<td>Add/Alternate #7</td>
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NAE = Network Automation Engine  
NCM = Network Control Module  
NIE = Network Integration Engine

### 4.0 BIDDER REQUIREMENTS

4.1.1 The bidder’s company shall have minimum 10 years of experience with installing Tridium based systems.
4.1.2 The bidder shall have experience working with Higher Education campuses, specifically a minimum of 5 years at San José City College.
4.1.3 The bidder shall appropriately provide a bid broken down based on the add/alternates described in the Construction documents.
4.1.4 The bidder shall have personnel factory trained in the following:

- 4.1.4.1 Niagara AX (JCI FX specific)
- 4.1.4.2 Metasys PMI (DDL, GPL & JC Basic)
- 4.1.4.3 NAE, NCM and N2 Protocol
4.1.5 Top two candidates may be invited to an additional interview with Engineer and District.

### 5.0 PRICING
San José City College is soliciting proposals from highly qualified companies to provide a “Turn Key” proposal for completing the new BAS installation.

Pricing shall include all labor, supervision, coordination, waterproofing, fire penetrations and removal of old equipment at the direction of the District. All means and methods shall be approved by the District.
PART 1 – GENERAL

1.01 Work Included:

A. General - Building Management System (BMS) Contractor shall provide and install the following. The preferred District BMS vendor is Bay Point Control, Inc. (ph. 510-352-0200):

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. The software shall be Tridium’s Niagara Framework. All new supervisory controllers, replaced as part of this project, shall be Johnson Controls FX70. No substitutions allowed.

2. All interlocking, wiring and installation of control devices for a complete operational system.

3. 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 electrical specifications, NEC and local building code.
   c. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator’s workstations.
   d. All low voltage electrical control wiring throughout the building whether in exposed areas shall be run in conduit in accordance with the electrical specifications, local building code and the NEC.
   e. Provide replacement of supervisory control devices per the base bid and add/alternate package. All existing points, graphics, trends and sequences of operation shall be transferred to new control device.

4. 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 BACnet/IP and TCP/IP protocol.
   b. System shall be capable of BACnet communication according to ANSI/ASHRAE 135-2012.
   c. The system shall be capable of supporting wireless field level network and sensor communications using a mesh topology and IEEE 802.15.4 network.
   d. The system shall be capable of supporting both standard and vendor specific protocols to integrate a wide variety of third-party devices and legacy systems.
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e. 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.

5. 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.

6. One (1) personal computer operator workstation, associated peripherals and equipment required to set up dynamic color graphic PC console.

7. Three (3) Portable Operator Terminal to be connected and communicating simultaneously with the entire BMS from any DDC Controller. The portable terminal shall be able to monitor, adjust, trend, edit, modify, add, and delete, all system information or points.

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 specially 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 to multiple operator workstations without dependence upon a central or intermediate processing device.

1.02 Quality Assurance
A. The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel. Refer to Section 4.0 of the "Performance Specification – Summary" for a complete list of factory training. 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. The Bidder shall also have a minimum of five (5) years of experience specifically at San José City College.

B. 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.

C. 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 916 category PAZX; Standard UL 864, categories UDTZ, and QVAX and be so listed at the time of Bid.

D. The BAS peer-to-peer network controllers and local user display shall also comply with the European Electromagnetic Compatibility (EMC) Framework, and bear the CE-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.

E. 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.

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

G. The manufacturer of the building 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.

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

3. Underwriters Laboratories (UL) listing and labels.
4. UL 916 Energy Management
5. NFPA 70 - National Electrical Code.
8. American Society of Mechanical Engineers (ASME).
10. Institute of Electrical and Electronic Engineers (IEEE).
13. Occupational Safety and Health Administration (OSHA).
16. Americans Disability Act (ADA)
17. ANSI/ASHRAE Standard 135-2012 (BACnet)

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

1.04 Submittals

A. All shop drawings shall be prepared in AutoCAD software. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. “Typicals” will be allowed where appropriate.

B. Submittal data shall contain manufacturer’s data on all hardware and software products required by the specification. Provide a complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used. Valve, damper and air flow station schedules shall indicate size, configuration, capacity and location of all equipment.

C. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms and configuration to be furnished with the workstation software.
D. Submit three (3) copies of submittal data and shop drawings to the District for review prior to ordering or fabrication of the equipment. The Contractor prior to submitting shall check all documents for accuracy. Begin no work until submittals have been approved for conformity with design intent.

E. The District will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the District and the submittals are fully approved.

F. Project Record Documents: Submit 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 compatible file.

2. Testing and Commissioning Reports and Checklists.


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

1.05 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 District. Respond during normal business hours within 24 hours of District's warranty service request.

B. Work shall have a single warranty date, even if District 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 District determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, District 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, District 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 District'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 District'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.

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. 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 be an open protocol system, capable of supporting 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 Communication:

1. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.

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

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

D. Primary Network Communication

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, OPC 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 PC to the controllers on the Primary Network shall result in a notification at the PC.

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. Any break in Ethernet communication between the standard client and server workstations on the Primary Network shall result in a notification at each workstation.

10. Access to the system database shall be available from any standard client workstation on the Primary Network.

E. Primary Network - Panel to Panel Communication:

1. All Building Controllers shall directly reside on the primary BACnet/IP Ethernet network so 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 BACnet/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:
Building Management System Upgrade

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. Communication over the secondary network shall be BACnet MS/TP protocol.

3. Communication over the secondary network shall utilize a wireless MESH topology based on an IEEE 802.15.4 network. Point-to-point communication shall not be unacceptable

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

5. The Application Specific Controllers shall communicate bi-directionally with the primary network through Building Controllers for transmission of global data.
6. A maximum of 30 terminal equipment controllers may be configured on individual secondary networks to ensure 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. Coordinate with District regarding which specific numbers

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. 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.

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

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

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

2.03 Operator Interface:

A. Workstation hardware:

1. Personal computer operator workstation shall be provided for command entry, information management, system monitor, alarm management and database
management functions. All real-time control functions shall be resident in the Building Controllers to facilitate greater distribution, fault tolerance and reliability of the building automation control.

a. Provide workstation(s) of equal capability as specified by District.

b. Workstation shall consist of a computer by Dell Precision WorkStation T35000 or equal with minimum 12 GB RAM, hard drive with 320 GB 72500 RPM, video card with nVidia Quadro 4000-2GB running 1280x1024, CD-RW (DVD-RW Preferred), CPU with Intel Xeon CPU W3670 6 Cores HT EMT64 VT-x 12 MB Cache and DVD-ROM Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows 10 Professional x64 or comparable operating system and shall include a dual core processor. Verify with District.

c. The PC monitor shall be of LED flat panel type and shall support a minimum display resolution of no less than 1920 × 1080 pixels. The display shall have a minimum of 27-inch visible area in diagonal. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective. Verify with District.

d. Provide a color printer for printing of dynamic trend graph report, Excel reports, graphics and any other screen displays. Printer shall Include as a minimum Okidata Microline 590 or equivalent. Verify with District.

e. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

B. Server hardware:

1. The server hardware shall be of equal or better than the District standard of Dell PowerEdge R630 rack server.

C. Operator Interface Software:

1. Basic Interface Description

a. 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.

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

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

1) Real-time graphical viewing and control of the BMS environment.
Building Management System Upgrade

2) Reporting of both real time and historical information.
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 and definition details 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 third-party spreadsheet software
   a) Scheduling reports
   b) Operator Activity Log

   d. 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.

   e. Each BMS workstation user account shall use a Windows Operating System user account as a foundation. BAS System administrator shall be able to add users to the BMS system by pulling in accounts from the Active Directory. Users will use the same Login ID/Password combination as to log into the corporate network.

   f. 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.

   g. 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.
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6) 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.

7) 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.

8) Ability to create dashboard views that graphically display system and/or energy performance. Dashboards will consist of gauges and charts.

h. 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) System diagnostic reports including, list of Building panels online and communicating, status of all Building terminal unit device points
7) List of Building Control panels
8) Point Trend data listings
9) User activity report

i. 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 offline, 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) Daily, Weekly, and Monthly schedules

b) Ability to combine multiple points into a logical grouping (Zone) for ease of scheduling (e.g., Building 1 lights)
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c) Ability to combine multiple groups of points into a common collection (Event) for scheduling (e.g., Building 1 and Parking Lot A lights).

d) Schedule predefined reports that can be sent to a printer, hard drive location, or emailed.

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

j. 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 and 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) Panels shall have a trending level above which the data will be automatically uploaded to the BMS server to prevent overwriting the data in the field panel. The trending level will be user defined in % of available space (e.g., automatically upload when the trend buffer is at 75% of allocated space).

3) 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 online 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.

4) 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.

k. 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 for 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.

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.

I. 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 third-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing third-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 online 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 online.

5) User shall be able to edit point configuration online within a dedicated editor application that is part of 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) Users shall have the ability to view the program(s) that is/are currently running in a Building Controller. The display shall mark the program lines with the following: disabled, comment, unresolved, and trace bits.

m. 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 and 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 and 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 option 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.
n. 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) 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.

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

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

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

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

2.04 Building (Supervisory) Controllers

A. Building Controllers shall be 32-bit, multi-tasking, multi-user, real-time 100 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 plus 25% for future expansion on each controller. Each controller shall have 25% more AO, AI, DO and DI points for each point type.

B. Each Building Controller shall have sufficient memory, a minimum of 24 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.

C. Provide Universal I/O capability.
Each Building Controller shall support a minimum of three (3) directly connected Secondary Networks.

Building Controller shall have an integral real-time clock.

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

Each Building Controller shall support:

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

2. Monitoring of Industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

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/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.

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.

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 30 days.

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).

Immunity to power and noise.
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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 (RFCl) per ENV 50141 (IEC 1000-4-6) at 3V
   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 500V 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:
   b. UL 864 Supply Line Transients
   c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

2.05 Input/Output Interface:

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

B. Modular, "hot-swappable" I/O so that the electronics of a small portion of the I/O can be replaced without effecting the power or communication for the other points.

C. 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 24V of any duration, such that contact with this voltage will cause no damage to the controller.

D. 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.

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

G. 24 Vdc shall be available next to the point signal for powering the output device.

H. 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.

I. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 Vdc or 4 to 20 mA signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

J. 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.

K. Point name labels. Print customized name labels for each I/O point and install on an existing holder on the I/O device.

L. 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.

2.06 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.
2.07 Auxiliary Control Devices

A. Electric Damper Actuators

1. General

   a. The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.

   b. Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing. Alternatively, an uninterruptible power supply (UPS) may be provided. On terminal unit valves actuators and 2-second timing damper actuators capacitor driven fail action is permitted.

   c. Proportional 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. Modulating actuator shall accept a 0-10 Vdc control signal and provide a 0-10 Vdc operating range.

   d. All 24 Vac/Vdc actuators shall operate on Class 2 wiring.

   e. All actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 Nm (60 in.-lb) torque capacity shall have a manual crank for this purpose.

   f. Electric actuators for emergency generator damper control shall be rated for 350°F. maximum operating temperature and capable to drive fully open and close within 15 seconds.

   g. All damper actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp. V-bolt type damper shaft clamp is not acceptable.

   h. All actuators that provide a factory mounted electrical appliance or plenum rated cabling must be marked with numbers on the wires as well as color coded.

   i. Control damper actuators shall be RoHS Part A complaint.

B. 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 lugge 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 to 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.

C. Ball Valves

1. Furnish automatic full port ball valves for isolation requirements on line sizes up to 2 feet 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. The valves shall be line size as shown on plans.

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

h. For modulating service that require large valve size (above 6 inches), 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.

E. Temperature sensors.

1. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensor shall use platinum RTD elements only, nickel or silicon are 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: none required
   e. Factory calibration point: 32°F
   f. Accuracy at calibration point: +/- 0.5°F

3. Liquid Immersion Temperature
   a. Temperature monitoring range: +30/+250°F, +20/+70°F or +32/+212°F
   b. Output signal: 4-20 mA
   c. Installation adjustment: none required
   d. Calibration adjustments: none required
   e. Factory calibration point: 32°F
   e. Accuracy at calibration point: +/- 0.54°F

4. Duct (Single Point) Temperature
   a. Temperature monitoring range: +20/+120°F or +30/+250°F
   b. Output signal: 4-20 mA
   c. Installation adjustments: none required
   d. Calibration adjustments: none required
   e. Factory calibration point: 70°F
   f. Accuracy at calibration point: +/- 0.54°F

5. Duct (Averaging) Temperature
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a. Temperature monitoring range +20/+120°F
b. Output signal 4 - 20 mA
c. Installation adjustments none required
d. Calibration adjustments none required
e. Factory calibration point 32°F
f. Accuracy at calibration point +/- 0.54°F

6. Mixed Air (Averaging) Temperature

   a. Temperature range -50/+275°F
   b. Gasket Temperature Range 212°F max
c. Leadwires AWG 22, PTFE insulated, 8” long
d. Sensor Type Bendable Averaging Sensor with copper sheaths
e. RTDs Platinum 1000 Ohm at 0°C
f. Box Weatherproof Connection Box
g. Accuracy +/- 1°F
h. Make/Model Access: Micro/S488PW or equal
i. Use about 1 ft of sensor per sq. ft. of mixed air plenum. Largest mixed air plenum size is 16’x56’.

7. Outside Air Temperature

   a. Temperature monitoring range -58/+122°F
   b. Output signal 4-20 mA
c. Installation adjustments none required
d. Calibration adjustments none required
e. Factory calibration point 70°F
f. Accuracy at calibration point +0.5°F

F. 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 and span
d. Factory calibration point 70°F
e. Accuracy at calibration point +2.0°F DP

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 none required
g. Operating temperature 15°F to +170°F
h. Voltage requirement 12-36 Vdc

3. Room Hygrostat
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4. **Duct Hygrostat**
   |   |
   | **a.** Humidity setpoint range | 15 to 95% |
   | **b.** Switching differential | +/- 4% |
   | **c.** Output signal | On/off |
   | **d.** Setpoint | Exposed or concealed |
   | **e.** Switch type | Single pole microswitch |
   | **f.** Operating temperature | 32 to 158°F |
   | **g.** Agency listing | UL (low voltage) |

5. **Condensation Sensor**
   |   |
   | **a.** Switching point on RH Increase | 95% |
   | **b.** Operating Voltage | 24 Vac/Vdc |
   | **c.** Operating Temperature | -12 to 122°F |
   | **d.** Operating Humidity | 5 to 95% |
   | **e.** Relay Output | NO/NC dry contact |
   | **f.** Switching Differential | 5% rh |
   | **g.** Response time (max) | 3 minutes |
   | **h.** Power Consumption (max) | 1 VA |

G. **Pressure sensors**

1. **Air Static Pressure Sensor**
   |   |
   | **a.** Duct Static range | -.5 to + 7.5" wg |
   | **b.** Accuracy | + .05" wg |
   | **c.** Output signal | 4 - 20 mA |

H. **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. Overrange 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.

I. 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 setpoint. 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.).

J. Analog water level sensors

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

K. 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. Locating leak detection panel (TTB-FA)
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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). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.
   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
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continuity wire and a return wire. All four wires shall be coated and insulated with a fluoropolymer and wound helically around a fluoropolymer 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 24 Vdc 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, 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.
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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.

L. Water Flow Switches

1. Shall use either a microswitch or reed contact.

2. UL Listed for low voltage.

3. Supports media temperature up to 230°F.

M. Indoor air quality (CO2/VOC) sensors

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

2. The CO2 sensor shall be of microprocessor-based non-dispersive infrared type.

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.
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5. Duct mounted sensors shall be provided without the need for a separate aspirator box.

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

7. 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 – 10V VOC
   i. Permissible air velocity in duct: <26.2 ft/s.

N. 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 setpoint 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.

O. 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.

P. Current transmitters.

1. 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 10A, 20A, 50A, 100A, 150A, and 200A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.

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

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

Q. 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 5A full-scale output.

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

R. 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.

S. 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.

T. 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 ±3% at 1.0 power factor or ±2.5% at 0.5 power factor.

U. 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.

V. Pressure-electric (pe) switches

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale setpoint 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.

W. 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 control input.

2. E/P transducer shall be equipped with the following features:
   a. Separate span and zero adjustments
   b. Manual output adjustments
   c. Pressure gauge assembly
   d. Feedback loop control
   e. Air consumption of 0.05 l/s (0.1 scfm) at mid-range

X. 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.

Y. Local user display

1. The controllers on the peer to peer building level network shall have a touch display and keypad for global interface. A keypad shall be provided for interrogating and commanding all points on the system. One (1) touch display is required for a group or individual controller(s) in each room.

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 graphical 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.

2.08 Communication and Control Wiring

A. General:

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

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

3. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2 inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit sealoff fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.

4. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.

5. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

6. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.

7. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.

B. Wire Sizing and Insulation

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

<table>
<thead>
<tr>
<th>Service</th>
<th>Minimum Gage/Type</th>
<th>Insulation Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. AC 24V Power</td>
<td>12 Ga Solid</td>
<td>600 Volt</td>
</tr>
<tr>
<td>b. DC 24V Power</td>
<td>10 Ga Solid</td>
<td>600 Volt</td>
</tr>
<tr>
<td>c. Class 1</td>
<td>14 Ga Stranded</td>
<td>600 Volt</td>
</tr>
<tr>
<td>d. Class 2</td>
<td>18 Ga Stranded</td>
<td>300 Volt</td>
</tr>
<tr>
<td>e. Class 3</td>
<td>18 Ga Stranded</td>
<td>300 Volt</td>
</tr>
</tbody>
</table>
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 – Wiring of this specification.

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 twisted pair, insulated.
2. Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.
3. Actuators with tri-state control shall use 3 conductor with same characteristics

E. Communication Wiring
1. 300 feet and below: Ethernet Cable shall be minimum CAT6.
2. Above 300 feet: Ethernet Cable shall be 62.5/125μ multimode fiber.
3. Secondary level network shall be 24 gage, 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

2.09 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 62.5/125µm 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.
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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 275 m. Single mode Ethernet requires two strands of 9 um cable.

PART 3 – EXECUTION

3.01 Coordination

A. Site

1. 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.

2. 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.

3. 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.

4. 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 section in PART 1-GENERAL of this specification for requirements.

C. Coordination with controls specified in other sections.

1. Other sections 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 the Communication section in PART 2 – PRODUCTS 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 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.

3.02 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.

3.03 Field Quality Control

A. 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 I—GENERAL of this specification.

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

3.04 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. The contractor is responsible for testing controlled devices and reporting for repairs needed.

3.05 Wiring

A. All control and interlock wiring shall comply with national and local electrical codes and electrical specification. Where the requirements of this section differ from those in electrical specs, 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 electrical specification 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)
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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 120V. 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.
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S. Conceal all conduit, 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 the electrical specification 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 1/2 inch 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.

3.06 Communication Wiring

A. The contractor shall adhere to the items listed in the Wiring section in PART 3 – EXECUTION 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 arrester must be installed between the lines and ground. The lighting arrester 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.
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I. Grounding of coaxial cable shall be in accordance with NEC regulations article on *Communications Circuits, Cable, and Protector Grounding.*

3.07 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.

D. Copper (CAT6E) will be the preferred medium for Ethernet connection to the controls system unless the distance exceeds 100 meters in which case 62.5/125μ multimode fiber will be used.

3.08 Warning labels and Identification tags

A. 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. Identify room sensors relating to terminal box or valves with nameplates.

4. Manufacturers’ nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

3.09 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 (1/2 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.

3.10 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 the Submittals section in PART 1 – GENERAL of this specification.

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. Embed 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:

f. 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 programming and compilation wizard to allow for ease of editing.

g. Graphic-based:

1) Must provide actions for all possible situations.
2) Must provide programming 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 setpoints.
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 the Operator Interface Software section in PART 2–PRODUCTS of this specification.

3.11 Control system checkout and testing

A. Additional testing, debugging and fine tuning

1. Provide an additional 24 hours of appropriate highest labor cost category to be used at the owner's discretion to test, debug and fine tune the system during standard business hours.

3.12 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 of the installation, start-up, and debugging process and as specified in the Control System Checkout and Testing section in PART 3–EXECUTION 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 the Submittals section in PART 1–GENERAL of this specification. 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 the System Performance section in PART 1–GENERAL of this specification.

7. Demonstrate compliance with sequences of operation through all modes of operation.

8. Demonstrate complete operation of operator Interface.

9. 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 the Submittals section in PART 1–GENERAL of this specification.

3.13 Cleaning

A. The contractor shall clean up all debris resulting from their activities daily. Contractor shall remove all cartons, containers, crates, etc., under their 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.

3.14 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.
Onsite training shall be for six (6) employees. Training shall not be more than four (4) hours per day increments. Coordinate with District for final schedule and personnel to be trained.

In addition to the site specific training on the system installed, as outlined below, provide enrollment for two (2) building operators in a four (4) day course at a manufacturer’s factory training center. All course tuition, course material fees and transportation to and from the training center are to be included in the proposal. Expenses for lodging and meals will be provided.

1. The training will include:
   a. System architecture and configuration of the system
   b. Navigation through the system
   c. Customizing the main menu
   d. Define and generate reports
   e. Schedule reports to run automatically
   f. Identify the DDC hardware used to control and monitor building equipment
   g. Describe system architecture and system profile
   h. Address and modify points
   i. System operation, including DDC system control and optimizing routines
   j. Manage system alarms and alarm messages
   k. Monitor and command system points to control building equipment
   l. Manage alarms from Graphics
   m. Utilize dynamic information in the graphics
   n. Create trend definitions and collect trend data
   o. Override scheduled events and zones
   p. Generate a dynamic plot to monitor system information

Provide 40 hours, or a lesser value if requested by the District, 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 setpoints, time schedules, and holiday schedules
Building Management System Upgrade

1. 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 alarms
   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
Building Management System Upgrade

b. Interface with job-specific, third-party operator software

c. Add new users and understand password security procedures

E. Provide 8 hours of additional training quarterly during warranty period.

F. Since the District 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.

G. Provide course outline and materials in accordance with the Submittals section in PART 1 - GENERAL of this specification. The Instructor(s) shall provide one copy of training material per student.

H. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

3.15 Point list

A. Provide three (3) copies of the update points list to the District upon completion of project. Points list shall consists of the following hierarchy:

1. Building Name.
2. Equipment/System Name.
3. Control Valve/Damper Name (if applicable).
4. Specific Point Name.

*****END OF SECTION*****