

## SECTION 17000 – BUILDING MANAGEMENT SYSTEM

## PART 1 - GENERAL

## 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

## 1.2 SUMMARY

- A. This Section includes the design and installation of a direct digital control (DDC) Building Management System (BMS). Include control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-packaged controls. Provide DDC controls, with associated devices and components, where specified. Provide installation of controls that are part of the HVAC system whether they are a part of the DDC system or not.
- B. This Section includes DDC controls for Lighting system installed on the same operator interface as the HVAC controls.
- C. See "Sequence of Operation" for requirements that relate to this Section.

## 1.3 SCOPE OF WORK

- A. The BMS contractor shall comply with the following:
  - 1. Provide a server-hardware based Web-enabled operator interface for managing the primary interface to the system for 20 simultaneous users.
  - 2. Provide a PC based Web-enabled operator interface for managing the primary interface to the system for 6 simultaneous users.
  - 3. Provide a PC based operator workstation with all of the control system programming, graphics generation, binding, downloading and service tools that are available for the control system. This workstation shall work independent from the Web server.
  - 4. Provide an open protocol network based upon ASHRAE 135-2001 BACnet standard. The intent is for all distributed controllers down to the terminal unit level to reside on an open protocol network.

## 1.4 DESIGN REQUIREMENTS

- A. The BMS contractor shall comply with the following:
  - 1. Provide a peer-to-peer network between DDC controllers so that information from any controller can be shared with any other controller with the need for an intermediate translator or global controller. Only routers are allowed between network types so that the peer-to-peer topology is maintained.
  - 2. Use BACnet BTL listed products wherever they are available.

3. Gateways are not allowed between subnetworks of DDC controllers. Gateways are only allowed for interoperating with a specific piece of packaged equipment, such as a chiller or VFD.
4. Splitting control points associated with a particular system between separate DDC controllers is not allowed. Controllers for systems that exceed input/output point counts of controllers shall use point expansion modules so that one program is used for sequencing the entire system.
5. Provide one application specific controller for each terminal unit.
6. All damper and valve actuation shall electronic.

## 1.5 PERFORMANCE REQUIREMENTS

- A. The BMS contractor shall provide a system that meets the following performance:
  1. The primary backbone of the DDC network shall provide high-speed data transfer between the workstation, server, and major DDC controllers for alarm reporting, quick data loading for graphics and trends viewing, and efficient program upload and downloads.
  2. System performance shall ensure that an initial point alarm from any major piece of equipment is displayed/logged at the operator workstation or server within 2 seconds of the event happening.
  3. System performance shall ensure that each individual graphic display at the workstation or server is fully displayed with the associated real time date within 5 seconds of the operator request. Repetitive requests for graphics shall not affect the response time.
  4. Each and every real input and output and every adjustable setpoint shall reside on a graphical display. Setpoint shall not be buried in a program or database that requires a separate piece of software or a paid technician to manipulate.
  5. Every point shall have an Object Name in the program that can be edited so that the end user can edit and modify names for user-friendliness.
  6. Provide a graphical flow diagram for every system and piece of equipment. Provide floor plan graphics showing locations of space sensors and associated temperatures and setpoints.
  7. Text-based points listings are not acceptable as the primary operator interface method for the BAS operations staff.

## 1.6 RELATED SECTIONS

- A. Division 15 Sections on mechanical equipment that require control for field installation or factory mounting and wiring.
- B. Division 16 Sections on Basic Materials and Methods and Cabling.

## 1.7 DEFINITIONS

- A. BACNet: An industry standard data communication protocol for Building Automation and Control Networks. Refer to AHSRAE standard 135-2001
- B. BIBB: BACnet Interoperability Building Blocks

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- C. BMS: Building Management System
- D. DDC: Direct digital controls
- E. IP: Internet Protocol
- F. LAN: Local area network.
- G. MS/TP: Master-slave/token-passing. Refer to AHSRAE standard 135-2001
- H. TCP: Transfer Control Protocol

#### 1.8 WORK INCLUDED

- A. Furnish a complete distributed direct digital control system in accordance with this specification section. This includes all system controllers, logic controllers, and all input/output devices. Items of work included are as follows:
  - 1. Provide a submittal that meets the requirements below for approval.
  - 2. Coordinate installation schedule with the mechanical contractor and general contractor.
  - 3. Provide installation of all panels and devices unless otherwise stated.
  - 4. Provide power for panels and control devices from a source designated by the electrical contractor.
  - 5. Provide all low voltage control wiring for the DDC system.
  - 6. Provide miscellaneous control wiring for HVAC and related systems regardless of voltage.
  - 7. Provide engineering and technician labor to program and commission software for each system and operator interface. Submit commissioning reports for approval.
  - 8. Provide testing, demonstration and training as specified below.

#### 1.9 SUBMITTALS

- A. Provide submittals for fast track items that need to be approved and released to meet the schedule of the project. Provide submissions for the following items separately:
  - 1. Valve schedule and cut sheets
  - 2. Factory mounting and wiring diagrams and cut sheets
  - 3. Thermostat locations
- B. Provide a complete submittal with all controls system information for approval before construction starts. Include the following:
  - 1. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  - 2. Wiring Diagrams: Power, signal, and control wiring.
  - 3. Details of control panel faces, including sizes, controls, instruments, and labeling.
  - 4. Schedule of dampers including size, leakage, and flow characteristics.
  - 5. Schedule of valves including leakage and flow characteristics.
  - 6. Written description of the Sequence of Operations.

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7. Network riser diagram showing wiring types, network protocols, locations of floor penetrations and number of control panels. Label control panels with network addresses and BACnet device instance numbers. Show all routers, switches, hubs and repeaters.
  8. Starter and variable frequency drive wiring details of all automatically controlled motors.
  9. Reduced size floor plan drawings showing locations of control panels, thermostats and any devices mounted in occupied space.
  10. Check-out and commissioning sheets
  11. Variance letter
- C. Product Data: Include manufacturer's technical literature for each control device indicated, labeled with setting or adjustable range of control. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
- D. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
- E. Wiring Diagrams: Detail the wiring of the control devices and the panels. Show point-to-point wiring from field devices to the control panel. Show point-to-point wiring of hardwired interlocks. Show a ladder diagram or schematic of wiring internal to the panels, including numbered terminals. Clearly designate wiring that is done at a factory, at a panel shop or in the field.
- F. Submit blank field check-out and commissioning test reports, customized for each panel or system, that will be filled out by the technician during start-up.
- G. Variance letter: Submit a letter detailing each item in the submission that varies from the contract specification or sequence of operation in any way.
- H. After the BMS system is approved for construction, submit sample operator workstation graphics for typical systems for approval. Print and submit the graphics that the operator will use to view the systems, change setpoints, modify parameters and issue manual commands. Programming shall not commence until typical graphics are approved.
- 1.10 QUALITY ASSURANCE
- A. Installing contractor shall be in the business of installing and servicing DDC controls for mechanical systems, temperature and ventilation control, environmental control, lighting control, access and security controls, and energy management as their primary business. The contractor shall be able to demonstrate at least 5 years experience installing native BACnet networks and controls and integrating to HVAC equipment manufacturer provided native BACnet controls. The contractor shall also demonstrate experience installing Internet Protocol based network communication to remote sites.
- B. Installer Qualifications: An experienced installer who is the authorized representative of the automatic control system manufacturer for both installation and maintenance of controls required for this Project.

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- C. Engineering, drafting, programming, and graphics generation shall be performed by the local branch engineers and technicians directly employed by the Building Management System Contractor.
  - D. Supervision, checkout and commissioning of the system shall be by the local branch engineers and technicians directly employed by the Building Management System Contractor. They shall perform commissioning and complete testing of the BMS system.
  - E. Manufacturer Qualifications: A firm with at least 20 years experience in manufacturing microprocessor based, distributed direct digital automatic temperature control systems with a documentable record of successful in-service performance. Manufacturer must provide a complete, internet accessible, thin-client, native BACnet system including Webserver.
  - F. Provide electrical installation based upon methods and materials as specified in Division 16000 of this specification, based upon UL listed devices, and based upon NEC and NYC BEC.
  - G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  - H. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
  - I. Comply with ASHRAE 135-2001 BACNet: A Data Communication Protocol for Building Automation and Control Networks.
  - J. All equipment shall be UL listed and approved and shall meet with all applicable NFPA standards, including UL 916 - PAZX Energy Management Systems, UL 864 - UDTZ Signal Appliances, System Units, where required by code.
  - K. Provide written approvals and certifications after installation has been completed.
  - L. Final determination of compliance with these specifications shall rest solely with the Engineers and Owner who will require proof of prior satisfactory performance.
  - M. For any BMS system and equipment submitted for approval, the BMS contractor shall state what, if any, specific points of system operation differ from these specifications.
- 1.11 DELIVERY, STORAGE, AND HANDLING
- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.
- 1.12 COORDINATION
- A. Coordinate location of thermostats, humidistats, panels, and other exposed control components with plans and room details before installation.
  - B. Coordinate equipment with Division 16 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

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- C. Coordinate supply of conditioned electrical circuits for control units and operator workstation.
- D. Coordinate equipment with Division 15 Section on starters and drives to achieve compatibility with motor starter control coils and VFD control wiring.
- E. Coordinate scheduling with the mechanical contractor and general contractor. Submit a schedule for approval based upon the installation schedule of the mechanical equipment.

#### 1.13 WARRANTY

- A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one year from completion of system demonstration.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.
- C. This warranty shall apply equally to both hardware and software.

#### 1.14 ACCEPTABLE SYSTEMS

- A. Provide a system from one of the following:
  - 1. Delta Controls provided by Delta Controls Chicago, Inc. 105 S. York Rd, Elmhurst, IL 630-589-3800.
- B. Contractors not listed above must provide a technical proposal for approval by the Architect and Owner before they will be accepted as a vendor for the BMS.
- C. Technical Proposal
  - 1. Provide a detailed technical proposal describing all elements of the system. A schematic system layout shall be provided, showing relation of these elements and a description of how they operationally interrelate. Technical specification data sheets shall be provided for all proposed system components and devices.
  - 2. Provide a paragraph-by-paragraph statement of conformance with the specifications. This statement shall consist of a list of all numbered paragraphs. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the paragraph number. Where the proposed system does not comply, or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
  - 3. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
  - 4. Provide a System Architecture drawing showing typical DDC controller part numbers for the types of systems used on this project. Detail the types of networks, speeds and protocols used by each network leg.
  - 5. Submit a write-up of the application software that will be used on the operator workstation including revision level, functionality and software applications required to meet the specifications.
  - 6. Provide a statement of Interoperability stating what protocols and devices are used to interoperate with other manufacturers of controls systems and microprocessor devices.

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Provide a list of interoperable installations where systems from different manufactures were integrated using an industry standard protocol such as BACnet or an open protocol such as MODbus.

## PART 2 - PRODUCTS

### 2.1 BMS NETWORK

- A. All control products provided for this project shall comprise an industry standard open protocol internetwork. Communication involving control components (i.e. all types of controllers and operator interfaces) shall conform to ASHRAE 135-2001 BACnet standard. Networks and protocols proprietary to one company or distributed by one company are prohibited.
- B. The system must be fully BACnet at the time of installation. This means that the system must use BACnet as the native communications protocol between distributed controllers communicating on the controller network, and must at a minimum support the BACnet Interoperability Building Blocks (BIBBs) for each DDC application as specified herein.
- C. Provide all communication media, connectors, repeaters, bridges, switches, and routers necessary for the inter-network.
- D. The system shall meet peer-to-peer communication services such that the connection of any operator interface to any one controller shall allow the operator to interface with all other controllers. The software shall provide transparent viewing and editing of all data, control programs, schedules, trends, alarms from any one controller through connection to any other controller on the internetwork, regardless of subnetwork routers.
- E. The system shall meet peer-to-peer communication services such that the values in any one controller can be read or changed from all other controllers. The software shall provide transparent transfer of all data, control programs, schedules, trends, alarms from any one controller through the internetwork to any other controller, regardless of subnetwork routers.
- F. The network architecture shall consist of three levels of networks:
  - 1. The floor level network shall be BACnet over MS/TP. It shall network to all of the DDC controlled equipment on a floor or in a system and network to a router that connects to the base building BMS backbone.
  - 2. The Base Building Backbone level shall be BACnet over Ethernet. It shall network all routers, switches, and the Web Server.
  - 3. The Operator Interface level shall be BACnet/IP over Ethernet and Web Technology tools over TCP/IP.
- G. Limit the number of controllers on an MS/TP network to 40 per trunk to maintain system speed and response.
- H. Provide an Ethernet level router or controller for every 80 controllers on MS/TP networks to maintain system speed and response.
- I. Systems that use variations of BACnet using PTP between controllers, gateways, bridges or networks that are not peer-to-peer are not allowed.

- J. The BMS design shall allow the co-existence of current and future primary control panels and personal computer operator workstations on the same primary network.
- K. Remote Communications: Provide a TCP/IP compatible communication port for connection to the Owner's network for remote communications. Provide coordination with the Owner for addressing and router configuration on both ends of the remote network.
- L. Telecommunication Capability: One system controller shall provide capability to connect to the system through a 56K modem as a backup to other remote communications. The system shall not rely upon a PC workstation or server for communications. The Owner will provide a POTS telephone line and service dedicated for use by the BMS system. Remote operator interface via this modem shall allow for communication with any and all controllers on this network as described below. Demonstrate that this connection works when the system is turned over.

## 2.2 OPERATOR INTERFACE HARDWARE

- A. Operator Interface: Furnish one PC-based Graphical User Interface (GUI) as shown on the system drawings. Each of these workstations shall be able to access all information in the system. These workstations shall reside on the same BACnet/IP protocol network as the System Controllers.
- B. Hardware: Each GUI shall consist of the following:
  - 1. Personal Computer. Furnish IBM compatible PCs as shown. The CPU shall be a minimum of an Intel Pentium and operate at a minimum of 900 MHz. A minimum of 512 megabytes of RAM, CD/RW drive and a 80GB hard disk running at 7200 RPM shall be provided. Provide all peripherals to operate the PC. Furnish all required serial, parallel, and network communication ports, and all cables for proper system operation. Furnish a minimum 19" SVGA monitor.
  - 2. Printers. Each workstation shall have one printer equivalent to a Lexmark Z22 color inkjet and associated cables.
  - 3. The main PC/server shall serve as a HVAC controls web server for client machines.
- C. Software: The laptop shall be provide with the following software licenses, preloaded on the laptop for the Owner: MS Office Professional, PC anywhere, Internet Explorer, MS Outlook, Acrobat Reader, CAD Viewer. Set up an icon on the desktop to take the Owner directly to the BMS system login page.

## 2.3 OPERATOR INTERFACE LAPTOP

- A. Provide a laptop PC for the operator to use as an interface to the BMS system. Provide hardware from Dell, Gateway or Compaq.
- B. The PC shall meet the following specifications at a minimum:
  - 1. Intel 2.66GHz Pentium IV Processor
  - 2. 512MB, 266MHz memory
  - 3. 80GB Ultra ATA hard drive
  - 4. 16MB ATi Mobility Radeon 7500
  - 5. Integrated Network Card, 100/10 Mb
  - 6. Read/Write CD reader/burner

7. 56k internal modem
8. MS Windows XP

- C. Software: The laptop shall be provide with the following software licenses, preloaded on the laptop for the Owner: MS Office Professional, PC anywhere, Internet Explorer, MS Outlook, Acrobat Reader, CAD Viewer. Set up an icon on the desktop to take the Owner directly to the BMS system login page.

#### 2.4 WEB SERVER and GUI INTERFACE (B-OWS)

- A. The BMS contractor shall provide system software based upon a server/thin-client architecture, designed around the open standards of web technology. The BMS server shall communicate using ASHRAE's BACnet/IP protocol, as well as all other IP protocols. Protocols not using TCP/IP are specifically excluded. The Owner's technology department will not support or allow another packet types on their network. Server shall be accessed using a web browser over The Owner's intranet and remotely over the Internet.
- B. The intent of the thin-client architecture is to provide the operator(s) complete access to the BMS system via a web browser. No special software, (active-x components or fat java clients) shall be required to be installed on the PC's / PDA's used to access the BMS via a web browser. No special server hardware shall be required.
- C. The BMS server software must support at least the following server platforms (Windows NT and Linux). The BMS server software shall be developed and tested by the manufacturer of the system standalone controllers and network controllers/routers. Third party manufactured and developed BMS software is not acceptable.
- D. The BMS server shall meet the BACnet device profile of an Operator Workstation and shall support the following BACnet BIBBs:
1. Data Sharing
    - a. Data Sharing-Read Property-A (DS-RP-A)
    - b. Data Sharing-Read Property-B (DS-RP-B)
    - c. Data Sharing-Read Property Multiple-A (DS-RPM-A)
    - d. Data Sharing-Read Property Multiple-B (DS-RPM-B)
    - e. Data Sharing-Write Property-A (DS-WP-A)
    - f. Data Sharing-Write Property-B (DS-WP-B)
    - g. Data Sharing-Write Property Multiple-A (DS-WPM-A)
    - h. Data Sharing-Write Property Multiple-B (DS-WPM-B)
    - i. Data Sharing-COV-A (DS-COV-A)
    - j. Data Sharing-COV-B (DS-COV-B)
    - k. Data Sharing-COV-Unsolicited-A (DS-COVU-A)
    - l. Data Sharing-COV-Unsolicited-B (DS-COVU-B)
  2. Scheduling
    - a. Scheduling-A (SCHED-A)
    - b. Scheduling-Internal-B (SCHED-I-B)
    - c. Scheduling-External-B (SCHED-E-B)
  3. Trending
    - a. Trending-Viewing and Modifying Trends-A (T-VMT-A)
    - b. Trending-Viewing and Modifying Trends-Internal-B (T-VMT-I-B)
  4. Network Management

- a. Network Management-Connection Establishment-A (NM-CE-A)
- b. Network Management-Connection Establishment-B (NM-CE-B)
- 5. Alarming
  - a. Alarm and Event-Notification-A (AE-N-A)
  - b. Alarm and Event-Notification Internal-B (AE-N-I-B)
  - c. Alarm and Event-Notification External-A (AE-N-E-A)
  - d. Alarm and Event-ACK-A (AE-ACK-A)
  - e. Alarm and Event-ACK-B (AE-ACK-B)
  - f. Alarm and Event –Alarm Summary-A (AE-ASUM-A)
  - g. Alarm and Event –Alarm Summary-B (AE-ASUM-B)
- 6. Device Management
  - a. Device Management-Dynamic Device Binding-A (DM-DDB-A)
  - b. Device Management-Dynamic Device Binding-B (DM-DDB-B)
  - c. Device Management-Dynamic Object Binding-B (DM-DOB-B)
  - d. Device Management-Device Communication Control-A (DM-DCC-A)
  - e. Device Management-Device Communication Control-B (DM-DCC-B)
  - f. Device Management-Private Transfer-A (DM-PT-A)
  - g. Device Management-Private Transfer-B (DM-PT-B)
  - h. Device Management-Text Message-B (DM-TM-B)
  - i. Device Management-Time Synchronization-A (DM-TS-A)
  - j. Device Management-Time Synchronization-B (DM-TS-B)
  - k. Device Management-UTC Time Synchronization-A (DM-UTC-A)
  - l. Device Management-Reinitialize Device-A (DM-RD-A)
  - m. Device Management-List Manipulation-B (DM-LM-B)
  - n. Device Management-Object Creation and Deletion-A (DM-OCD-A)
  - o. Device Management-Object Creation and Deletion-B (DM-OCD-B)
- E. The web browser GUI shall provide a completely interactive user interface and must offer the following features as a minimum:
  - 1. Trending
  - 2. Scheduling
  - 3. Downloading Memory to field devices
  - 4. Real time ‘live’ Graphic Programs
  - 5. System Name and Geographic Navigation Trees
  - 6. Parameter changes of all object properties
  - 7. Setpoint Adjustments
  - 8. Alarms and Events
  - 9. Operators Usage
  - 10. Hyperlinks
- F. Web Browser Interface
  - 1. The Server shall be accessible simultaneously by an unlimited number of users. Unlimited is only to be defined by the Owner’s stipulation or the capabilities of their infrastructure and not by any licensing agreement required by the control supplier or manufacturer. Systems that have user restrictions, simultaneous or otherwise are not acceptable as it is impractical to forecast the future needs of the client.
  - 2. The thin-client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to “feel” like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be provide the various means of navigation as described herein.

3. On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator's role privileges, and geographic area of responsibility
4. The System Navigation Pane shall be comprised of a tree that represents the relationships among all controlled or monitored equipment. HVAC, Lighting, and Security shall be represented on the tree but each as the highest level in the hierarchy.
5. The Geographic Navigation Pane shall be comprised of drop down menus that allow the user to navigate without the need for having knowledge in the systems controlled. The drop downs shall be arranged to depict the commonly understood layout of the facility such as: cities, sites, buildings, floors, rooms, occupant, etc. Systems that navigate solely by mechanical system or network systems are not acceptable.
6. The navigation trees define a geographic and equipment hierarchy of the BMS system. Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft's Explorer program), and/or by selecting dynamic links to other system graphics from displayed system graphics. Both the navigation tree and graphic shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the graphic corresponding to the highlighted position in the navigation tree.
7. A system graphic shall allow the operator to move up or down the system hierarchy by clicking on the graphic. An operator, for example, shall be able to click on the incoming chilled water piping to move to the associated chilled water system. To assist in navigation all physical links to and from one piece of equipment to its superior or its subordinate shall be represented by virtual links. The operator shall be able to navigate from the home page through all screens by clicking on the graphic screen maps, buildings, floor plans, and the hierarchy links described above.
8. Graphics: Using animated gifs or other graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic setpoint controls, web content, and other valid HTML, XML, SVG elements. The data on each graphic page shall automatically refresh at a rate defined by the operator.
9. Display size shall be dynamic changing size based on the viewers chosen screen resolution. Systems that depend on scroll bars are not acceptable.
10. Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints.
  - a. The colors shall be updated dynamically as a zone's actual temperature to setpoint changes. These full screen plans shall be accessible by rolling over the floor on the building elevation rendering. This will provide the viewer a quick and accurate overview of the building zone conditions.
  - b. The viewer may then click on any zone to be brought to the HVAC, Lighting or access system related to that zone. Rolling over any zone will bring up the zone description and temperature in a pop-up flag. Flags are used to keep the zone information legible regardless of how small the zone is depicted on the plan
  - c. All floor plans shall be vector based to allow for zooming in and out of floor plans without pixelization.
11. Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability. Each piece of equipment being monitored

- or controlled shall be depicted including: Each piece of equipment including each terminal unit, each building, each floor and each zone.
12. Utilizing a mouse, it shall be possible to select occupied or unoccupied setpoints (corresponding to the floor plan colors) and drag the color bars to increase or decrease heating and cooling setpoints. In addition to the slide bars, an operator may type the numeric value of the heating and cooling setpoints. The floor plan graphic shall then change colors on a zone-by-zone basis to reflect the actual temperature in each zone relative to the adjusted heating or cooling setpoint.
    - a. The viewer shall be able to adjust the alarm trip points in the same manner for high and low space temperature alarm.
    - b. The color bars shall indicate which bar is active for the zone monitored.
    - c. An energy bar shall not be adjustable but shall be maintained by demand limiting or consumption limiting software. The high/low alarm points shall be automatically set by the BMS to correspond to the occupied alarm offsets set by the viewer. If the energy bar is active its color representations on the floor plan shall be active and occupied/unoccupied shall be made inactive.
  13. Scheduling shall be accomplished by using the system geographic navigation tree. The viewer shall be able to define a Time of Day, Holiday or Event schedule for an individual piece of equipment, room, area, floor, tenant, building, campus, site, etc. For example, a new time schedule for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree.
  14. Schedules shall comply with the BACnet standard, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled. Schedules shall have the ability to be created in the following manner: A specific date, A range of dates, Any combination of Month of Year (1-12, any), Day of Week, Wildcard (example, allow combinations like second Tuesday of every month).
  15. An alarm icon shall display on the navigation tree if any alarm exists in any part of the system. An alarm icon shall display on a specific screen if there is an active alarm on the system being displayed.
  16. Trends shall conform to the BACnet Trend Log Object specification. The system shall be able to trend and display graphically any analog, digital or calculated points.
  17. Systems that Security access from the web browser GUI to BMS server shall require a Login Name and Password. Access to different areas of the BMS system security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application.
  18. System Graphics. The GUI shall allow display of up to 10 dynamic and animated graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.
  19. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Visio or AutoCad.

20. Dynamic Data Exchange (DDE). Software shall support dynamic data sharing with other Windows-based programs for third party add-on functionality e.g. preventative maintenance, tenant billing, etc.

## 2.5 SYSTEM APPLICATION SOFTWARE

- A. Provide a copy of the software (or all softwares if there are multiple) used to program and download sequences to controllers. Provide a backup of the all of the programs used in the system for storage by the Owner.
- B. The system software shall have the following features:
  1. System Database Save and Restore. The software shall store on the hard disk a copy of the current database of each DDC Controller. This database shall be updated whenever an operator initiates a save command.
  2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to save the database from any DDC controller. The operator shall be able to clear a panel database via the network and may initiate a download of a specified database to any panel in the system from the network.
  3. System Configuration. The software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection.
  4. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application.
  5. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.
  6. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm, in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon acronyms or other mnemonics.
  7. Alarm Reactions. The operator shall be able to determine (by object) what if any actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation.
  8. Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include change-of-value digital, change-of-value analog, time interval, start time, and stop time. Trend data shall be sampled and stored on the DDC controller, and be uploaded and archived on the hard disk and be retrievable for use in spreadsheets and standard database programs.
  9. Alarm and Event Log. The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms.
  10. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs. The software shall have the capability to create, delete and support the following Objects:
    - a. Analog input, analog output and analog value
    - b. Binary input, binary output and binary value

- c. Calendar
  - d. Device
  - e. Event Enrollment (Alarming)
  - f. File
  - g. Loop (PID)
  - h. Notification Class
  - i. Program
  - j. Schedule
  - k. Trend Log
11. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. The system shall be fully operable while custom routines are edited, compiled, and downloaded.

## 2.6 CONTROL PANELS

- A. Unitized cabinet with suitable brackets for wall or floor mounting, located adjacent to each system under automatic control. Provide common keying for all panels. Fabricate panels of 16 gauge, furniture-quality steel, or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with ANSI 61 gray polyester-powder painted finish, UL listed.
- B. Alarm Indication Station: Provide a common alarm indication station where specified in the sequence of operations. It shall have a light, horn, and horn silence switch mounted in an enclosure. Provide Kele model AIS or approved equal.
  - 1. Alarm Condition: Indicating light on and horn sounds.
  - 2. Silence button: Horn is silent and indicating light is steady.
  - 3. Alarm Condition Cleared: System is reset and indicating light is extinguished.

## 2.7 BUILDING CONTROLLERS – (B-BC)

- A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.
- B. This controller shall have the BTL listing and meet the BACnet device profile of an Advanced Application Controller and shall support the following BACnet BIBBs:
  - 1. Data Sharing
    - a. Data Sharing-Read Property-A (DS-RP-A)
    - b. Data Sharing-Read Property-B (DS-RP-B)
    - c. Data Sharing-Read Property Multiple-B (DS-RPM-B)
    - d. Data Sharing-Write Property-A (DS-WP-A)
    - e. Data Sharing-Write Property-B (DS-WP-B)
    - f. Data Sharing-Write Property Multiple-B (DS-WPM-B)
    - g. Data Sharing-COV-A (DS-COV-A)
    - h. Data Sharing-COV-B (DS-COV-B)
    - i. Data Sharing-COV-Unsolicited-A (DS-COVU-A)
    - j. Data Sharing-COV-Unsolicited-B (DS-COVU-B)

2. Scheduling
  - a. Scheduling-A (SCED-A)
  - b. Scheduling-Internal-B (SCHED-I-B)
  - c. Scheduling-External-A (SCHED-E-B)
3. Trending
  - a. Trending-Viewing and Modifying Trends Internal-B (T-VMT-I-B)
  - b. Trending-Viewing and Modifying Trends-External-B (T-VMT-E-B)
  - c. Trending-Automated Trend Retrieval-B (T-ATR-B)
4. Network Management
  - a. Network Management-Connection Establishment-A (NM-CE-A)
  - b. Network Management-Connection Establishment-B (NM-CE-B)
5. Alarming
  - a. Alarm and Event-Notification Internal-B (AE-N-E-B)
  - b. Alarm and Event-Notification External-B (AE-N-E-B)
  - c. Alarm and Event-ACK-B (AE-ACK-B)
  - d. Alarm and Event –Alarm Summary-B (AE-ASUM-B)
  - e. Alarm and Event –Enrollment Summary-B (AE-ESUM-B)
6. Device Management
  - a. Device Management-Dynamic Device Binding-A (DM-DDB-A)
  - b. Device Management-Dynamic Device Binding-B (DM-DDB-B)
  - c. Device Management-Dynamic Object Binding-B (DM-DOB-B)
  - d. Device Management-Device Communication Control-B (DM-DCC-B)
  - e. Device Management-Private Transfer-A (DM-PT-A)
  - f. Device Management-Private Transfer-B (DM-PT-B)
  - g. Device Management-Text Message-A (DM-TM-A)
  - h. Device Management-Time Synchronization-A (DM-TS-A)
  - i. Device Management-Time Synchronization-B (DM-TS-B)
  - j. Device Management-UTC Time Synchronization-A (DM-UTC-A)
  - k. Device Management-UTC Time Synchronization-B (DM-UTC-B)
  - l. Device Management-Reinitialize Device-B (DM-RD-B)
  - m. Device Management-Object Creation and Deletion-B (DM-OCD-B)

C. This level of controller shall be used for the following types of systems:

1. Chiller plant systems
2. Heating plant systems
3. Large VAV air handlers
4. Air handlers over 15,000 cfm
5. Systems with over 20 controlled points

D. Each System Level Control Panel shall, at a minimum, be provided with:

- a. Appropriate NEMA rated metal enclosure.
- b. A 16-bit, stand-alone, multi-tasking, multi-user, real-time digital control microprocessor module.
- c. 10-bit resolution inputs
- d. Primary Network communication module, if needed for primary network communications.
- e. Secondary Network communication module, if needed for secondary network communications.
- f. Memory module (4 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, 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, dial-up communications.
- g. Real time clock and battery
  - h. Data collection/ Data Trend module sized for 10,000 data samples.
  - i. Power supplies as required for all associated modules, sensors, actuators, etc.
  - j. Input/output point modules as required including spare capacity.
  - k. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
  - l. Monitoring of the status of all hand-off-auto switches. The status of the hand-off-auto switch shall be available as a BMS data point.
  - m. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
  - n. Local 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. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
  - o. Graduated intensity LEDs or analog indication of value for each analog output.
  - p. Approvals and standards: UL916; CE; FCC
2. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. These override switches shall be operable whether the panel processor is operational or not. Provide hand/off/auto switch for each digital output, including spares. Provide hand/auto switch and gradual positioning potentiometer for each analog output, including spares.
  3. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.
  4. Each System Level Control Panel shall provide battery backup to support the real-time clock and all memory and programs for a minimum of 100 hours.
  5. Each System Level Control Panel shall support firmware upgrades without the need to replace hardware.
  6. System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
  7. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- E. Spare Capacity: Provide 4 spare inputs and 4 spare outputs to handle expansion for new equipment in the future. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

- F. Provide a UPS power conditioner and backup for the System Level Controller to provide 15 minutes of power backup.

## 2.8 ADVANCED APPLICATION CONTROLLERS – (B-AAC)

- A. Provide all necessary hardware for a complete operating system as required. The Advanced Application level control panel shall be able to operate as a standalone panel and shall not be dependent upon any higher level computer or another controller for operation.
- B. This controller shall have the BTL listing and meet the BACnet device profile of an Advanced Application Controller and shall support the following BACnet BIBBs:
1. Data Sharing
    - a. Data Sharing-Read Property-A (DS-RP-A)
    - b. Data Sharing-Read Property-B (DS-RP-B)
    - c. Data Sharing-Read Property Multiple-B (DS-RPM-B)
    - d. Data Sharing-Write Property-A (DS-WP-A)
    - e. Data Sharing-Write Property-B (DS-WP-B)
    - f. Data Sharing-Write Property Multiple-B (DS-WPM-B)
    - g. Data Sharing-COV-A (DS-COV-A)
    - h. Data Sharing-COV-B (DS-COV-B)
    - i. Data Sharing-COV-Unsolicited-A (DS-COVU-A)
    - j. Data Sharing-COV-Unsolicited-B (DS-COVU-B)
  2. Scheduling
    - a. Scheduling-A (SCED-A)
    - b. Scheduling-Internal-B (SCHED-I-B)
    - c. Scheduling-External-A (SCHED-E-B)
  3. Trending
    - a. Trending-Viewing and Modifying Trends Internal-B (T-VMT-I-B)
    - b. Trending-Viewing and Modifying Trends-External-B (T-VMT-E-B)
    - c. Trending-Automated Trend Retrieval-B (T-ATR-B)
  4. Network Management
    - a. Network Management-Connection Establishment-A (NM-CE-A)
    - b. Network Management-Connection Establishment-B (NM-CE-B)
  5. Alarming
    - a. Alarm and Event-Notification Internal-B (AE-N-E-B)
    - b. Alarm and Event-Notification External-B (AE-N-E-B)
    - c. Alarm and Event-ACK-B (AE-ACK-B)
    - d. Alarm and Event –Alarm Summary-B (AE-ASUM-B)
    - e. Alarm and Event –Enrollment Summary-B (AE-ESUM-B)
  6. Device Management
    - a. Device Management-Dynamic Device Binding-A (DM-DDB-A)
    - b. Device Management-Dynamic Device Binding-B (DM-DDB-B)
    - c. Device Management-Dynamic Object Binding-B (DM-DOB-B)
    - d. Device Management-Device Communication Control-B (DM-DCC-B)
    - e. Device Management-Private Transfer-A (DM-PT-A)
    - f. Device Management-Private Transfer-B (DM-PT-B)
    - g. Device Management-Text Message-A (DM-TM-A)
    - h. Device Management-Time Synchronization-A (DM-TS-A)
    - i. Device Management-Time Synchronization-B (DM-TS-B)
    - j. Device Management-UTC Time Synchronization-A (DM-UTC-A)

- k. Device Management-UTC Time Synchronization-B (DM-UTC-B)
  - l. Device Management-Reinitialize Device-B (DM-RD-B)
  - m. Device Management-Object Creation and Deletion-B (DM-OCD-B)
- C. This level of controller shall be used for the following types of systems:
- 1. Cooling Towers
  - 2. Pumping systems
  - 3. Small VAV air handlers
  - 4. Air handlers under 15,000 cfm
  - 5. Systems with up to 20 controlled points
- D. Each System Level Control Panel shall, at a minimum, be provided with:
- a. Appropriate NEMA rated metal enclosure.
  - b. A 16-bit, stand-alone, multi-tasking, multi-user, real-time digital control microprocessor module.
  - c. 10-bit resolution inputs
  - d. Primary Network communication module, if needed for primary network communications.
  - e. Secondary Network communication module, if needed for secondary network communications.
  - f. Memory module (4 Megabyte, minimum) to accommodate all Primary Control Panel software requirements, including but not limited to, 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, dial-up communications.
  - g. Real time clock and battery
  - h. Data collection/ Data Trend module sized for 10,000 data samples.
  - i. Power supplies as required for all associated modules, sensors, actuators, etc.
  - j. Input/output point modules as required including spare capacity.
  - k. Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.
  - l. Monitoring of the status of all hand-off-auto switches. The status of the hand-off-auto switch shall be available as a BMS data point.
  - m. Monitoring of all industry standard types of analog and digital inputs and outputs, without the addition of equipment to the primary control panel.
  - n. Local 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. Each primary control panel shall perform diagnostics on all inputs and outputs and a failure of any input or output shall be indicated both locally and at the operator workstation.
  - o. Graduated intensity LEDs or analog indication of value for each analog output.
  - p. Approvals and standards: UL916; CE; FCC
2. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. These override switches shall be operable whether the panel processor is operational or not. Provide hand/off/auto switch for each digital output, including spares. Provide hand/auto switch and gradual positioning potentiometer for each analog output, including spares.

3. Each System Level Control Panel shall continuously perform self-diagnostics on all hardware modules and network communications. The System Level Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication with any system.
  4. Each System Level Control Panel shall provide battery backup to support the real-time clock and all memory and programs for a minimum of 100 hours.
  5. Each System Level Control Panel shall support firmware upgrades without the need to replace hardware.
  6. System Level control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.
  7. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- E. Spare Capacity: Provide 4 spare inputs and 4 spare outputs to handle expansion for new equipment in the future. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.
- F. Provide a UPS power conditioner and backup for the System Level Controller to provide 15 minutes of power backup.

## 2.9 APPLICATION SPECIFIC CONTROLLERS – (B-ASC)

- A. Each Application Level Control Panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each application specific controller shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- B. This controller shall have the BTL listing and meet the BACnet device profile of an Advanced Specific Controller and shall support the following BACnet BIBBs:
  1. Data Sharing
    - a. Data Sharing-Read Property-A (DS-RP-A)
    - b. Data Sharing-Read Property-B (DS-RP-B)
    - c. Data Sharing-Read Property Multiple-B (DS-RPM-B)
    - d. Data Sharing-Write Property-A (DS-WP-A)
    - e. Data Sharing-Write Property-B (DS-WP-B)
    - f. Data Sharing-Write Property Multiple-B (DS-WPM-B)
    - g. Data Sharing-COV-A (DS-COV-A)
    - h. Data Sharing-COV-B (DS-COV-B)
    - i. Data Sharing-COV-Unsolicited-A (DS-COVU-A)
    - j. Data Sharing-COV-Unsolicited-B (DS-COVU-B)
  2. Scheduling
    - a. Scheduling-A (SCED-A)
    - b. Scheduling-Internal-B (SCHED-I-B)
    - c. Scheduling-External-A (SCHED-E-B)
  3. Trending

- a. Trending-Viewing and Modifying Trends Internal-B (T-VMT-I-B)
- b. Trending-Viewing and Modifying Trends-External-B (T-VMT-E-B)
- c. Trending-Automated Trend Retrieval-B (T-ATR-B)
- 4. Network Management
  - a. Network Management-Connection Establishment-A (NM-CE-A)
  - b. Network Management-Connection Establishment-B (NM-CE-B)
- 5. Alarming
  - a. Alarm and Event-Notification Internal-B (AE-N-I-B)
  - b. Alarm and Event-Notification External-B (AE-N-E-B)
  - c. Alarm and Event-ACK-B (AE-ACK-B)
  - d. Alarm and Event –Alarm Summary-B (AE-ASUM-B)
  - e. Alarm and Event –Enrollment Summary-B (AE-ESUM-B)
- 6. Device Management
  - a. Device Management-Dynamic Device Binding-A (DM-DDB-A)
  - b. Device Management-Dynamic Device Binding-B (DM-DDB-B)
  - c. Device Management-Dynamic Object Binding-B (DM-DOB-B)
  - d. Device Management-Device Communication Control-B (DM-DCC-B)
  - e. Device Management-Private Transfer-A (DM-PT-A)
  - f. Device Management-Private Transfer-B (DM-PT-B)
  - g. Device Management-Text Message-A (DM-TM-A)
  - h. Device Management-Time Synchronization-A (DM-TS-A)
  - i. Device Management-Time Synchronization-B (DM-TS-B)
  - j. Device Management-UTC Time Synchronization-A (DM-UTC-A)
  - k. Device Management-UTC Time Synchronization-B (DM-UTC-B)
  - l. Device Management-Reinitialize Device-B (DM-RD-B)
  - m. Device Management-Object Creation and Deletion-B (DM-OCD-B)
- C. Provide a Application Specific Control Panel for each of the following types of equipment (if applicable):
  - 1. Constant Air Volume (CAV) boxes
  - 2. Duct-mounted reheat coils
  - 3. Fancoil Units
  - 4. Fan-Powered Variable Air Volume (VAV) Boxes
  - 5. Reheat Coils
  - 6. Supplemental AC units
  - 7. Variable Air Volume (VAV) Boxes
  - 8. Other terminal equipment
- D. Each Application Specific Controller shall, at a minimum, be provided with:
  - 1. Appropriate NEMA rated enclosure
  - 2. A 16-bit stand-alone real-time digital control microprocessor module
  - 3. Secondary network communications ability
  - 4. Power supplies as required for all associated modules, sensors, actuators, etc.
  - 5. 10-bit resolution input/output points as required
  - 6. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable
  - 7. A portable operator terminal connection port
  - 8. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure
  - 9. Local LED status indication for each digital input and output

10. Each controller measuring air volume shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time
  11. Each controller measuring air volume shall include a differential pressure transducer
  12. SCR control of electric heaters
  13. Fan speed controller for fan powered VAV boxes
  14. Fan relay for fan powered VAV boxes and fan coil units
  15. Approvals and standards: UL916; CE; FCC
- E. Each Application Specific Controller shall continuously perform self-diagnostics on all hardware and secondary network communications. The Application Specific Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.
- F. Provide each Application Specific Controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or a minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.
- G. The Application Specific Controller shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of 18 to 28 VAC (-25% to +17%), allowing for power source fluctuations and voltage drops. Install plenum data line and sensor cable in accordance with local code and NEC. The BMS contractor shall provide a dedicated power source and separate isolation transformer for each controller to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

## 2.10 LOCAL BMS INTERFACES

- A. Each operator interface shall operate as a stand-alone device capable of performing its user selectable control routines independently of any controller in the system. Each operator interface shall be a microprocessor-based, real-time window into the entire network.
- B. The software in this device shall meet the BACnet device profile of an AAC and shall support the following BACnet BIBBs:
1. Data Sharing
    - a. Data Sharing-Read Property-A (DS-RP-A)
    - b. Data Sharing-Read Property-B (DS-RP-B)
    - c. Data Sharing-Read Property Multiple-B (DS-RPM-B)
    - d. Data Sharing-Write Property-A (DS-WP-A)
    - e. Data Sharing-Write Property-B (DS-WP-B)
    - f. Data Sharing-Write Property Multiple-B (DS-WPM-B)
    - g. Data Sharing-COV-A (DS-COV-A)

- h. Data Sharing-COV-B (DS-COV-B)
  - i. Data Sharing-COV-Unsolicited-A (DS-COVU-A)
  - j. Data Sharing-COV-Unsolicited-B (DS-COVU-B)
  - 2. Scheduling
    - a. Scheduling-A (SCED-A)
    - b. Scheduling-Internal-B (SCHED-I-B)
    - c. Scheduling-External-A (SCHED-E-B)
  - 3. Trending
    - a. Trending-Viewing and Modifying Trends Internal-B (T-VMT-I-B)
    - b. Trending-Viewing and Modifying Trends-External-B (T-VMT-E-B)
    - c. Trending-Automated Trend Retrieval-B (T-ATR-B)
  - 4. Network Management
    - a. Network Management-Connection Establishment-A (NM-CE-A)
    - b. Network Management-Connection Establishment-B (NM-CE-B)
  - 5. Alarming
    - a. Alarm and Event-Notification Internal-B (AE-N-I-B)
    - b. Alarm and Event-Notification External-B (AE-N-E-B)
    - c. Alarm and Event-ACK-B (AE-ACK-B)
    - d. Alarm and Event –Alarm Summary-B (AE-ASUM-B)
    - e. Alarm and Event –Enrollment Summary-B (AE-ESUM-B)
  - 6. Device Management
    - a. Device Management-Dynamic Device Binding-A (DM-DDB-A)
    - b. Device Management-Dynamic Device Binding-B (DM-DDB-B)
    - c. Device Management-Dynamic Object Binding-B (DM-DOB-B)
    - d. Device Management-Device Communication Control-B (DM-DCC-B)
    - e. Device Management-Private Transfer-A (DM-PT-A)
    - f. Device Management-Private Transfer-B (DM-PT-B)
    - g. Device Management-Text Message-A (DM-TM-A)
    - h. Device Management-Time Synchronization-A (DM-TS-A)
    - i. Device Management-Time Synchronization-B (DM-TS-B)
    - j. Device Management-UTC Time Synchronization-A (DM-UTC-A)
    - k. Device Management-UTC Time Synchronization-B (DM-UTC-B)
    - l. Device Management-Reinitialize Device-B (DM-RD-B)
    - m. Device Management-Object Creation and Deletion-B (DM-OCD-B)
- C. Provide an operator interface for each floor stored in a locked room accessible to the building personnel.
- D. Each operator interface shall, at a minimum, be provided with:
- 1. Cover for protecting keypad
  - 2. Numbers keypad for punching in numbers without scrolling
  - 3. Arrow button for scrolling
  - 4. A 16-bit minimum stand-alone real-time microprocessor
  - 5. Network interface ports and necessary cables
  - 6. Power supplies as required
  - 7. Lighted screen
  - 8. Graphical icon screen
  - 9. Software as required for all operator interface functions
  - 10. Audible alarm buzzer
  - 11. Approvals and standards: UL916; CE; FCC

- E. The operator interface shall display all programmed points suitable for the systems it serves. It shall use plain English text descriptions for all system and points so that the operator does not need any codes to find points. All variables shall be numerals with units (e.g. F, C, or %) or shall be text variables.
- F. The systems and points shall be organized in layers so that the operator has an easy time navigating through systems and locating information.

## 2.11 ROUTERS

- A. Provide a router for each subnetwork to connect the floor level network to the base building backbone level network. The router shall connect BACnet MS/TP subnetworks to BACnet over Ethernet.
- B. The router shall be capable of handling all of the BACnet BIBBs that are listed for the controller that reside on the subnetwork.

## 2.12 BASE BUILDING BACKBONE PORTS

- A. On each floor provide an Ethernet RJ45 connection that allows connection to the BACnet network. An open port shall always be available and shall not require any part of the network to be disconnected. The location shall be accessible to the base building personnel and not in a location where the tenant can restrict the access.

## 2.13 SENSORS

- A. Temperature Sensors
  - 1. All temperature sensors shall meet the following specifications:
    - a. Accuracy: Plus or minus 0.2 percent at calibration point.
    - b. Wire: Twisted, shielded-pair cable.
    - c. Vibration and corrosion resistant
  - 2. Space temperature sensors shall meet the following specifications:
    - a. 10k ohm type 2 thermisters
  - 3. Insertion Elements in Ducts shall meet the following specifications:
    - a. Single point 10k ohm thermister
    - b. Use where not affected by temperature stratification
    - c. The sensor shall reach more that 1/3 the distance from the duct wall
    - d. Junction box for wire splices
  - 4. Averaging Elements in Ducts shall meet the following specifications:
    - a. 72 inches (183 cm) long
    - b. Flexible
    - c. Use where prone to temperature stratification, in front of coils, or where ducts are larger than 9 sq. ft.
    - d. Junction box for wire splices
  - 5. Insertion Elements for Liquids shall meet the following specifications:
    - a. Platinum RTD with 4-20mA transmitter
    - b. Threaded mounting with matching well

- c. Brass well with minimum insertion length of 2-1/2 inches for pipes up to 4" diameter
    - d. Brass well with insertion length of 6 inches for pipes up to 10" diameter
    - e. Junction box for wire splices
  6. Outside-Air Sensors Platinum RTD with 4-20mA transmitter:
    - a. Watertight enclosure, shielded from direct sunlight
    - b. Circulation fan
    - c. Watertight conduit fitting
- B. Where called for in the sequences of operations, provide the following feature on space sensors and thermostats:
  1. Security Sensors: Stainless-steel cover plate with insulated back and security screws
  2. Space sensors with setpoint adjust: Plain white plastic cover with slide potentiometer to signal a setpoint adjustment to the DDC
  3. Space Sensors with LCD display:
    - a. Delta BACstat II LCD display
    - b. Operator buttons for adjusting setpoints, setting fans speeds and overriding unit to on/off
    - c. Graphical LCD icons for signaling heating/cooling mode, fans speed, schedule mode, actual temperature and current setpoint
- C. Humidity Sensors shall meet the following specifications:
  1. Bulk polymer sensor element
  2. Accuracy: 2 percent full range with linear output
  3. Room Sensors: With locking cover matching room thermostats, span of 0 to 100 percent relative humidity
  4. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity
- D. Air Static Pressure Transmitter shall meet the following specifications:
  1. Nondirectional sensor with suitable range for expected input, and temperature compensated.
  2. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
  3. Output: 4 to 20 mA.
  4. Building Static-Pressure Range: 0 to 0.25 inches wg.
  5. Duct Static-Pressure Range: 0 to 5 inches wg.
- E. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- F. Equipment operation sensors as follows:
  1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg.
  2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
  3. Status Inputs for direct drive electric motors: Current-sensing relay with current transformers, adjustable and sized for 175 percent of rated motor current.
  4. Status inputs for belt drive electric motors: Current sensing transmitter with linear 4-20mA output

- G. Electronic Valve/Damper Position indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- H. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vaporproof type.
- I. Air Differential Pressure Switches: Diaphragm type air differential pressure switches with die-cast aluminum housing, adjustable setpoint, minimum 5 amp switch rating at 120VAC, SPDT switches, and the switch pressure range shall be suited for the application. Provide Dwyer or equal. These switches shall be utilized for filter status.
- J. Leak detectors: Provide spot leak detectors that can be secured to the floor or secured to a drain pan. The detection shall use a microchip controlled energized probes. The detector shall operate on 24V or less. Provide a way to adjust the height of the leak probes. The SPDT contacts shall be inside a watertight enclosure.

#### 2.14 ELECTRO-MECHANICAL THERMOSTATS

- A. Fire-Protection Thermostats: UL listed with fixed or adjustable settings to operate at not less than 75 deg F above normal maximum operating temperature, with the following:
  - 1. Reset: Automatic with control circuit arranged to require manual reset at central control panel, with pilot light and reset switch on panel labeled to indicate operation.
- B. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Setpoint shall be adjustable.
  - 1. Bulb Length: Minimum 20 feet.
  - 2. Quantity: One thermostat for every 20 sq. ft. of coil surface.
- C. Electric space thermostats: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V. Provide Johnson T26 or similar.
- D. Aquastat: Provide a charged element type stat with snap acting SPDT switch. The switch shall be rated for 16A or 1HP at 120V. Provide Johnson Penn A19 or similar.

#### 2.15 SMOKE DETECTORS

- A. Provide a smoke detector for each unit above 2000 cfm. Turn it over to the mechanical contractor for installation. Wire it to stop the fan upon sensing smoke.

#### 2.16 AUTOMATIC CONTROL VALVES

- A. General:
  - 1. All automatic control valves shall be fully proportioning, unless specified otherwise. The valves shall be quiet in operation and fail-safe in either normally open or normally closed

position in the event of control air failure. All valves shall be capable of operating at varying rates of speed to correspond to the exact dictates of the controllers and variable load requirements. The valves shall be capable of operating in sequence with other valves and/or dampers when required by the sequence of operation. All control valves shall be sized by the control vendor and shall be guaranteed to accommodate the flow rates as scheduled. All control valves shall be suitable for the pressure conditions and shall close against the differential pressures involved. Body pressure rating and connection type construction shall conform to fitting and valve schedules. Control valve operators shall be sized to close against a differential pressure equal to the design pump heads plus 10 percent.

2. Cold water, hot water and steam valves, throttling type, and bypass valves shall have equal percentage flow characteristics.
3. Unless otherwise specified, control valves 2 inches and smaller shall have cast iron or bronze bodies with screwed NPT connections.
4. Valves between 2-1/2 inch and 4 inch shall have cast iron bodies with flanged connections.
5. All automatic control valves installed exposed to the elements shall be provided with electric actuators with operating characteristics and accessories as described in herein. Coordinate with electrical contractor for power availability and point of connection.

B. Butterfly Control Valves:

1. All butterfly control valves, where shown on the drawings or specified herein, shall be butterfly type with lug ends and shall be furnished with electric or pneumatic spring return diaphragm operators. All such valves shall be provided under this Section. Valve body shall be cast iron with Teflon coated disc, 17-4 PH stainless shaft. Seat and seal materials shall be Teflon. The valve shall be provided with a speed control device (adjustable) to prevent the valve from too rapid a closure rate. Valves shall be rated in all sizes for bubble tight closure at 150 PSI, or the required differential pressure across the disc and a maximum system operating temperature (minimum of 212deg F). The operator shall be provided with an external position indicator. Valves shall be full-bodied, full lug type only (Wafer type or semi-lugged valves will not be permitted). Valves shall be bolted from both ends of the flanges.
2. All valves shall be provided with manually operated handwheels for overriding the spring and diaphragm operator.

## 2.17 ELECTRONIC ACTUATOR SPECIFICATION

A. ELECTRONIC VALVE ACTUATORS

1. Actuator shall be fully modulating, floating (tri-state), two position, and/or spring return as indicated in the control sequences. Specified fail safe actuators shall require mechanical spring return.
2. Modulating valves shall be positive positioning, responding to a 2-10VDC or 4-20mA signal. There shall be a visual valve position indicator.
3. The actuator shall have the capability of adding auxiliary switches or feedback potentiometer if specified.
4. Actuator shall provide minimum torque required for proper valve close-off. The actuator shall be designed with a current limiting motor protection. A release button (clutch) or handle on the actuator shall be provided to allow for manual override (except when actuator is spring return type).
5. Actuators shall be UL listed.

**B. ELECTRONIC DAMPER ACTUATORS**

1. Actuator shall be direct coupled (over the shaft), enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator-to-shaft clamp shall use a "V" bolt and "V" shaped, toothed cradle to attach to the damper shaft for maximum holding strength. Single bolt or set screw type fasteners are not acceptable.
2. Actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator. End switches to deactivate the actuator at the end of rotation or magnetic clutch are not acceptable.
3. For power-failure/safety applications, a mechanical, spring return mechanism shall be used.
4. Actuators with spring return mechanisms shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
5. Proportional actuators shall accept a 2-10VDC, 4-20mA signal, or be of the 2 point floating type and provide a 2-10VDC actuator position feedback signal.
6. All actuators shall have an external manual gear release (clutch) or manual crank to aid in installation and for allowing manual positioning when the actuator is not powered.
7. All actuators shall have an external direction of rotation switch to aid in installation and to allow proper control response.
8. Actuators shall be provided with a factory-mounted 3-foot electrical cable and conduit fitting to provide easy hook-up to an electrical junction box.
9. Actuators shall be listed under Underwriters Laboratories Standard 873 and Canadian Standards Association. They must be manufactured under ISO 9001.

**PART 3 - EXECUTION****3.1 INSTALLATION**

- A. Provide all relays, switches, sources of emergency and UPS battery back-up electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified. All field wiring shall be by this contractor.
- B. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.
- C. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.
- D. Install equipment level and plumb.
- E. Install control valves horizontally with the power unit up.
- F. Unless otherwise noted, install wall mounted thermostats and humidistat 60" above the floor measured to the center line of the instrument, or as otherwise directed by the Architect.
- G. Install averaging elements in ducts and plenums in horizontal crossing or zigzag pattern.
- H. Install outdoor sensors in perforated tube and sunshield.

- I. Install damper motors on outside of duct in protected areas, not in locations exposed to outdoor temperatures.
- J. Install labels and nameplates on each control panel listing the name of the panel referenced in the graphics and a list of equipment numbers served by that panel.
- K. Furnish hydronic instrument wells, valves, and other accessories to the mechanical contractor for installation.
- L. Furnish automatic dampers to mechanical contractor for installation.

### 3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways and Boxes."
- B. Install building wire and cable according to Division 16 Section "Conductors and Cables."
- C. Installation shall meet the following requirements:
  - 1. Conceal cable and conduit, except in mechanical rooms and areas where other conduit and piping are exposed.
  - 2. Install exposed cable in raceway or conduit.
  - 3. Install concealed cable using plenum rated cable.
  - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
  - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
  - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
  - 7. All wiring in lab areas shall be in conduit.
  - 8. All unsupported risers shall be rigid steel conduit. Supported risers shall be EMT.
- D. Rigid conduit shall be steel, hot dip galvanized, threaded with couplings,  $\frac{3}{4}$  inch minimum size, manufactured in accordance with ANSI C-80-1. Electrical metallic tubing (EMT) with compression fittings or intermediate metallic conduit (IMC) may be used as conduit or raceway where permitted by the NEC.
- E. Concealed control conduit and wiring shall be provided in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

### 3.3 CONNECTIONS

- A. Install conduit adjacent to machine to allow service and maintenance.
- B. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

- C. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
- D. Ground equipment.

### 3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
  - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest.
  - 3. Calibration test controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
- B. Engage a factory-authorized service representative to perform startup service.
- C. Replace damaged or malfunctioning controls and equipment.
  - 1. Start, test, and adjust control systems.
  - 2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
  - 3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

### 3.5 SYSTEM CHECKOUT AND STARTUP

- A. Inspect each termination in the MER control panels and devices to make sure all wires are connected according to the wiring diagrams and all termination are tight.
- B. After the controls devices and panels are installed and power is available to the controls, perform a static checkout of all the points, including the following:
  - 1. Inspect the setup and reading on each temperature sensor against a thermometer to verify its accuracy.
  - 2. Inspect the setup and reading on each humidity sensor against a hygrometer to verify its accuracy.
  - 3. Inspect the reading on each CO2 sensor using a calibration kit to verify the sensor range an accuracy matches the DDC setup.
  - 4. Inspect the reading of each status switch to verify the DDC reads the open and close correctly.
  - 5. Command each relay to open and close to verify its operation.
  - 6. Command each 2-position damper actuator to open and close to verify operation.
  - 7. Command each 2-position valve to open and close to verify operation.
  - 8. Ramp each modulating actuator to 0%, 25%, 50%, 75% and 100% to verify its operation.
  - 9. Ramp each modulating output signal, such as a VFD speed, to verify its operation.

10. Test each safety device with a real life simulation, for instance check freezestats with ice water, water detectors with water, etc.
- C. Document that each point was verified and operating correctly. Correct each failed point before proceeding to the dynamic startup.
- D. Verify that each DDC controller communicates on its respective network correctly.
- E. After all of the points are verified, and power is available to the mechanical system, coordinate a startup of each system with the mechanical contractor. Include the following tests:
  1. Start systems from DDC.
  2. Verify that each setpoint can be met by the system.
  3. Change setpoints and verify system response.
  4. Change sensor readings to verify system response.
  5. Test safety shutdowns.
  6. Verify time delays.
  7. Verify mode changes.
  8. Adjust filter switches and current switches for proper reactions.
  9. Adjust proportional bands and integration times to stabilize control loops.
- F. Perform all program changes and debugging of the system for a fully operational system.
- G. Verify that all graphics at the operator workstations correspond to the systems as installed. Verify that the points on the screens appear and react properly. Verify that all adjustable setpoints and manual commands operate from the operator workstations.
- H. After the sequence of operation is verified, setup the trends that are listed in the sequence of operations for logging and archiving for the commissioning procedure.

### 3.6 SYSTEM COMMISSIONING, DEMONSTRATION AND TURNOVER

- A. The BMS Contractor shall prepare and submit for approval a complete acceptance test procedure including submittal data relevant to point index, functions, sequence, inter-locks, and associated parameters, and other pertinent information for the operating system. Prior to acceptance of the BMS by the Owner and Engineer, the BMS contractor shall completely test the BMS using the approved test procedure.
- B. After the BMS contractor has completed the tests and certified the BMS is 100% complete, the Engineer shall be requested, in writing, to approve the satisfactory operation of the system, sub-systems and accessories. The BMS contractor shall submit Maintenance and Operating manuals at this time for approval. An acceptance test in the presence of the Engineer and Owner's representative shall be performed. The Owner will then shake down the system for a fixed period of time (30 days).
- C. The BMS contractor shall fix punch list items within 30 days of acceptance.
- D. When the system performance is deemed satisfactory in whole or in part by these observers, the system parts will be accepted for beneficial use and placed under warranty.

### 3.7 TRAINING

- A. During System commissioning and at such time as acceptable performance of the Building Management System hardware and software has been established, the BMS contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction during normal working hours shall be performed by a competent building automation contractor representative familiar with the Building Management System's software, hardware and accessories.
- B. At a time mutually agreed upon, during System commissioning as stated above, the BMS contractor shall give 16-hours of on site training on the operation of all BMS equipment. Describe its intended use with respect to the programmed functions specified. Operator orientation of the automation system shall include, but not be limited to:
1. Explanation of drawings, operator's and maintenance manuals.
  2. Walk-through of the job to locate all control components.
  3. Operator workstation and peripherals.
  4. DDC Controller and ASC operation/sequence.
  5. Operator control functions including scheduling, alarming, and trending.
  6. Explanation of adjustment, calibration and replacement procedures.
- C. An additional 8-hours of training shall be given after the 30 day shakedown period.
- D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

### 3.8 WARRANTY

- A. The system, including all hardware and software components, shall be warranted for two years following the date of beneficial use and Owner's acceptance. Any manufacturing defects arising during this warranty period shall be corrected without cost to the Owner.

### 3.9 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: At approximately 120-days from acceptance of the system, provide a complete checkout of the system. Adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

### 3.10 SERVICE CONTRACT

- A. The System Contractor shall, within sixty days after installation of the system begins, present a three (3) year maintenance contract for the Owner's signature. The price is to be indicated for each year with all payment terms and conditions. The contract should state that the Owner has the option to accept or reject the second or third year contract price, given that notice of

cancellation should be in writing and given not less than thirty (30) days prior to the anniversary date of the agreement.

- B. The contract should state that the Owner has the option to reject the First Year Service, accepting only the System Contractor's obligation as specified herein the warranty section. System Contractor shall provide a clear comparison of warranty coverage versus First Year Service.
- C. First, Second, and Third Year Service shall include the following provisions:
1. On-Line Service - Diagnostic and troubleshooting services shall be provided via remote communications capabilities. Response time to Owner requests for this type of corrective maintenance shall be within two (2) hours.
  2. Software Maintenance and Consultation - The System Contractor shall review the need for software modifications to the existing database semi-annually, and implement modifications. Backup of the database shall be made semi-annually and retained by the System Contractor.
  3. Software Maintenance - Software revisions shall be provided as they become available.
  4. Emergency Service - The System Contractor shall provide emergency service, between scheduled preventive maintenance calls, including overtime, necessary to keep equipment and components in proper operation. When a site visit is required to complete troubleshooting procedures, the System Contractor shall be on-site within 24 hours.
  5. The System Contractor shall guarantee future availability of continuous, twenty-four hour, seven days a week service for the systems through available maintenance contracts.
  6. Service shall be performed by factory trained and employed service representatives of the System Manufacturer.
  7. Provide a basic service contract from the manufacturer of the central workstation computer, providing uniform service and parts availability.
  8. Provide a basic service contract from the manufacturer of peripherals.
  9. Preventive Maintenance shall be performed in accordance with a program of standardized maintenance routines applied to the Owner's equipment. Each schedule shall list the equipment name, location, and appropriate preventive maintenance functions to be performed during that inspection.
  10. The System Contractor shall perform regular and systematic preventive maintenance during normal working hours six (6) times per year on approximately the schedule described below. Maintenance routines shall consist of:
    - a. Checking performance of equipment and components.
    - b. Diagnostic test, examination, cleaning, lubrication, adjustment and calibration of equipment and their components. Such components shall include but are not limited to: Central Processing Unit, disk memory, color graphic CRT, printer, direct digital control units, printed circuit boards, and associated sensors and controllers, including all electric and electronic devices on the systems.
- D. The service contract shall be renewable at the Owner's option and shall include provision for increased charges due to the expansion of the system changes, in service coverage and/or inflation.

## PART 4 - SEQUENCE OF OPERATIONS

### 4.1 GENERAL

Date

Project Name  
Location

A. Not Used

#### 4.2 PRODUCT

A. Not used.

#### 4.3 EXECUTION

##### A. General Requirements

1. All electric motor driven equipment shall be programmed with adjustable 5 minute minimum OFF time delays to prevent short cycling.
2. The start commands to all major equipment shall be staggered to reduce electrical demand.
3. All DDC system control points shall have a default value in case of system failure or logic error.
4. All setpoints and program parameters shall be made adjustable from the BMS system (based on password) unless otherwise noted.
5. Furnish, install, coordinate and integrate chiller evaporator and condenser dedicated pressure switches with the chiller control panel. New differential pressure switches to be Dwyer H3, no substitutions.
6. Furnish and install new Dwyer Series 645 differential pressure transmitters across each chiller's evaporator and each chillers condenser, dedicated to the DDC system.
7. The BMS contractor shall allow time to coordinate and setup the routing of alarms to the proper email accounts, cell phones, PDAs and PCs at the direction of the Owner. Provide an alarm schedule as documentation in the O & M manual as to how alarms are annunciated.

#### 4.4 Central Plant Equipment

##### A. General

1. The central plant equipment shall be controlled and monitored by the BMS. The controller shall be a BACnet BC level controller.
2. Provide controllers with status lights on inputs, HOA switches on all outputs and Ethernet communication to other panels.

##### B. Points Lists:

1. Program a BACnet compatible alarm point for every equipment failure point and each safety device.
2. Program a BACnet compatible trend log for every real input reading and every setpoint.
3. All start and stop times shall be from BACnet compatible scheduling.
4. Input points:
5. Output points:

#### 4.5 Air Handling Units - Major Equipment

##### A. General

Consultant

Building Management System  
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1. The air handling equipment shall be controlled and monitored by the BMS. The controller shall be a BACnet AAC level controller.
2. Provide controllers with status lights on inputs, HOA switches on all outputs and Ethernet communication to other panels.

B. Points Lists:

1. Program a BACnet compatible alarm point for every equipment failure point and each safety device.
2. Program a BACnet compatible trend log for every real input reading and every setpoint.
3. All start and stop times shall be from BACnet compatible scheduling.
4. Input points:
5. Output points:

#### 4.6 Terminal Equipment

A. General

1. The terminal equipment shall be controlled and monitored by the BMS. The controller shall be a BACnet ASC level controller.
2. Provide controllers with status MS/TP communication to other controllers.

B. Points Lists:

1. Program a BACnet compatible alarm point for every equipment failure point and each safety device.
2. Program a BACnet compatible trend log for every real input reading and every setpoint.
3. All start and stop times shall be from BACnet compatible scheduling.
4. Input points:
5. Output points:

#### 4.7 Lighting Controllers

A. General

1. The lighting shall be controlled and monitored by the BMS. The controller shall be a BACnet ASC level controller.
2. Provide controllers with status MS/TP communication to other controllers.

B. Points Lists:

1. Program a BACnet compatible alarm point for every equipment failure point and each safety device.
2. Program a BACnet compatible trend log for every real input reading and every setpoint.
3. All start and stop times shall be from BACnet compatible scheduling.
4. Input points:
5. Output points:

END OF 17000