SECTION 23 09 23

BUILDING AUTOMATION SYSTEM

NOTE – This guide specification is meant to assist you with developing a final, ready for bidding and construction BAS specification based on current technology and industry standards. Please review and edit this document as needed to meet the specific/unique needs of your project. To assist you in this editing process there are designer instructions that are in bold and bracketed by double asterisks "" (i.e., "**designer instructions in bold text. These instructions may not cover all possibilities for your unique project and it is possible that some requirements in the specification may need editing even if not identified by design instructions (for example, this specification does not include requirements for adding and/or extending a BAS in an existing building).**

PART 1 – GENERAL

1.1   DESCRIPTION OF WORK

   A.   Provide all labor, materials, equipment and services necessary for a complete Building Automation System (BAS) comprised of various types of BTL-listed BACnet-communicating Direct Digital Control (DDC) controllers (referred to as "BAS Controllers"), BTL-listed BACnet-communicating Operator Interface software, conventional electric/electronic controls, and equipment-mounted controls, as indicated. The system shall be fully functional and include all software and hardware for all specified capabilities.

   B.   Summary of Project Scope:

       1.   ****List here a summary of the controls work to be provided. An example would include:**

           1.   This project is a replacement for an existing pneumatic control system.

           2.   All existing pneumatic controls devices, enclosures, tubing, etc. shall be removed including pneumatic actuators/valves which shall be upgraded to electronic.

           3.   Chiller Plant – Control of new Cooling tower VFD's (specified elsewhere), addition of BACnet interfaces to the chillers to provide chiller load information for optimum control,…

       The above summary is most useful on retrofit projects. Some of the above may be unnecessary (i.e., descriptions of the work for each system/equipment) if this is shown on the drawings, and/or all of the above may be unnecessary if this a new construction project.**

   C.   All controls required by this project shall be integrated into a single system and coordinated by the Contractor as follows. ("Contractor" is defined here as that responsible for this project in its entirety.)

       1.   The Contractor is responsible for providing all controls described in the construction documents regardless of where within the documents these controls are described.

       2.   Each supplier of a controls product is responsible for the installation, configuration, programming, start-up and testing of that product unless otherwise stated.

3. The Contractor shall coordinate the resolution of any incompatibility issues between the BAS products provided under this section and those provided elsewhere in this specification.

4. The Contractor is responsible for all material and labor to interconnect control products provided by multiple suppliers regardless of where these products are described within the contract documents.

5. The Contractor is responsible for providing sufficient space and power for the BAS components.

6. The Contractor is responsible for resolving any conflicts that arise in control of the same equipment by both the BAS and fire alarm systems.

1.2 RELATED DOCUMENTS

A. The following documents include requirements that pertain to and are hereby made part of the work of this section: **list all applicable divisions (such as Division 1, the Division 23 general mechanical requirement section and the mech/elec sections for equipment to be integrated to and/or controlled by the BAS**.

1.3 RELATED WORK

A. Installation of the following items supplied under this section are specified for installation under other Division 23 sections: valves, water flow switches, flow sensors, thermowells, and pressure taps.

B. Equipment or systems specified under other Division 23 and/or 26 sections are part of or integrated with the BAS, or installed under this section. These include, but are not limited to (see the remainder of this section along with each associated equipment/system specification section for more information): **edit list the following list to match that for this project**VFD's, chiller controls, refrigerant leak detection, boiler controls, VAV box control accessories (crossflow sensor, fan relay, and transformer), control dampers, smoke and fire/smoke dampers, smoke and fire/smoke damper actuators, variable frequency drives, packaged equipment controls, packaged equipment thermostats and fire alarm system status.

C. Power: See the Division 26 drawings for the location of 120 VAC power, if any, provided for the BAS. Any power in addition to that shown shall be provided under this section, shall be from an emergency power source, if available, and shall comply with the requirements of Division 26.

D. IP Communications: IP communications shell be provided by the owner for connection to the Network Connected, BMS controllers. **state here whether the IP communications will be owner-provided or specified in Division 27, or if an IP communications system dedicated to the BAS is to be provided by the BAS contractor**

E. Duct Smoke Detectors: Duct smoke detectors and control for fan shutdown are specified in the Fire Alarm System specification. Wiring from each fire alarm system fan shutdown relay module to the associated fan motor starter to shut down the fan upon actuation of the module is to be provided under this section.

F. Fire/Smoke Dampers: Power for electric fire/smoke dampers and control of fire/smoke dampers are specified in Power Wiring and Fire Alarm System specifications.

G.   ****delete the following if inapplicable****Smoke Control: Except when described elsewhere in this section, control of motors and dampers for smoke control is specified under the Fire Alarm system specification. However, the contractor shall coordinate any fire alarm control of HVAC equipment that is also controlled under this section (e.g., an AHU) so that both controls operate as intended and with priority of control given to the fire alarm system.

H.   Test and Balance: Provide assistance to the efforts specified in Test and Balance specification. This assistance shall include on-site instruction on operator interface to the BAS, the provision of software and any special hardware (e.g., cables, signal converters) to allow for PC operator interface to the BAS, and instruction on access to all setpoints or parameters that need to be adjusted for balancing.

I.   Thermostats: Install/wire all thermostats provided with equipment specified in other Division 23 sections at the locations shown.

1.4   QUALITY ASSURANCE

A.   All materials and equipment shall be new unless otherwise specified.

B.   Materials and equipment shall be the manufacturer's latest standard design that complies with the specification requirements.

C.   Codes and Standards:

1.   All electrical installation work shall comply with the latest version of the National Electrical Code.

2.   Provide electrical products which have been tested, listed and labeled by UL and comply with NEMA standards.

3.   UL916 – Energy Management Equipment

4.   ASHRAE BACnet Standard 135, 2004 revision or later

5.   ****The following certification is optional and shall be added only if the BAS is an active participant in a life-safety smoke control system and if this certification is required by the AHJ and/or fire marshal. If so, this certification should also be added to the Part 2 Network and Advance Application Controller requirements though it may be required only for those controller types/instances that are directly involved in smoke control (which again is per the requirements of the AHJ and/or fire marshal):** UL864 - UUKL Smoke Control******

1.5   DEFINITIONS/ABBREVIATIONS

A.   Advanced Application Controller – A fully programmable controller which is BTL-listed as a B-AAC device and which communicates via BACnet MS/TP to an associated Network Controller (NC). In the Honeywell ComfortPoint Open system these controllers are used for terminal unit (including VAV boxes) and small AHU/RTU control.

B.   Application Specific Controller – A low-level MS/TP controller typically not custom-programmable and BTL-listed as a B-ASC device. The Honeywell ComfortPoint Open system does not use these devices due to their limited capabilities (i.e., they do not support scheduling, alarming, etc.).

C.   BACnet – "Building Automation Control Network", the data communications technology defined by ASHRAE standard 135

D.   BACnet/IP - The use of the Ethernet and IP data/network link protocols for the transport of BACnet messages.

E.   B-BC, B-AAC, B-ASC and B-AWS – Abbreviations for BACnet Building Controller, BACnet Advanced Application Controller, BACnet Application Specific Controller. BACnet Advanced Operator Workstation Software. Used by the BACnet standard and BTL to define the various device and software profiles, and BACnet functionality to be provided by different classes of DDC Devices (for support of interoperability).

F.   BBMD – BACnet/IP Broadcast Management Device. The method used by BACnet for handling broadcast messages over IP (which does not support broadcasting). The approach involves the use of one BACnet/IP device per IP segment to maintain a Broadcast Distribution Table (BDT) listing all other BACnet devices on that network segment. This allows a multi-cast message sent over IP (to each BBMD) to be in turn broadcasted to all other devices on each BACnet/IP segment.

G.   BTL – BACnet Testing Laboratory. Provides BACnet conformance testing (e.g., to confirm that a B-BC device meets the minimum requirements for the Building Controller profile as defined in the BACnet standard). If the device passes BTL testing it is said to be "BTL-listed" as, say, a "B-BC device". Also note that devices tested by an ISO accredited laboratory may also issue a certificate, and be referred to as "BTL-certified" device.

H.   COV (Change of Value) – An optional BACnet service that allows data to be communicated only when it has changed state and/or has changed its value by a pre-defined threshold. This service substantially reduces the use of communications bandwidth by BACnet in lieu of using the standard "Read" services (which must be polled at regular intervals to ensure that changes in values are seen by the system).

I.   EIA-485 – The standard which dictates the physical attributes (i.e., Layer 1 of the OSI model) of a multi-drop topology used as the basis for many low-speed (i.e., ~100 kbps or less) communications protocols (i.e., BACnet MS/TP, Modbus-485, and most proprietary BAS protocols).

J.   Gateway – Software used to translate one applications protocol data (i.e., BACnet) to another (e.g., Modbus or LonTalk). This software can be installed as a "driver" in a BAS controller (i.e., for Modbus) or provided by a separate gateway device (i.e., for LonTalk) so that the BAS can connect to "Third Party" devices)..

K. LonTalk - The communications protocol defined by ANSI/CEA 709.1. Additionally, "LonMark-certified" devices are LonTalk devices that meet additional applications and interoperability guidelines specific to the HVAC market.

L. Mobile Device – A smartphone, tablet, etc. that uses a mobile operating system (i.e., Android, Apple iOS, Blackberry, Windows Mobile, etc.) that supports internet communications and web-browsing.

M. Modbus - A master/slave protocol (i.e., all data must be "read") that can be used over serial (EIA-232), EIA-485 (i.e. Modbus-RTU or 485), and IP (i.e., Modbus-TCP) connections. It was developed by the Modicon Corporation and is managed by the Modbus Organization, but has not been codified as a standard.

N. MS/TP - An EIA-485 data link technology unique to and defined by BACnet for the transport of BACnet messages.

O. NC - Network Controller, the highest-level controller in the BAS architecture, with B-BC listing, BACnet/IP communications, and routing to/from MS/TP controller sub-networks.

P. Operator Interface – Refers to any BAS functionality that allows a user to monitor, control, debug and/or modify the system (including Thin Client support via the Web Server and Service Software).

Q. PICS – Protocol Implementation Conformance Statement. A BACnet form that must be completed for BTL-listing in which the device's BACnet device profile (e.g., B-BC), required feature choices (e.g., BACnet/IP vs. MS/TP), and optional features (e.g., COV) are to be documented.

R. Service Software - A suite of optional Operator Interface software modules/functions used mainly by the contractor during installation or service, such as system configuration, setup, programming, graphics development, etc.

S. Thick Client – A PC that must have Operator Interface software installed on it to perform operator interface functions.

T. Thin Client - A PC that accesses Operator Interface functions via a Web Browser.

U. Third-Party Controls - Any controls integral to and/or provided with system/equipment (e.g., "factory-provided" controls mounted on chillers and/or boiler equipment) that are to be integrated digitally (e.g., via BACnet or Modbus) to the BAS.

V. Web Server – A BAS component (Operator Interface software or Network Controller) which provides access via a Thin Client.

1.6 SUBMITTALS

A. Product Data and Shop Drawing Submittals:

1. Manufacturer's Product Data:

a. For each furnished control device submit catalog data including manufacturer's name, product name and specific model number, options included, product image, proof of BTL-listing, dimensions, functional description and operating characteristics, protocol conformance information, and electrical requirements (AC

vs. DC, voltage and current draw, or VA). Data sheets shall be keyed to the shop drawings' bill of material lists.

b.   ****The following is optional and is generally only needed to confirm if BACnet services beyond that required by BTL—like COV reporting—or other services that might be needed to support proper integration with specialty equipment:** Provide a BACnet PICS for each BAS controller and Operator Interface software package.**

c.   Provide a schedule for control valves indicating service, size, arrangement (2 , or 3-way), application (water, steam, on/off/ modulation), failsafe, actuator model, use of actuator end switches, flows, flow coefficient, and pressure drops for each system.

2.   Shop Drawings shall be generated in AutoCAD and include:

a.   System architecture diagram showing the communications wiring topology, model # or designation of each communicating device (e.g., BAS controller, Workstation, Server, etc.) including the HVAC or other system/equipment controlled, location and designation of each enclosure containing one or more communicating devices, and connections to third party controls.

b.   Floor plans showing enclosure locations, field devices not mounted in enclosures or on equipment (e.g., space temperature), terminal devices (e.g., VAV box) controller locations, and Workstation/Server locations.

c.   Schematic diagram of each controlled system/equipment showing point devices/interfaces with a point naming scheme matching that used on the associated control enclosure wiring diagram. Provide a bill of material for all of the devices shown with nomenclature keyed to the catalog data.

d.   Enclosure layout and wiring diagram showing the BAS Controllers, gateways/interfaces to third-party controls, enclosure-mounted field devices, internal wiring and wiring to field devices (with wiring tags matching those used on the schematic diagrams), a point list with expanded point description information, communications wiring connections, and power supply. All enclosure devices shall be labeled and keyed to a bill of materials.

e.   Sequence of operation modified and expanded from that provided in this specification to include control details specific to the mechanical and controls equipment provided.

f.   List of all data communicated via digital communications interfaces to third-party controls (e.g., a chiller gateway).

1)   Prior to completion of the submittals coordinate with the Third Party equipment suppliers to review their documentation and verify that the data (i.e., BACnet objects and properties, Modbus registers, etc.) required to complete the system is available.

2)   Prior to completion of the submittals meet with the Owner or Owner's representative to review the data lists available for communication to/from the Third Party controls. Based on the Owner's input modify the list of data

to be communicated from that specified. It is the Contractor's responsibility to schedule this meeting with the Owner.

      g.   Wiring details not shown on any of the above drawings.

3.   Graphic Screens: Provide a list of graphic screens, and, for each screen, the conceptual layout with the points/data to be included and linkages to other screens. Meet with Owner prior to submittals to determine their graphic screen format and content preferences.

4.   ****Coordinate the following with the Commissioning Specification if applicable; if not, use as-is**** BAS Testing: Provide for approval a description of all system acceptance tests along with the forms/checklists that shall be used in the testing.

5.   ****The following is optional and generally only needed if other project specifications (i.e., the Division 1 or the general requirements section of Division 23) do not include sufficient information about this issue or if this is a BAS-only project:** Provide ****select quantity**** copies of the submittals.******

B.   Record **(**As-Built**)** Document Submittals

1.   Drawings: As-built versions of the shop drawings along with CD/DVD copies of the AutoCAD files.

2.   Operation and Maintenance Manuals shall include the following:

      a.   As-Built versions of the Manufacturer's Product Data.

      b.   Maintenance information for all devices.

      c.   An operator's manual which will include detailed instructions for all operations of the BAS.

      d.   A programmer's manual which will include all information necessary to perform programming functions.

      e.   Complete project-specific graphic screens, custom sequence programming, system databases, parameter listings, etc. for the equipment controlled under this phase of the work (backed up to the Operator Interface or Web Server and onto CD/DVD's).

      f.   A copy of the warranty.

      g.   Operating and maintenance cautions and instructions.

      h.   Log-in requirements, information, and/or /instructions (including any hardware key(s) or software licensing documentation) to allow Owner access (for both viewing and modification) to all system set-up databases, custom programming, Service Software, etc. at the highest user level provided by the manufacturer.

      i.   Recommended spare parts list.

      j.   All original issue documentation and software DVD's/CD's (if applicable) for third party hardware and software.

3. **** Coordinate the following with the Commissioning Specification if applicable; if not, use as-is****Completed BAS test forms/checklists.

4. ****The following is optional and generally only needed if other project specifications (i.e., Division 1 or the general requirements section of Division 23) do not include sufficient information about this issue or if this is a BAS-only project:** Provide ****select quantity**** copies of the submittals.**

PART 2 – PRODUCTS

2.1   SUBSTITUTIONS

A.   Any products specified by manufacturer and model # shall be provided as specified with no substitution allowed unless the product is no longer available. If so, consult with the Engineer prior to submittal to determine a mutually acceptable substitute. Substitutions that are submitted without this prior approval will be rejected.

2.2   ACCEPTABLE MANUFACTURERS AND CONTRACTORS

A.   The following manufacturers (restricted to the product line listed, if any) and contractors (if listed) are acceptable:

1.   Honeywell International, Inc., Enterprise Buildng Integrator (EBI) and ComfortPoint Open ****complete the following if desired:** installed and project managed by a Honeywell Corporate Branch office ******

2.   ****Add to this list or state that "**Alternates may be submitted with prior approval according to the contract document's requirements concerning substitutions. No alternates will be accepted unless the contractor is located within 25 ****select quantity**** miles of the project site, and demonstrated experience with a minimum of three (3) reference installations within the previous 24 months with contact details available to verify references.****list any other requirements that might not be covered by the substitution process like years in business, references, etc.****

B.   All BAS controllers and Operator Interface software shall be by one of the above manufacturers, except when the controls are specified under another section (i.e., referenced as "controls provided with the unit," "factory-mounted controls," or "unit manufacturer provided controls," etc. within this section). "BAS Components" includes BAS Controllers; and Operator Interface Software. Manufacturers of valves, actuators, sensors, and other field devices shall be as specified in the remainder of this section.

2.3   BAS ARCHITECTURE AND GENERAL REQUIREMENTS

A.   Provide a minimum of one Network Controller (NC) that is BTL-listed to the B-BC BACnet profile. More than one NC may be needed to meet the requirements in the remainder of this paragraph.****Note:**

1.   **Critical applications (i.e., computer rooms in data centers, surgical suites, certain laboratory applications) may be best served by NC's due to their IP communications.**

2.   **Critical Applications may also be best served by implementing Redndant DDC controllers with programming with continuous data synchronization of data and**

switch-over from the primary to back-up NC within 5 seconds without disrupting the output control signal conditions during redundant controller switch-over.

3. **For projects with large numbers of VAV boxes or other similar terminal equipment) (i.e., over 90) fed by a single AHU, it is recommended that requirements for the use of additional, dedicated NC's for this terminal equipment be included. For example, one NC per x floors should be provided (with x selected to keep the number of terminal units per NC under 90), and that each NC shall be connected to terminal unit controllers on its associated floor and, say, the adjacent floor above and below (again based on keeping the number of connected terminal units under 90). The purpose of these requirements is to prevent the contractor from attempting to overload NC's with more than the manufacturer's-recommended terminal equipment controllers, and to prevent them from laying out the associated MS/TP networks in a chaotic manner.**

4. **If VFD's, Chillers, etc. are connected to the BAS via MS/TP a requirement should be included that they be connected to the same NC that controls the associated AHU, chiller plant etc.****

B. All NC's shall be connected together by BACnet/IP.

C. Operator Interface PCs installed on the project site shall be connected to the BAS via BACnet/IP.

D. Remote Communications: The BAS shall be remotely accessible via an internet connection provided by the Owner in****indicate location of connection****.

E. All Advanced Application and Application Specific Controllers shall be connected to NC's via BACnet MS/TP.

1. A sufficient number of NC's shall be provided to support the number of Advanced Application and Application Specific Controllers.

2. No more than 30 ****Best practice is to reduce this to, say, 28, to allow for additional controllers to be more easily added due to remodeling, etc.****Advanced Application and Application Specific Controllers shall be connected to a single NC network (e.g., that connected to a single MS/TP port on an NC).

3. Controllers for terminal equipment (e.g., VAV boxes) shall be connected to the same NC used to control the associated AHU (i.e., the AHU which feeds supply air to the terminal equipment).****Note that this requirement is the best practice for AHU's for which the quantity of associated terminal units is less than the maximum that can be connected to an NC, which is 90 for the Honeywell NC specified here. If a larger quantity of terminal units are fed by a single AHU this requirement should be deleted and the optional requirement in A.2 above be used instead.****

F. A sufficient number of BAS Controllers shall be provided to meet the memory needs of the project programming, alarming and trending (24 samples for each point) along with 25% spare capacity for future use.

G. A sufficient number of BAS Controllers and Point Expansion Modules shall be provided to meet the point needs of the project. Point termination types shall include:

1. Analog Input (AI) - Thermistor, 0-10 VDC or 4-20 maDC.

2.	Binary Input (BI) - Monitoring of dry contacts, including contact closure "pulses" up to 10 per second.

3.	Analog Output (AO) - 0-10 VDC, 0-20 VDC or 4-20 maDC.

4.	Binary Output (BO) - Two-state DC voltage signal or magnetically held dry contact closure.

H.	Each BAS NC shall have a spare (e.g., not used for network communications purposes) Ethernet/IP port connection (e.g., for a Cat5 or 6 connection) for local connection of an Operator Interface. Devices not equipped with an additional integral IP port shall include a separate, functional/powered network switch in the control panel.

I.	Each BAS Controller shall continue to execute its control software, sample input points, and update output points without connection to its BACnet/IP or MSTP network or an Operator Interface.

J.	**Delete the following if not needed:** Other requirements: **This can be used for more stringent requirements such as those in critical applications like data center and certain hospital spaces. An example might be requiring that each critical AHU be controlled by its own dedicated BAS controller which, in turn, is powered by its own dedicated UPS-backed electrical circuit. Another example is to require that no critical system be controlled by more than one BAS controller to avoid a partial loss of controller and the use of network communications to execute the full sequence.**:

1.	

2.	**

K.	All BAS Controllers shall utilize non-volatile or battery-backed volatile memory for writable information (e.g., setpoints and other control parameters, custom control software, and the device's control state at power loss). Battery backup for volatile memory shall provide for at least 72 hours of power loss.

1.	Each BAS Controller shall be able detect a changeover to battery-backed power and modify the state of the control program, if required by the Sequence of Operation.

2.	Application Specific Controllers need not have battery backup for volatile memory used for the devices' control state (battery backup is only required if volatile memory is used for setpoints and other control parameters, and control software).

3.	NOTE – Upon the reestablishment of power to a BAS Controller these devices shall return to normal operation (e.g., network communications, scanning of inputs, execution of the sequence of operation, and control of the outputs) in less than one minute. If this requirement cannot be met the Contractor shall provide 24 hours of uninterruptible power supply to each BAS Controller so that they are not affected by a loss of power in the building (and the sequence of operation shall be modified accordingly so that nuisance alarms do not occur during a loss of building power).

L.	**Delete the following if not applicable**Digital Communications to Third-Party Controls

1.	The BAS is required to send/receive information via digital communications technologies (i.e. Ethernet/IP, or EIA-485) and application protocols (i.e., BACnet, or Modbus) to specified "Third-Party" controls provided under other sections of this specification (e.g., VFD's, Chillers, etc.).**Note that the BAS may be used in an existing building to

interface to existing "Third Party" devices; if so, this requirement needs to be added to this section along with details concerning the types, quantities and protocol(s) involved.**

2. See the specification sections of the equipment involved (e.g., the VFD, Chiller, etc. section) for the type of communications technology/interface (e.g., the data link layer protocol) and application protocol used by each of the Third-Party controls, and for the list of data to be shared with these controls.

3. Communications not requiring a BAS Gateway (i.e., BACnet) - Design the BAS to include the NC's and sufficient EIA-485 communications ports (for MS/TP) to support the communications and data handling capacities required.

4. Communications Requiring a Network Controller "Driver" (e.g., Modbus) – Design the BAS to include the NC's and sufficient EIA-485 communications ports (for Modbus-RTU), and any optional software "drivers" and/or hardware if necessary to support the communications technology and application protocol gateway interfaces.

5. ****DELETE this paragraph if not applicable**** Communications Requiring a Gateway (e.g., LonTalk) – Design the BAS to include sufficient Honeywell CP-AX's, or equivalent BACnet/IP-communicating devices, with sufficient LonTalk communications capacity to support the LonTalk Third-Party devices in this project

2.4 NETWORK CONTROLLER (NC)

A. An NC is a BTL-listed BACnet B-BC device with the BACnet options specified below, non-volatile memory for operating system software; read/write memory for custom control programming, trending, and alarming; real time clock; integral point or point expansion terminations; and communications support to other NC's. Allowable products are the Honeywell Comfort Point Open Plant Controller, CPO-PC400, or equivalent.

B. NC Communications Network: Provide 100baseT Ethernet minimum communications with BACnet/IP support for interconnection to other NC's, Operator Interfaces, and to an Internet/Intranet connection, if specified.

C. Web-Server – Provide password-protected access directly to the controller to view, diagnose and modify operating features/parameter using a web browser. The web pages used for this capability shall include factory provided pages for fast access point monitoring and command, alarming, trending, schedluling, and require no setup other than that required for programming the controller. Additional capability for customer graphics based upon HTML5 shall be provided for the equipment inder direct control by the NC.

D. Point Termination – NC's shall provide point termination for up to 500 physical points per NC through a choice of I/O expansion units (based on the type of communications connection to the NC):

1. Expansion I/O Board or Controller (Honeywell CP-EXPIO, CPO-DIO, XF8 IO module, or equivalent)

   a. These high point-density expansion I/O devices connect via an EIA-485 communications port locally and/or remotely from the NC at a distance of up to 1,200 meters, and with up to 15 devices on a single network.

   b. Each board supports 8 AI's (configurable as BI's), 6 BI's, 6 AO's and 4 BO's.

c. Each controller supports 8 universal inputs (configurable as either AI's or BI's), 8 BI's, and 16 BO's.

d. Each board's BO and BI points shall have an associated on/off status LED indicator.

e. XF8 IO modules shall also support manual overrides to meet Sequence of Operations included in the project drawngs.

2. Field Bus Adapters (Honeywell CPO-FBA series or equivalent)

a. These low point-density I/O adapters connect via an EIA-485 communications port locally and/or remotely from the NC at a distance of up to 1,200 meters, and with up to 31 adapters on a single network.

b. Each adapter in the series supports up to 4 point connections in four I/O type combinations.

3. ****The following should only be used if output points with manual overrides are required. If these overrides are required on all NC-controlled points then the two other above I/O expansion choices should be edited to allow use with input points (AI's & BI's) only:** Panel Bus I/O Modules (Honeywell XF series or equivalent)

a. These modules connects via the NC's dedicated "Panel Bus" (i.e., it cannot be used for any other purpose), can be mounted local to and/or remotely from the NC at a distance of up to 1,000 meters, and with up to 16 modules total on a single NC's Panel Bus.

b. Modules are available with 8 AO's or 6 BO's.

c. Each BO point shall have an associated override (i.e., "HOA") switch and on/off status LED indicator.

d. Each AO point shall have an associated auto/manual override switch and manual output signal adjustment knob.**

E. Controller Network – An NC shall provide:

1. Communications support as a Master to up to three separate 76.8Kbps minimum BACnet MS/TP data link layer communications connections for Advanced Application and Application Specific Controllers.

2. BACnet Clause 6 Routing (between the specified NC's and Controller Network technologies) and BACnet/IP Broadcast Management (BBMD).

2.5 ADVANCED APPLICATION CONTROLLER

A. An Advanced Application Controller is a BTL-listed BACnet B-AAC device with non-volatile memory for operating system software; read/write memory for custom programming; and communications support for Operator Interface and the Controller Network. Allowable products are Honeywell ComfortPoint Open: CPO-Rxx (Room Controller), CPO-DIO Digital I/O

Controller, CPO-VAV2A and CP-VAV Unitary Controller, CP-SPC Small Point Controller, or equivalents.

B. Advanced Application Controller Network – Provide 76.8Kbps minimum BACnet MS/TP communications.

C. Point Termination – Advanced Application Controllers shall provide direct point termination through integral point connections.

D. VAV Terminal Unit Flow Sensing – Provide an integral differential pressure sensor for controllers used for control of VAV terminal unit's provided with pitot-tube style flow probe.

2.6   APPLICATION SPECIFIC CONTROLLER**The following paragraph should not be used unless an alternate to Honeywell ComfortPoint Open will be allowed or considered as a substitute, and such alternate does not use B-AAC listed controllers for terminal units. Note also that if a B-ASC listed Application Specific Controller is allowed then the performance of the BAS will be degraded by the fact that these devices do not have their own time clocks and scheduling capability, cannot track and issue alarms, and cannot issue COV messages, all of which must instead be performed by the associated NC. These devices also typically cannot be custom programmed to meet sequences of operation that are not considered "typical" by the manufacturer (e.g., the new ASHRAE 90.1 requirements for controlling the reheat coil valve via supply air reset).**

A. An Application Specific Controller is a BTL-listed BACnet B-ASC device dedicated for use with specific equipment and applications. It shall be provided with non-volatile memory for operating system software; read/write memory for all other purposes; factory-provided control software; and communications support for Operator Interface, and the Controller Network.

    1. Application Specific Controllers shall not be used for systems/equipment that require custom application programming to meet the Sequence of Operation (i.e., if an Application Specific Controller is used the factory-provided control software/program must be able to perform the Sequence of Operation without "upper level" control from another BAS Controller).

    2. Application Specific Controllers shall only be used for terminal/zone equipment such as fan coil units, and heat pumps (i.e., when the factory-provided control software meets the Sequence of Operation); or where explicitly allowed by the Sequence of Operation.

B. ASC's for pressure independent applications shall have an integral differential pressure sensor for air flow measurement and an optionally integral damper actuator.

C. Each ASC shall have a 76.8Kbps minimum BACnet MS/TP Controller Network connection (as an MS/TP Master).

D. Each ASC shall be provided with integral point termination.

2.7   BAS OPERATOR INTERFACE SOFTWARE/HARDWARE

A. Operator Interface Software – The software shall include the following capabilities:

    1. Standard Operator Interface Features

        a. Graphic Screens - Display of custom graphic screens with dynamic point information and the ability to show animation by shifting image properties based on

the status of the point.

1)   The graphic screens shall have the capability to include hyperlinks to related information like sequences of operation, product cut-sheets, construction document floor plans, etc.

2)   NOTE - The terms "graphic screens" and "graphic(s)" in this specification refers to graphical images viewed via a PC running Operator Interface Software (a "Thick Client") or a PC viewing graphical images on web pages via a web browser (a "Thin Client").

b.   Help: Provide a context sensitive, help system to assist the operator in operation of the BAS.

c.   Security: Each operator shall be required to log on to the BAS with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator.

1)   The system shall support up to 1000 casual (i.e., all but the highest "administrative" level) users each with unique log in requirements.

2)   Operators with casual access shall be automatically disconnected from the BAS after an administrator set idle timeout period.

d.   Software Automatic Update Service – This feature automatically notifies the operator that updates to the Operator Interface or Workstation PC operating system is available for download and installation. The O.S. updates are not provided directly from the O.S. manufacturer (i.e., Microsoft) and are tested by the BAS manufacturer for compatibility with the Operator Interface software.

e.   The system shall automatically monitor the operation of all BAS Controllers including network communications and provide an alarm when a failure occurs.

f.   Point/Data Overrides/Modifications – Output points and system data (i.e., setpoints) shall be modifiable (i.e., auto vs. manual and overridden value) via a link to each item's graphic screen image.

g.   Alarm Processing/Management – An alarm summary screen with:

1)   A list of the alarms and their details including the priority level (low, high, and urgent) and a count of how many times that same alarm has occurred.. The list can be sorted or filtered based on operator-selectable characteristics.

2)   The ability to track and trend alarm metrics including the number of urgent, high or low priority alarms that have occurred.

3)   The ability to acknowledge an alarm with this action automatically recorded in the system even file and, optionally, on an alarm printer.

4)   The ability to configure alarm limits, and system reactions (e.g., an alarm message, communications method, etc.).

5)   The ability to selectably send alarms to pagers, mobile phones, email and SNMP managers. The alarms communicated in this manner can be selected based on alarm priority or the points involved, and can be selected to be sent

to only certain devices and/or based on time-of-day..

h.   Trend Logs: The ability to define a custom historical trend log for any data in the system with the following capabilities:

1)   The data can be collected as a "snapshot" (its value at a single point in time) or as an average.

2)   The data can be displayed tabular or graphical (line or bar charts with zoom in/out capability) with more than one trend log displayed at the same time.

i.   Scheduling: A graphical method for scheduling equipment operation including normal, holiday and exception scheduling.

1)   Multiple points or a range of points shall be controllable by a single schedule.

2)   A schedule shall not be limited to a single weekly pattern (i.e., each day of the year can be defined with a unique schedule if needed).

3)   Schedules can be set to recur on any multiples of weeks (i.e., every 1, 2…7, weeks).

4)   Exception schedules shall be used to override the normal schedule of one or more points controlled by a given schedule. These exception schedules can be a one-time date-based event, based on a list of calendar (i.e., holiday) dates, can recur daily or weekly until a specified date or without end, or can occur for greater than 24hrs. (e.g., from a given time on Saturday morning to another time on Sunday evening).

j.   Event Management

1)   All alarms, returns to normal, point changes of state, system restarts, system database changes (including operator login security information), and all operator actions shall automatically be saved by the system (subject to Workstation/Server disc space).

2)   Associated with each saved event shall be a date/time stamp, along with an event type/description and other information relevant to the event type such action, operator, value, source, etc.

3)   Operators shall be able to manually append a comment to each event with free-formatted text to record any other information related to the event.

4)   An operator can view all current or saved events at any time using an event report, which can be sorted by time/date, and other filters based on the information associated with the event. Standard reports available from the event management system shall include:

1)   Activity By Equipment – Displays systems/equipment that have had the most alarms or other events.

2)   Activity By Source – Displays the source of alarms and events by system/equipment.

3)   Alarm Activity by System/Equipment

4) Alarm and Event Daily Pattern – A visual representation of when alarm were triggered at different times of the day and on different days

5) Override Report

6) Point State Changes Report

7) Scheduled Resources Report – Lists the start/stop times, the controlled items, the schedule names, and the resulting changes of state.

8) Supply Temperature per equipment plotted against outside air temperature.

9) Supply Temperature per equipment plotted against its associated Return Temperature.

10) Thermal Profile – Displays supply & return temperature, and flow rate per equipment against outside air temperature.

11) Meter Profile Report – Energy use data from points identified as "meters".

12) Daily Demand (KW) Range against Outside Air Temperature

13) Daily Weather Conditions – Degree days and temperature range.

14) Equipment run-time

k. Web browser workstation software: The web browser workstation shall allow Thin Clients (PC's running web browser software) to perform all the capabilities described above.

1) The software shall support 2 **change this to up to "10" if needed** concurrent Thin Client users. Provide any web browser add-ons or utilities required for operating all owner Thin Clients with the Web Brower software. Supported web browsers shall include Internet Explorer 8.0 or 9.0.

2) **The following is an optional feature that should be deleted if not needed**The software shall support an unlimited number of Mobile Device users running any web browser. These Mobile Devices shall not need to be loaded with an "app" for this function. Devices supported include any mobile telephone/tablet/etc. with internet access and a web browser such as a Blackberry, Apple iOS devices, Windows Mobile devices, Android devices, etc.

l. BACnet Conformance - The software shall be BTL-listed as a BACnet B-AWS device.

m. Third-Party Software: Provide any other software and licenses needed for the operation of the Operator Interface Software, such as Microsoft SQL or .NET, Excel, etc.

n. Allowable Products – Honeywell Enterprise Building Integrator (EBI), or EBI-ComfortPoint Open, or equivalent.

2. Service Software Features**The following features are provided by the optional Honeywell software modules listed at the end of these requirements and will not be used by many clients – delete unless it is known that the client desires these features and will see the value in the added costs involved.**

 a. Configuration: Provide the programming tool and associated components, program blocks, and applications to set up and/or maintain BAS Controllers (e.g., communications addressing, point definition, etc.).

 b. Control Software Editors: This software shall allow for editing of all provided control applications in support of the delivered solution (i.e., the "Sequence of Operations" and other supporting features) including:

  1) Custom Control Programming: A full screen graphical editor for creating, modifying, and debugging the control macro program blocks all Controllers.

  2) Creation of default trend logs and alarms.

  3) Set up of standard reports.

 c. Graphic Generation: Graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as AutoCAD.

 d. Graphics Library: Furnish a library of the standard HVAC system/equipment graphics screens provided to maintain the project such as chillers, boilers, air handlers, terminals, fan coils, unit ventilators, etc.; and standard symbols for HVAC components including fans, pumps, coils, valves, piping, dampers, ductwork, etc.

 e. System Database Save and Restore: System shall be provided with Acronis or similar system database back-up and recovery solution. The system shall perform regularly scheduled database backups according to an administrative level adjustable time period.. The operator shall also be able to manually initiate a download of a specified database to any BAS Controller in the BAS.

 f. Note that Service Software for BACnet MS/TP devices shall be able to "tunnel" through NC's (i.e., a PC need not be directly connected to the MS/TP device or MS/TP network to perform its functions).

 g. Allowable Products – Honeywell ComfortPoint Open "Studio" (configuration/programming), "HMI Web Display Builder" (graphics screen editor), and "CPO Online" (programming simulation); or equivalents.

B. Hardware – Provide the following:

1. General – The specifications for the below equipment shall be the minimum provided. Expanded hardware capabilities (e.g., faster processor, larger hard drive, etc.) shall be provided based on the BAS manufacturer's Operator Interface requirements and that needed to meet the BAS needs for data storage (along with 25% spare capacity).

2. Operator Workstation and Web Server PC(s)**Note that that the Honeywell software can be loaded onto a PC or server provided by the client if that is preferred – if so, delete these requirements. Also note that the hardware specifications listed below**

are the minimum required for the software, and higher performing hardware can be specified if needed.**

    a.   Operator Workstation PC: Microsoft Windows-based desktop PC including an Intel Core^{TM} 2 Duo 2.8GHz T7400 processor, minimum, with 3MB cache, 4GB RAM, graphics card capable of 1280x1024 piccels and 65K colors, Windows 7 Professional-version 32-bit operating system, MS Internet Explorer 9, MS Excel 2010, one 16x CD/DVD +/-RW drive, 80 GB hard disk drive minimum, 10/100/1000 Mbps Ethernet card, 19" LCD color monitor, PS/2 standard keyboard, and a two button optical mouse.

    Edit the above based on the client's specific PC standards, if any.

    Note that the above is the standard hardware to be used on a "typical" project - both the Operator Interface and optional Service Software modules can operate from this one PC). Further, note that, if needed, this could be edited to be a "Laptop PC" if that is what is preferred by the client.

        1)   Uninterruptible Power Supply (UPS) – For backup power to all Operator Workstation components: APC Smart 750VA USB and Serial 120VAC, APC Part #SUA750.

    b.   ****The following shall only be used if the client prefers to have the Operator Interface software operating from the secure environment of an on-site computer room and/or data center. If so, delete the above Operator Workstation PC****Rack-Mounted Server PC: Microsoft Windows-based desktop PC including Intel Xeon processor with 3GHz speed with 3MB cache, 4GB RAM, graphics card capable of 1280x1024 piccels and 65K colors, Windows 7 Professional-version 32-bit operating system, MS Internet Explorer 9, MS Excel 2010, one 16x CD/DVD +/-RW drive, 7200rpm dual RAID 1TB hard disk drives, 10/100/1000 Mbps Ethernet card, a 19" LCD color monitor, PS/2 standard keyboard, and a two button optical mouse.

    c.   ****Delete if not needed. If retained select a printer model based on owner standards or your preference**** Printer: ******

    3.   Mobile Device(s): For use as mobile Thin Clients provide****List a mobile device type, such as an iPad, and quantity if desired; if not delete****

2.8   SENSOR/TRANSMITTERS****Add any additional sensors to the below that may be needed for the project; e.g., CO^2, Gauge Pressure, Amp/KW, etc.****

    A.   Temperature Sensors: Thermistor or RTD with a minimum accuracy of +/- 0.5 degrees F throughout the specified temperature range.

        1.   Duct: Utilize a capillary type (20' min.) averaging sensor for all mixing box applications, and supply ducts with a cross sectional area in excess of 20 square feet; 0 to 100° F range.

        2.   Outside Air: -30ºF to 120ºF range.

        3.   Pipe: 20 to 220 degrees F. Immersion style with thermowells: Series 300 stainless steel for steam lines; stainless steel or brass for water lines.

4. Space: Surface mounted**change to flush mounted or with locking, steel, ventilated enclosures for secure areas**, ventilated enclosure**add the choice of the following** with set point adjustment, unoccupied mode override button, and temperature indication. Space sensors used for terminal unit control shall have an integral port that is connected to the corresponding controller's operator interface port. 50 to 90 degrees F. range.

5. Where a "Matched Temperature Sensor Pair" is shown/specified the sensors shall be tested and documented by the sensor manufacturer as being accurate to within 0.1 ºF of each other.

B. Flow Elements/Transducers:

1. VAV Terminal Unit: Differential pressure transducer integral to the Advanced Application Controller. Connect to pitot-tube element provided with terminal unit.

2. Other Flow Devices: Intentionally left blank**add water or air flow sensors if needed for chiller plant operation, outside air measurements, etc. If pitot-based airflow sensors are being specified then add a low-static pressure, high-accuracy DP sensor model to the below paragraph.**

C. Differential Pressure Sensors: Differential pressure sensors (air or water) shall be temperature compensated with an accuracy of +/- 1% of range and repeatability/hysteresis of 0.5% of range.

1. Air - Sensor shall be able to withstand a maximum port pressure of 10psig.

2. Water – Wetted parts shall be stainless steel. Sensor shall be able to withstand a maximum port pressure of 250psig; and a maximum differential pressure of 150psi or 300% of the rated range, whichever is greater.

D. Humidity: Solid state polymer design, +/- 3% **choose 1% or 2% in more critical applications** accuracy over a 5% to 95% range, linear output to match AI signal requirements, and without provision or requirement for field calibration.

2.9 VALVES

A. Control Valves: Provide factory fabricated globe or characterized ball valves of pressure class for the scheduled service. Size modulating valves for a pressure drop of 3 to 5 PSI for water service and 80% of the supply pressure for steam service, unless otherwise noted. Two-position valves shall be line size.

1. Water Service Valves: Equal percentage characteristics with rangeability of 50 to 1, and maximum full flow pressure drop of 5 psig.

2. Single Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.

3. Double Seated Valves: Balanced plug type, with cage type trim providing seating and guiding surfaces on "top and bottom" guided plugs.

4. Valve Trim and Stems: Polished stainless steel.

5. Packing: Spring-loaded Teflon, self-adjusting.

6. Valves - 1/2" through 2": Valves shall be constructed with a cast brass body and screwed ends. For 1-1/2" and 2" special duty; valves may be selected by the control manufacturer to have either bronze or cast iron bodies with screwed or flanged ends.

7. Valves - 2-1/2" and above: Valves shall be constructed with a cast iron body and have flanged connections.

8. Two-Position Application – Line size. Solenoid actuated valves may be used.

9. Acceptable Products – Honeywell or equivalent.

B. Butterfly Valves:

1. Full-lug type, 200 psi WOG, extended neck, cast iron body, aluminum/bronze or ductile iron disk, stainless steel shaft, field replaceable cartridge design, EPDM seat and seal, and integral actuator. Tyco Keystone Fig. 212, Centerline 200 series, or equivalent.

2. 3-Way Operation – A single, linked actuator shall only be used for 2-position operation. Provide separate actuators for each valve for modulating service.

3. Shall only be used for modulating service when for valves larger than 6". Size for a 3 psi pressure drop when used for modulating service.

2.12   ACTUATORS

A. Electronic

1. Design for direct mounting on the device and attachment to the driving shaft (damper actuator only); adjustable angle of rotation or range of actuation; and built in overload protection. Size each motor for 150% of the application requirement and with sufficient reserve power to provide smooth action.

2. Modulating actuators shall use a 0-10 VDC or 4-20 mADC signal input to match controller AO signal output, and 24VAC power. Three-wire, bi-directional motor actuators controlled by BO point pairs are acceptable on terminal VAV boxes, terminal heating/reheat coils, and fan coil units only.

3. Two-position actuators shall be 120VAC, two-wire, spring-return. Spring actuation return actuation time shall be less than 30 seconds.

4. Damper Actuators - 95º rotation maximum, with built-in adjustable mechanical stop to limit rotation to that of the damper and/or to meet TAB requirements.

5. End Switches – Provide actuator with integral, adjustable-position indication end switches (one for each fully actuated position) when the actuated device is specified with an end switch BI point(s).

B. Provide valve actuators capable of close-off against a pressure greater than the respective pump system shut-off head.

C. Failsafe: Provide spring-return failsafe (or battery/capacitor actuated failsafe on butterfly valves over 4") to the following position upon loss of power or control signal: **list the requirements here or indicate using "N.C." and "N.O." notations on the drawings**

D.   Acceptable Products – Honeywell or equivalent.

2.13   SWITCHES AND AUXILIARY CONTROL DEVICES**Add any additional devices to the below that may be needed for the project; e.g., humidistats, strap-on thermostats, etc.**

A.   Control relays: Plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage suitable for the application.

B.   Low-Temperature Detection Switches (Freezestats): Provide DPDT low-temperature protection thermostats of manual-reset type, with sensing elements of the proper length, but in no case less than 20'-0" in length. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire duct width. Provide separate thermostats for each 25 sq. ft. of coil face area or fraction thereof. The set point shall be 42° F unless otherwise specified on the plans or sequence of operations.

C.   Current Sensing Switches: Used for all motor status BI points unless otherwise noted. Self-powered, solid-state with adjustable trip current. The switch shall be selected to match the current of the application and input requirements of the BAS.

D.   Differential Pressure Switches: Used only for duct pressure safety cut-offs unless otherwise noted. Adjustable trip pressure with range suitable for the application.

E.   On-Off Thermostats: Provide thermostats of bi-metal actuated open contact, bellows actuated enclosed snap-switch type, or equivalent solid-state type with electrical rating to meet the application. Provide with surface mounted, ventilated enclosure.

PART 3 - EXECUTION

3.1   INSTALLATION

A.   Install BAS components and materials in accordance with manufacturer's instructions. Where the drawings conflict with these instructions, the Contractor shall submit a written request for clarification.

B.   Contractor shall coordinate installation with all other trades to avoid field condition conflicts.

C.   Electrical products and execution shall comply with requirements of applicable Division 26 sections of these specifications.

D.   Operator Workstation(s) – Install in **add location(s)**

E.   Web Server – Install in **add location** (only applicable if Web Server capability requires a PC separate from the Operator Workstation).

F.   Control Wiring and Communications Cabling:

1.   Install control wiring in EMT in exposed or concealed, inaccessible locations. UL plenum rated cable is acceptable for concealed, accessible locations.

a.   Field devices provided with pig-tail wiring without any integral means of flexible metal raceway attachment shall be enclosed with a suitable means to allow for flexible metal raceway attachment.

2. Install parallel to building lines, supported from structural members. Raceway or plenum wiring supported from or anchored to piping, duct supports (raceway only), the ceiling suspension system (raceway only), or other electrical conduits is not acceptable.

3. Flexible metal raceway, not in excess of three feet in length, shall be used for termination of raceway on vibrating equipment. The flexible metal raceway shall be supported at each end.

4. Shielded wiring shall be used where recommended by the manufacturer and installed according to the manufacturer's installations.

5. All communications wiring shall be installed as continuous lengths with no splices between termination points.

6. ****Delete if IP Communications is provided by others****All Ethernet/IP communications wiring and devices (hubs, repeaters, etc.) shall be provided by the Contractor and dedicated for use by the BAS.

G. Enclosures:

1. All BAS components, including controllers, sensors and other devices, shall be installed within enclosures.

2. Enclosure locations shall be coordinated with other trades and shown in the submittals for approval.

3. Enclosures for all devices except space sensors shall be NEMA rated for the location.

H. Field Devices

1. Locations shown on the drawings shall be used. Other locations shall be shown on the submittals for approval.

2. Space thermostats and sensors shall be mounted 4'-0" AFF unless otherwise noted.

3. Outdoor temperature sensors shall be located on a north exposure, in a shaded location, and installed in a sunshield.

4. Differential Air Pressure Sensors:

   a. Pipe the outdoor reference of a space static pressure sensor to a Dwyer A-306 (or equivalent) located 10' minimum above the highest point of the building.

   b. Pipe the high pressure port of a space static pressure sensor to a Kele RPS (or equivalent) at the location shown.

   c. Pipe the high pressure port of a duct space static pressure sensor to a Dwyer A-301 or 302 (or equivalent) at a location 75% the distance from the first VAV box to the most remote box.

5. Differential Water Pressure Sensors for Variable Volume Pumping: Pipe across the control valve, balancing valve and coil on the unit hydraulically furthest from the pumping system.

6. Freezestats shall be located so that the reset button and SetPoint adjustment are accessible using no more than a 6' ladder. For equipment mounted above this height the freezestat shall not be mounted on the equipment so that this height limit is met (e.g., on an adjacent wall).

I. Third-Party Controls – "Third-Party" controls are supplied or provided under other sections of this specification. The following installation requirements apply to these controls: **For each Third-Party equipment type and/or system (e.g., Chiller, VFD, Boiler Controller, Fire Alarm, Lighting Controls…) describe what installation efforts need to be provided by the BAS contractor. For example, outboard BACnet gateways to some rooftop/unitary equipment controls or fire alarm systems are usually best installed/powered by the BAS contractor. Consult with the supplier of this equipment**

1. **List/describe requirements for each Third Party device**

2. General Communications Requirement – For BACnet communications listed above, alarms and/or data will be automatically transmitted via BACnet Alarm and Event services, if supported by the Third Party Controls. If not, the BAS shall use polling (e.g., regular ReadProperty service calls for BACnet) to request the alarms on a frequency determined based on consultation with the Owner, and request any data used by the BAS for control on a frequency appropriate for the control application.

J. Safeties

1. All safety devices (smoke detectors, freezestats, duct high/low pressure switches, etc.) shall be hard-wired directly to the controlled equipment (i.e., the safety sequence shall not be implemented through a "software interlock").

2. Duct smoke detectors for air handling equipment shutdown shall be provided by others. However, final wiring from the associated fire alarm system control module to the controlled equipment shall be by this section's Contractor.

K. Identification

1. All BAS components, including controllers, sensors and other devices, shall be identified with nameplate designations to match the shop drawings.

2. Components mounted within enclosures shall be identified with adhesive backed metalized polyester film labels with designations printed by a laser printer or other indelible method.

3. Enclosures and other devices mounted in the field shall be identified with engraved plastic laminate labels affixed with rivets.

4. Wiring shall be identified at each point of termination using a printed tag to match that shown on the drawings and affixed using a heat shrink sleeve.

3.2   SYSTEM TESTING AND ACCEPTANCE **Coordinate the following requirements with the Commissioning Specification if applicable; if not, use as-is**

A.   All BAS acceptance testing shall be performed in the presence of the Owner or Owner-designated representative. The system shall not be considered substantially complete until the testing is complete and approved. The contractor shall perform all calibration, start-up and testing procedures necessary to assure the completion of the system acceptance testing prior to commencement of the system acceptance tests.

B.   Point Tests - Perform the following tests for each point:

1.   Analog Input - Compare sensor reading to that of a calibrated portable measurement device.

2.   Binary Input – Manually actuate the monitored equipment and compare actual state with that read by the system.

3.   Analog Output – Through software, set the output to three or more values across the full range of actuation and compare with position of controlled device (or output signal for controlled device positions that cannot be visually observed).

4.   Binary Output – Through software, actuate the output and compare the control command with the actual operation of the controlled device.

5.   Data (from digital communications with "Third-Party Controls") – Perform the above tests, though the comparison (except for data representing binary outputs) shall be between that provided at the Third-party controller display and the BAS. Perform the above "Binary Output" test for data that represents digital outputs.

C.   System Tests – Perform the following tests for all sequences of operation:

1.   Develop trend data in graphical form showing the properly damped step response of each DDC loop.

2.   Simulate varying input values to verify reset schedules, and temperature lockouts.

3.   Manually initiate system start-ups to verify interlocks and sequencing.

4.   Simulate safety device and fire alarm system contact actuation to verify emergency, alarm, and life safety sequences.

5.   Simulate day/night changeover to observe occupied, unoccupied, optimum start, and warm-up modes.

6.   Simulate seasonal changeovers to observe proper operation of heating and cooling modes.

3.3   WARRANTY

A.   Provide all labor, material and equipment necessary for operation of the BAS according to the design for a period of one year after substantial completion of the project. All warranty or final completion service shall be scheduled with the Owner to minimize disruptions to facility operations.

B.   Emergency Service: Owner will initiate service calls when the BAS is not functioning properly. Contractor personnel shall be available to provide emergency warranty service. The Owner shall be provided with a telephone number where service representative can be reached at all times. Within 24 hours after receiving a request for service the problem shall be remotely resolved (i.e. via remote communications with the BAS) or service personnel shall be at the site. The Contractor shall fully restore the BAS to proper operating condition within two (2) days.

3.4   TRAINING**Edit the following to fit the specific needs of the client and/or project**

A.   The Contractor shall provide instruction to designated personnel in the adjustment, operation and maintenance of the specific BAS components and BAS installed. All training shall be held during normal work hours of 8:00 a.m. to 5:00 p.m. weekdays as scheduled in advance with the Owner.

B.   Provide **edit**two 8-hour, off-site training classes in the **fill in** area. Training shall include:

1.   Overview of BAS architecture and products.

2.   Use of the operator's manuals and shop drawings to understand and troubleshoot the system.

3.   Use of the Operator Interface(s).

4.   Logging on and off of the BAS.

5.   Accessing point (and Third-Party data) status/alarm reports, graphics, schedules and trend logs.

6.   Accessing and adjusting set points and schedules.

7.   Manual BAS overrides.

8.   **Delete the following unless the optional Service Software is specified in Part 2**Introduction to the Service Software functions (i.e., graphics development, custom application programming, etc.).

C.   Provide **edit**16 hours of on-site BAS demonstration, training and/or assistance for a period of one year from final completion of the project. Demonstration and training topics to include:

1.   Explanation of drawings, and operations and maintenance manuals.

2.   Walk-through of the job to locate control components.

3.   Overview of the Sequences of Operation.

4.   Use of Operator Workstation and peripherals.

5. BAS architecture.

6. Operator interface functions including as listed in the above off-site training curriculum.

7. Operation of operator interface PC's and mobile devices.

8. Explanation of adjustment, calibration and replacement procedures.

9. ****Delete the following unless the optional Service Software is specified in Part 2****Use of Service Software functions (i.e., graphics development, custom application programming, etc.).

3.5 SOFTWARE SETUP, CONFIGURATION AND PROGRAMMING

A. All data base entry, software configuration, initialization of trends and alarms, and custom application programming to meet this specification shall be provided.

B. All setpoints, PID tuning parameters, control deadbands, operating differentials, reset schedules, etc. shall be adjustable by an operator without need for accessing/modifying custom control programming code.

C. The following control software shall be provided in addition to that described in the Sequence of Operation (where applicable):

1. PID Control: Each control loop shall be controlled by a PID (proportional-integral-derivative) algorithm. The loop shall be tuned using the P and I gains as a minimum.

2. Reset: Unless otherwise noted, any SetPoint required to be reset shall use a cascaded PID loop or an "every x minutes increment/decrement by y" algorithm. Contractor to tune these reset loops to provide stable control.

3. Anti-Short Cycling: All BO points shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected. Unless otherwise noted, all motors shall be limited to four starts per hour (one per hour for a chiller, six for cooling tower fans).

4. Optimum Start: All air handlers that do not operate continuously shall be optimally started at the latest possible time to meet the occupied conditions at the time of occupancy. Utilize all space temperature inputs associated with the air handler, along with the outside air temperature. The algorithm shall include tuning parameters for adjusting the influence of space and outside air temperature on the start time.

   a. Warm-up Mode – An optimally started AHU shall operate in the warm-up mode until occupancy. The outside air damper(s) close and the return air dampers open. If the AHU supplies multiple zones (e.g., VAV boxes) the supply air temperature shall be the space temperature SetPoint (adj.).

5. Night Setback – When not in the occupied or warm-up modes an AHU shall cycle on to maintain a night setback temperature of 60ºF (adj.) if the AHU supplies a single zone or if the zones that cannot provide heating without operation of the AHU (pinch-down VAV boxes with reheat coils)

6. Alarm Communications: The BAS's alarm/event communications features shall be set up to automatically initiate IP-based alarm/event communications (i.e., to pagers, mobile

phones, email, alarm printers, etc.) for selected alarms/events. Consult with the Owner to determine what communications method(s) is required, the communications devices involved, and what alarm conditions/priority/time-of-day shall initiate these communications.

7.   Demand Limiting/Response: **describe specific to this project**

8.   Staggered Start: **describe specific to this project a sequence that might be needed to prevent exceeding a demand peak, during operation of standby power, etc.**

D.   Graphic Screens:

1.   Provide custom-developed graphic screens for the controls included in this project (including the points/data specified for digital communication with "Third Party" controls). The screens shall include schematic representations of all controlled and/or monitored systems/equipment, points and relevant setpoints/parameters (consult with Owner for format and content), and floor plans with all space sensing points represented

2.   Prior to creation of graphic screens, meet with the Owner to develop for their approval a list of the screens to be provided; and, for each screen, a conceptual layout of the graphics, points/data included, and linkages to other screens.

E.   Point names, schedules, and space temperature set points shall be chosen to meet the approval of the owner (even if specified herein).

F.   Set up trend logs (including trended points/data, frequency and number of samples) and alarmed points (including alarm limits; alarm messages; the alarm message destination email, phone, printer, etc. addresses; and the alarm message transmission formats to be used) to meet the approval of the Owner (consult with the Owner).

1.   As a minimum the system shall automatically set up the following trends (or these trends shall be set up manually if this automatic function is not available):

a.   5 points per unitary equipment device

b.   10 points per AHU

c.   5 points per boiler, chiller, VFD

2.   The trends shall be set to an interval of 1 sampler per minute adjustable on a per point basis down to a 5 second interval.

G.   Only one NC's BACnet BBMD (broadcast messaging management) capability shall be enabled per IP subnet and configured with the list of all peer BBMD's and its subnet's devices.

H.   Duct static pressure set points for VAV air handling units shall be selected based on coordination with the TAB contractor to provide design air flows.

I.   Duct Differential Pressure High/Low Limit Settings – Coordinate setting values with the TAB contractor.

J.   Pipe static pressure set points for variable pumping systems shall be initially selected based on the scheduled pressure drop(s) of the coils at which the static pressure sensor(s) is installed.

Final selection shall be based on coordination with the TAB contractor to provide design water flows.

3.6   SEQUENCE OF OPERATION / POINT LIST

   A.   General:

       1.   Points - The points **state either** "shown/listed on the mechanical drawings**" or** "included with the below sequences**" shall be considered minimum. Provide all points and point types required to meet the sequence of operation.

       2.   DDC Sequence for Manually Started Equipment – Unless noted otherwise, when an operator starts the main component (e.g., fan, boiler, chiller, etc.) of an HVAC system (e.g., AHU, hot water plant, chiller plant, etc.) by a manual method outside of the BAS (e.g., a motor starter HOA) the BAS will execute the described system (based on sensing motor operation via the status input).

       3.   Safeties – None of the safety sequences described below shall be implemented by "software interlocks".

   B.   Specific Sequences**Either add these below or state** "- See the drawings"**

END OF SECTION