BUILDING AUTOMATION SYSTEM
PART 1 GENERAL

Commentary: *Division 23 lists existing University Control Centers. This Appendix applies to the Columbus Campus – Academics and Research -- FOD Control Center. This Appendix also applies to all other Control Centers [to all building automation systems in all University buildings on all University campuses and locations], except where noted otherwise in the BDS or hereinafter. For OSUMC systems, see the separate OSUMC Appendix A - WMC. For Student Life, see the separate Student Life Appendix A - SL. The individual Control Centers have the authority to amend the requirements of this Appendix with the approval of the University Engineer. References to the FOD Control Center, or to the FOD Building Automation Department, or to FOD should be interpreted as meaning the appropriate Control Center for the given project. Review with the OSU Project Manager.*

1.01 SCOPE

A. The intent of this Appendix is to give guidance to the A/E for specifying a Building Automation System for new and renovated buildings. This Appendix may not be applicable to all renovation projects; however, the design approach should be confirmed with the OSU Project Manager and the FOD Building Automation Department. The long-term goal is to provide the building with a complete Direct Digital Control (DDC) Temperature Control System to automatically control the operation of the entire Heating, Ventilating and Air Conditioning System and monitor and/or control auxiliary systems as applicable to the project scope of work. The new Building Automation System shall fully integrate into the existing district wide Building Automation BACnet network. The required integration shall include the creation of custom graphics and the compilation and display of all devices and objects on the existing Delta enteliWEB Frontend. All graphic displays will reside on the existing Delta Controls enteliWEB server and be modified accordingly. In addition, the system shall perform the said integration through the use of BACnet over IP communications (Annex J only). Failure to mention any specific item or device does not relieve the Contractor of the responsibility for installing or integrating such device/peripheral in order to comply with the intent of the Drawings or this Specification.

B. Building Automation System (BAS) Contractor shall provide:

1. A fully integrated and fully programmable BACnet building automation system (BAS), UL listed (UL916 and UL864 If applicable), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, as manufactured by Delta Controls by BCI, Siemens or Automated Logic Corporate Branch or an approved equivalent manufacturer. The A/E must submit the proposed “equivalent manufacturer” during the Schematic Design Phase to the OSU Project Manager for approval by the FOD Building Automation Department.

2. A UL864 listing shall be required for all controllers that are utilized in a smoke control sequence and as necessary to meet or exceed all national and local codes. In addition, UL864 devices and non UL864 shall not be permitted on the same network segment unless the devices are separated with a UL864 Ethernet switch. All MS/TP bus shall be consistent with its UL864 or non UL864 implementation. In other words, there shall not be UL864 product and non UL864 product on the same MS/TP bus.

2. Necessary conduit, wiring, enclosures, and panels, for all DDC temperature control equipment and devices. Installation shall comply with applicable local and national codes. Top control panel conduit penetrations shall use a gasketed Meyers hub to prevent water infiltration. Old control panels shall be demolished with the old controller turned over to FOD-BAS.

   Projects replacing or upgrading controllers may not reuse sensors, transducers, wiring, tubing or control cabinets. In cases where a controller is being replaced in a like for like manner, sometimes called a fast-forward, the A/E shall verify this type of procurement with the FOD-BAS Assistant Director during the design phase to verify the existing controls components can be reused

   Instances where Pneumatic Control lines are being terminated due to DDC retrofit, the pneumatic lines must be terminated with brass pneumatic fittings for plugging/capping air lines. Poly (plastic) tubing will be terminated with brass barbed plugs or brass compression plugs; copper lines are to be terminated with brass compression plugs or soldered on copper caps (any other piping material will be capped with similar piping material).

3. All components and control devices necessary to provide a complete and operable DDC system.

4. All final electrical connections to each stand-alone DDC Controller. Connect to 120VAC power as provided by the Division 26 contractor, to be terminated within 5 feet of the DDC Controller. [Note: A/E clearly defines the scope of work for each Prime Contractor in the Contract Documents.]

5. BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as defined In the Contract Documents. This BAS control wiring shall be furnished and installed in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes.

6. All Ethernet level devices require surge transient protection and shall be incorporated in design of system to protect electrical components. This includes but is not limited to, Building Controllers, Advanced Application Controllers and operator's workstations. Provide an external protection device listed under UL 1449 with minimum clamping voltage of 130 VRMS and surge current capability of 22,500Amps for all custom fabricated control panels (all main system components (i.e., AHUs, Chillers, Boilers, etc.).

7. All 120V and low voltage electrical control wiring exposed throughout the building shall be run in conduit in accordance with the Electrical requirements as specified in Division 26, the National Electric Code, and all applicable local codes. All low voltage wiring that is concealed in accessible ceilings may be run in plenum rated cable per the National and Local Electrical codes.

8. All 24VAC power required for operation of the BAS shall be by the BAS Contractor and shall be limited to 100 VA per the aforementioned codes. Any 24VAC power link that exceeds the 100 VA rating must be installed in conduit per Division 26 and all applicable codes, regardless of the nature of the installation.

9. BAS Contractor shall provide programming modifications necessary to fine tune sequences during commissioning and through the warranty period of system.

C. HVAC Contractor provides:

1. All wells and openings for water and air monitoring devices, temperature sensors, flow switches and alarms furnished by BAS Contractor.

2. Installation of all control valves as per the contract drawings. The HVAC contractor is responsible for the correct installation of any domestic, hot or chilled water control valves and shall seek guidance from the temperature control contractor, as needed.

3. Installation of all dampers and adjacent access doors for smoke; outdoor air, return air, exhaust air, and ventilation dampers.

4. All package unit control panels including but not limited to, factory boiler panels, factory chiller panels, refrigerant monitors and specialty interface modules required for BACnet compliance.

5. Instances where Pneumatic Control lines are being terminated due to terminal device replacement, the pneumatic lines must be terminated with brass pneumatic fittings for plugging/capping air lines. Poly (plastic) tubing will be terminated with brass barbed plugs or brass compression plugs; copper lines are to be terminated with brass compression plugs or soldered on copper caps (any other piping material will be capped with similar piping material).

D. Electrical Contractor provides:

1. Electrical Contractor shall provide dedicated 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for each DDC Controller and managed Ethernet switch. Run power circuit within 5 feet of equipment installed and connected by BAS Contractor.

2. Electrical contractor will also provide smoke detector and smoke damper interlock and power wiring for all life safety applications.

E. General Product Description:

1. The building automation system (BAS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection utilizing the BACnet protocol.

2. The building automation system shall consist of the following:

   a. Stand-alone peer-to-peer Building Controllers with 32 bit processors, a minimum of 2 MB of flash memory and 10 bit A/D converters. BACnet over Ethernet or BACnet over IP connectivity is required for all Building Level and Advanced Application Controllers.

   b. Stand-alone peer-to-peer Advanced Application Controllers with 16 bit or better processors, a minimum of 1 MB flash memory and 10-bit A/D converters, and must communicate via BACnet MS/TP with a minimum baud rate of 76.8 kbps. The use of ARCNET, LON, proprietary, or any other protocol other than BACnet is strictly prohibited.

Application Specific Controllers are not permitted at any level within the BAS system. All controllers must be Advanced Application Controllers and BTL listed.

c. Portable operator's terminal(s) when requested.

d. Provide seamless interconnection to the existing Delta Controls enteliWEB server, and build Delta Controls standard and customized graphics displays in accordance with the existing formats utilizing Delta enteliVIZ HTML5 Designer. If the BAS controls contractor is unable to build the graphics displays (FOD Building Automation Department has final say whether or not the displays meet the University Standards) then the BAS controls contractor must sub-contract the displays with Delta Controls BCI at their own expense.

e. All BACnet intrinsic alarming shall be disabled. All alarms shall reside in the local controller that is physically controlling the mechanical equipment. All alarms shall be setup as individual BACnet event objects, Support BACnet Event Enrollment, and support Delta Controls Auto Generated Messaging for alarms. Alarm delay times and messages must be completed to current standards of the FOD-BAS shop by the contractor. Non-Delta controllers must also set up their alarms and auto generated alarm messages at the BBMD level for the local subnet. If the BAS controls contractor is unable to set up the alarms (FOD Building Automation Department has final say whether or not the alarms meet the University Standards) then the BAS controls contractor must sub-contract the setup of the alarms with Delta Controls BCI at the expense of the BAS controls contractor.

3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Building Controllers, Advanced Application Controllers, expansion modules and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices. Alarm management and data collection that requires a single mechanism for user notification or viewing is strictly prohibited. A local outside air temperature reference is required for each facility. If applicable, the sensor must be hardwired to the hot water control panel. The local temperature reference may be shared with other controllers within the local facility. Sharing the outside temperature values between facilities is strictly prohibited unless fail over logic is in place. If the network share fails, then the panels have to refer to the local temperature reference for control.

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

6. All controllers shall pass a Building Automation shop BACnet plug test to confirm interoperability with the campus wide BACnet network. Firmware revisions or design changes to existing controllers shall require revalidation of interoperability.

   a. Plug test shall be passed prior to submittal of new equipment.

F. System Lifecycle Support

1. BACnet Field Devices: Manufacturer shall provide product updates for the lifecycle of the installed DDC hardware at no additional cost to the University. Manufacturers shall provide software tools, licensing, and training necessary for the University's field technicians to deploy and install updates. Updates shall include all patches, firmware, and software revisions for the lifecycle of the hardware or until the manufacturer no longer provides support for the product. Updates shall be available to all devices on the existing district wide Building Automation BACnet network so that all facilities with like hardware are running on the same firmware and software revisions. The requirement for these updates includes, but is not limited to, products with embedded OS, PLC's, building level controllers, advanced application controllers, unitary controllers, and component interfaces.

2. Server Frontend Applications, Data Historians, and BACnet Advanced Operator Workstations: Manufacturers shall provide product updates and licensing for the life of the application at no additional cost to the University. Manufacturers shall provide software tools, licensing, and training necessary for the University's field technicians to deploy and install updates. Updates shall include all patches, service packs, security updates, and software revisions. If newly installed hardware is no longer supported by the application, the manufacturer shall upgrade the application to the most current version. If the operating system on the machine running the application has reached the end of its lifecycle (e.g., Windows Server 08R2 or Windows 7), then the manufacturer shall provide software and licensing for the application to run on a modern operating system.

1.02 RELATED WORK

A. Specified elsewhere:

1. _____ - Sequence of Operation
2. _____ - Variable Speed Control
3. _____ - Basic Mechanical Requirements
4. _____ - Motors
5. _____ - HVAC Pumps
6. _____ - Boilers
7. _____ - Chillers
8. _____ - Cooling Tower
9. _____ - Terminal Heat Transfer Units
10. _____ - Air Handling Units
11. _____ - Testing, Adjusting and Balancing
12. _____ - Basic Electrical Materials and Methods
13. _____ - Equipment Wiring

B. Materials furnished by the BAS contractor, but installed by others:

1. BAS Contractor to furnish the following to the Heating, Ventilation and Air Conditioning Contractor for installation by the HVAC contractor:

    a. Control valves and temperature sensor wells for wet systems

    b. Location of all wells and openings for temperature, pressure, and flow sensors for pipe systems

    c. Control dampers for air systems

    d. Variable Frequency Drives

    e. Location of all ducts and openings for temperature, pressure, flow, and humidity sensors for air systems.

2. BAS Contractor to furnish the following network communications to the Building Automation System Manager for installation:

    a. Juniper firewalls and managed Juniper switches

    b. Delta eBMGR-2 (BBMD)

    c. Tenable.OT rack mount network sensor.

1.03 QUALITY ASSURANCE

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

B. Install system using competent workers who are fully trained and factory certified in the installation of temperature control equipment. The factory certified diplomas shall be readily available at the request of the owner or A/E engineer.

C. The complete installation and proper operation of the Building Automation Controls System shall include debugging and calibration of each component in the entire system and shall be the single source responsibility of supplier. The BAS must be supplied and installed by the same control contractor. Only Factory Authorized Distributors will be considered for installation. The letting of separate contracts by the prime HVAC Contractor for the Control System and a separate contract for its installation by a third party installer is strictly prohibited.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulations, Part 15, Subpart B, Class A, governing radio frequency electromagnetic interference, and be so labeled.

F. BAS shall comply with, and be listed at time of bid for the following Underwriters Laboratories Standards:

    1. UL 916 for Energy Management Equipment, per category PAZX for Energy Management Equipment.

    2. UL 864 for Control Units for Fire-Protective Signaling Systems, per category UUKL for Smoke Control System Equipment.

G. Design and build all system components to be fault-tolerant.

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3-Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protect communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC-coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All Building / System Controllers shall have real time clocks and data file RAM with battery and SRAM backup.

6. All controllers shall be EEPROM, flash driven.

7. The BAS Installer shall have a competent and factory certified Project Manager who is able to answer field questions, is aware of all schedules and schedule changes, and is responsible for the BAS Installer's work and the coordination of their work with all other trades. This Project Manager shall be available for onsite and shall respond to design, programming, and equipment related questions. Failure to provide the above services shall be considered a substantial breach of Contract Documents.

1.04 SUBMITTALS

A. Electronically submit a complete set of drawings showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system. **These drawings shall be submitted for approval to the A/E and FOD Building Automation Department**, together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system and schedule a review meeting with OSU and the A/E prior to the BAS contractor ordering material.

   1. Manufacturer's Product Data:

      a. All equipment components

   2. Shop Drawings:

      a. System wiring diagrams with sequence of operation for each system as specified.

      b. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.

      c. System configuration diagram showing all panel types and locations as well as communications network layout and workstations.

      d. Submit a list of points that will be alarmed with delay times and alarm messages.

B. Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the A/E prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

PART 2PRODUCTS

2.00 BACnet CONFORMANCE

A. The Building Automation System (BAS) contractor shall supply a BACnet (ANSI/ASHRAE 135-2016) compliant system. Each device category and its required compliance are listed below under sections F-H. BACnet compatible systems that employ the use of proprietary 'gateways' (i.e., protocol router/converter) will not be accepted unless otherwise noted.

B. The BACnet system shall be capable of BACnet over Internet Protocol (IP). Annex J will be the basis of design for all BACnet/IP devices. All other configurations must be submitted prior to bid, in writing, for final approval by FOD Building Automation Department.

C. The primary Local Area Network (LAN) on the building's subnet shall be based upon BACnet/IP Annex J and will be required for all Building Controllers, System Controllers and Operator Work Stations. The use of MS/TP communications for interconnecting the said devices is strictly prohibited. The installation of all Ethernet wiring, accessories, and connectors shall conform to the ISO standard and/or guidelines identified herein. The connection media shall be Category 6, Unshielded Twisted Pair (UTP) wire. The maximum single network run shall not exceed more than 100 meters. All panels must be home run to either the building's BAS managed Juniper SRX Series firewall (340) or a BAS managed Juniper EX series (2300-C or 3400) building switch that is in turn home run to the before mentioned firewall. (See fig.1 in SEC 2.01 A 2) BAS managed Juniper building switches must be secured in a key-accessed enclosure with an appropriate receptacle to power the equipment located within the enclosure or be placed in a secured MDF/IDF closet. Switches not located in a MDF/IDF closet must have a dedicated circuit breaker separate from DDC control panel power. The use of unmanaged switches, hubs, or daisy chaining Ethernet between controllers is prohibited. If a run exceeds 100m, fiber must be used with department approved media converters. All exceptions must be approved by FOD Building Automation Department management.

   The BAS system may, with FOD BAS approval, utilize the customer's existing Local Area Network (LAN) provided the bandwidth consumption is less than 10% of the total network bandwidth and is segregated onto a separate Virtual LAN (VLAN). Under no circumstances, shall the customer's LAN be subject to failure and/or abuse. In efforts to decrease liability, all BACnet devices that reside on the LAN must support the BACnet Broadcast Management Device (BBMD) scheme. Multi-casting or Global broadcasting will not be permitted without the use of a BBMD.

D. The secondary or sub-network shall utilize the Master-Slave/Token-Passing protocol, as acknowledged by the ANSI/ASHRAE 135 standard. Proprietary RS-485 or equivalent links will not be considered unless otherwise noted. The MS/TP bus shall operate at a 76.8 Kbps minimum. If a 3rd party device is unable to communicate at 76.8 Kbps it must be isolated to its own individual bus. Each subnet bus shall consist of no more than 50 devices and there shall be no more than 99 devices total per MS/TP router. All exceptions will have to be approved in writing by the FOD Building Automation Department. All devices on a bus shall be subordinates of a single mechanical system. For example, putting VAV's that are served from two different AHU's on the same physical bus is strictly prohibited. All devices on a MS/TP bus shall be from the same vendor, devices from other vendors shall be on a separate MS/TP bus. The use of MS/TP repeaters have to be approved in writing by the FOD Building Automation Department. If repeaters are permitted the location of the repeaters has to be labeled and identified in the enclosure of the Ethernet connected level device along with drawing schematics.

E. The use of proprietary gateways to transmit input/output data, and/or related information, must reside on the Ethernet LAN and be approved by FOD Building Automation Department, in writing, prior to the bid.

F. **Building Controller Conformance (BC)**: The building controller must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-BC (Annex L of the BACnet standard) with support of the following BIBBs:

Alarm and Event Management BIBBs

AE-ACK-B, AE-ASUM-B, AE-ESUM-B, AE-INFO-B, AE-N-A, AE-N-E-B, AE-N-I-B

Device Management BIBBs

DM-BR-B, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-OCD-B, DM-RD-B, DM-TM-A, DM-TS-A, DM-TS-B, DM-UTC-A, DM-UTC-B

Data Sharing BIBBS

DS-COV-A, DS-COV-B, DS-COVU-A, DS-COVU-B, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-B

Network Management BIBBS

NM-CE-A, NM-CE-B

Scheduling BIBBs

SCHED-A, SCHED-E-B, SCHED-I-B

Trending

T-ATR-B, T-VMT-E-B, T-VMT-I-B

G. **Advanced Application Controller Conformance (AAC)**: The AAC must be certified and listed by BTL (BACnet Testing Laboratory) under Device Profile B-AAC (Annex L of the BACnet standard) with support of the following BIBBs:

Alarm and Event Management BIBBs

AE-ACK-B, AE-ASUM-B, AE-ESUM-B, AE-INFO-B, AE-N-E-B, AE-N-I-B

Device Management BIBBs

DM-BR-B, DM-DCC-B, DM-DDB-A, DM-DDB-B, DM-DOB-A, DM-DOB-B, DM-LM-B, DM-OCD-B, DM-RD-B, DM-TM-A, DM-TS-B, DM-UTC-B

Data Sharing BIBBS

DS-COV-A, DS-COV-B, DS-COVU-A, DS-RP-A, DS-RP-B, DS-RPM-A, DS-RPM-B, DS-WP-A, DS-WP-B, DS-WPM-B

Network Management BIBBS

NM-CE-A

Scheduling BIBBs

SCHED-E-B, SCHED-I-B

Trending

T-ATR-B, T-VMT-E-B, T-VMT-I-B

H. **Read / Write Properties:** The entire BACnet BAS system (all BC, and AAC devices) shall support the following Read/Write properties within the given BACnet objects and shall permit dynamic creation and deletion thereof.

Analog Input Object

Read and Write Properties: Description, Name, Value, COV Increment, Out of Service, Reliability

Read Only Properties: Type, Units, Status Flags, Event State

Analog Output Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Units, COV Increment, Status Flags, Event State, Priority Array

Analog Variable Object

Read and Write Properties: Description, Name, Value, Units, COV Increment, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State`

Binary Input Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

Binary Output Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability, Minimum On/Off time

Read Only Properties: Type, Status Flags, Event State, Priority Array

Binary Variable Object

Read and Write Properties: Description, Name, Value, Out of Service, Reliability

Read Only Properties: Type, Status Flags, Event State

Event Enrollment Object

Read and Write Properties: Description, Name, Notification Class, Event Enable, Event Parameter, Event Type, Object Reference

Read Only Properties: Type, Event State, Event Time Stamps, Notification Type, Acknowledged Transactions

Notification Class Object

Read and Write Properties: Description, Name, Priority, Recipient List

Read Only Properties: Type, Notification Class

Calendar Object

Read and Write Properties: Description, Name

Read Only Properties: Type, Value

Schedule Object

Read and Write Properties: Description, Name, Object Reference, Weekly Schedule, Effective Period, Schedule Exceptions

Read Only Properties: Type, Value

Trend log Object

Read and Write Properties: None

Read Only Properties: Description, Name, Type, Notification Class, Event Enable, Event State, Event Time Stamps, Notification Type, Acknowledge Transactions, Log Enabled, Start/Stop Time, Log Interval

Program Object

Read and Write Properties: Description, Name, Out of Service, Reliability, Program Change

Read Only Properties: Type, Status Flags

Loop Object

Read and Write Properties: Description, Name, Value, COV Increment, Out of Service, Reliability, Tuning Parameters, Action, Controlled Variable

Read Only Properties: Event State, Status Flag, Type

File Object

Read and Write Properties: Description, Name

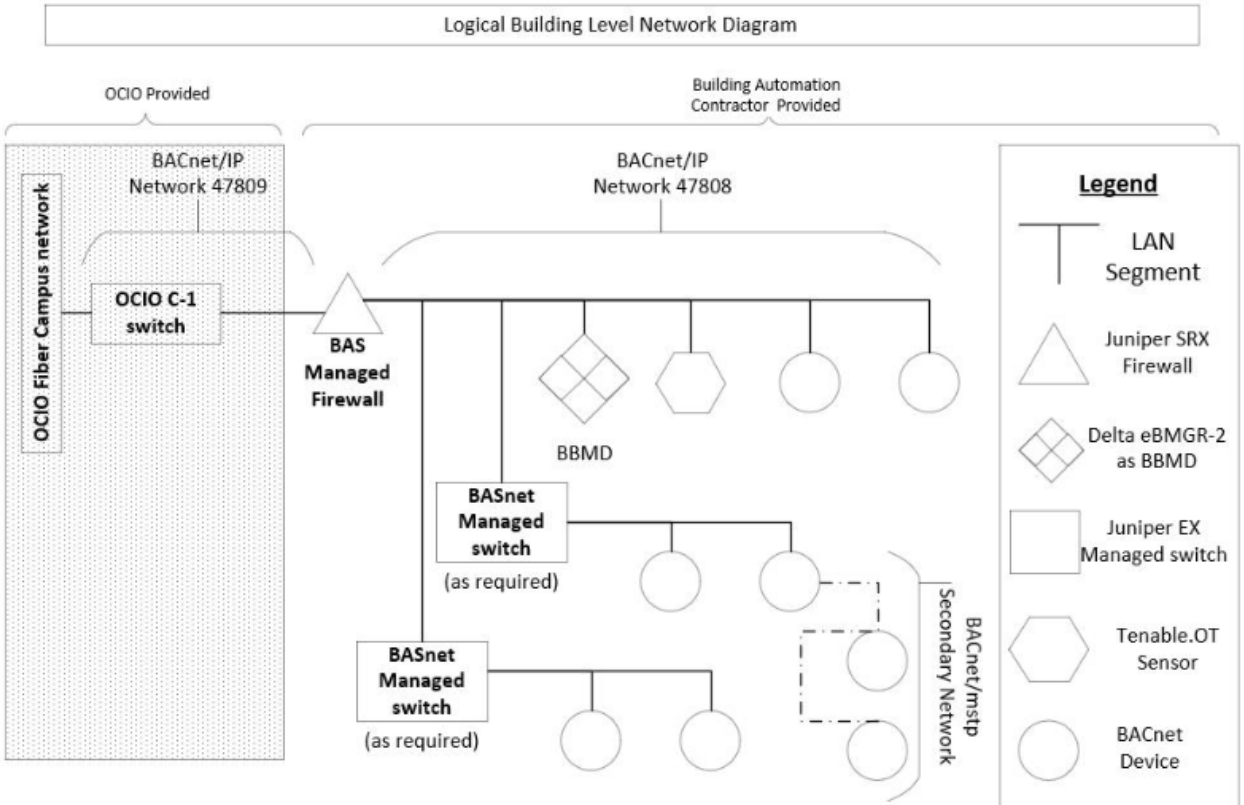
Read Only Properties: Type

2.01 NETWORKING COMMUNICATIONS

A. The design of the BAS network shall integrate operator workstations and stand-alone DDC Controllers on a peer-to-peer communications network, and other devices on other networks. The network architecture shall consist of the following four levels:

1. A district-wide Ethernet communications network based on the BACnet/IP protocol (Annex J.)

2. A building-wide peer-to-peer communications network between Building Controllers utilizing BACnet/IP Annex J supported by a local Delta eBMGR-2 acting as a BBMD and segmented from other building networks by using a Juniper SRX series Firewall.



Note: The physical network layout for Ethernet devices is a star topology with the managed firewall being the central connection point for either BACnet devices or any managed switches. Daisy chaining of Ethernet devices or switches is strictly prohibited.

Fig. 1

3. BACnet MS/TP buses extended from appropriate Building Controllers to associated Advanced Application Controllers.

4. Wireless communication between controllers or field devices is NOT permitted unless it has been submitted in writing for pre-approval from the FOD Building Automation Department.

5. Private or unmanaged internal Ethernet based networks shall not reside in packaged or equipment level control systems. These networks need to be managed utilizing VLAN separation on the BAS network using Building Automation Shop assigned IP addresses.

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

C. Network design shall include the following provisions:

1. Provide high-speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. System performance shall ensure that an alarm occurring at any DDC Controller is displayed at workstations and/or alarm printers within 5 seconds.

2. Support of any combination of DDC Controllers and operator workstations directly connected to the peer-to-peer network. A minimum of 50 devices shall be supported on a single network (including MS/TP).

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

4. Error detection, correction and retransmission shall be included to guarantee data integrity.

5. Synchronization of real-time clocks, to include automatic daylight savings time updating between all controllers shall be provided. Universal Time Coordinate based upon Greenwich Mean Time must be supported. (All BC devices must have Real Time Clocks with battery and SRAM backup, see section 1.03 H)

D. Acceptable protocols for intercommunications between building-wide peer-to-peer Building Controllers:

1. BACnet/IP

E. Secondary Local Area (communications) Network (LAN):

1. This communications network shall be limited to Building Controllers and Advanced Application Controllers and shall communicate bi-directionally with the BACnet peer-to-peer network.

2. Advanced Application Controllers shall be arranged on the LAN's in a functional relationship to the corresponding Building Controllers. For example, a VAV Advanced Application Controller serving a VAV terminal box shall be connected on a MS/TP bus from the Building Controller that is controlling the corresponding air handling unit.

3. A maximum of 50 Advanced Application Controllers may be configured on any individual LAN from any Building Controller to insure adequate global data and alarm response times.

4. Acceptable protocols for intercommunications between Advanced Application Controllers and Building Controllers on a secondary network (with the exception of lab controllers, see SEC 2.01 J 11) are as follows:

5. BACnet (MS/TP)

F. Network cabling should be in accordance with appropriate sections (i.e., Sections VI, VII, and IX) from APPENDIX M - Communications Wiring Standard. For all Building Automation Projects, follow standards that apply to the Office of Technology and Digital Innovation (OTDI) and replace OTDI with FOD Building Automation Department.

1. Network runs shall be terminated to either a patch panel or biscuit block using a Keystone style jack.

2. Final terminations between network runs and equipment shall be with CAT 6 patch cables.

2.02 BUILDING CONTROLLER

A. DDC (stand-alone) Controllers shall have a 32-bit processor with EEPROM, flash driven operating system (OS). They shall also be multi-tasking, multi-user, real-time digital control processors and permit I/O expansion for control / monitoring of up to 48 I/O. Controller size shall be sufficient to fully meet the requirements of this specification and provide a minimum scan rate of 3 scans per second.

B. Each Building Controller shall have sufficient flash memory (EEPROM), a minimum of 2 megabytes, to support its own operating system. In addition, there shall be additional SRAM memory for database handling, a minimum of 5 megabytes: Both the EEPROM and SRAM shall permit full implementation and support of all B-BC requirements of this specification, including:

1. Control processes
2. Energy management applications
3. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
4. Historical/trend data for points specified
5. Maintenance support applications
6. Custom processes
7. Operator I/O
8. Manual override monitoring

C. Each Building Controller shall support:

1. Monitoring of the following types of inputs, without the addition of equipment outside of the Building Controller cabinet:

a. Analog inputs

1) 4-20 mA
2) 0-10 Vdc
3) Thermistors

b. Digital inputs

1) Dry contact closure
2) Pulse Accumulator
3) Voltage Sensing

2. Each Building Controller shall be capable of providing the following control outputs without the addition of equipment outside the Building Controller cabinet:

a. Digital outputs (contact closure)

1) Contact closure (motor starters, up to size 4)

b. Analog outputs

1) 4-20 mA

2) 0-10 Vdc

3) 0-135 Ohm (with external Transducer)

D. Each Building Controller shall have a minimum of 10 percent spare (panel real estate) capacity for future point connection and shall support up to 48 I/O with modular expansion modules. All expansion modules shall be located in the building controller enclosure or an attached enclosure within line of sight of the controlled equipment. The type of spares shall be in the same proportion

as the implemented I/O functions of the panel, but in no case shall there be less than two spares of each implemented I/O type. Provide all processors, power supplies, database memory, program sequence memory, and communication controllers complete so that the implementation of any added point (within the above 10% spare) only requires the addition of the appropriate point input/output termination module, point sensor, and wiring.

1. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.

2. Building Controllers shall provide at least one RS-232C serial data communication ports (BACnet PTP compatible) for operation of operator I/O devices such as industry standard printers, operator terminals, modems and laptop portable operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals. System-wide access must be provided at each mechanical equipment room through the local Building Controller. Panel mounted terminals are not required. Furthermore, all Building Controllers shall include a hardwired, concealed and secured, RJ-11 or RJ-45 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Advanced Application Controller.

E. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points. These override switches shall be operable whether the panel processor is operational or not.

1. Switches shall be mounted either within the Building Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.

2. Building Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. Building Controllers shall also collect override activity information for reports.

G. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LED’s or analog indication of value shall also be provided for each analog output.

H. Each Building Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures and for repeated failure to establish network communications.

I. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with current IEEE Standard C62.41.

J. In the event of the loss of normal power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Programs residing in memory shall be protected either by using EEPROM under capacitor backup or by an uninterruptible power source (battery backup). The backup power source shall have sufficient capacity to maintain volatile memory in event of an AC power failure. Where interruptible power source is rechargeable (a rechargeable battery), provide sufficient capacity for a minimum of seventy-two hours backup. Charging circuitry, while the controller is operating under normal line

power, shall constantly charge the rechargeable power source. A non-rechargeable power source shall not be permitted. Batteries shall be implemented to allow replacement without soldering.

1. Upon restoration of normal power, the Building Controller shall automatically resume full operation without manual intervention.

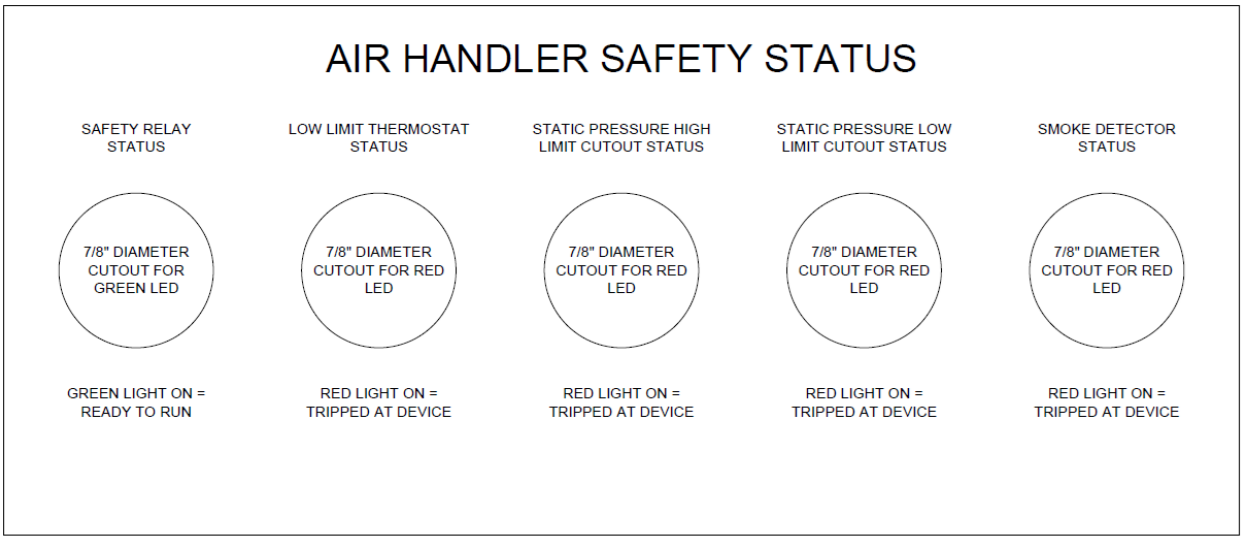
2. Should Building Controller memory be lost for any reason, the user shall have the capability of reloading the Building Controller via the local RS-232C port or from a network workstation PC.

K. Building Controllers must comply with Section 2.02, A-J and 2.03. Panels that lose communication or control due to a single sensor failure are not permitted.

L. Building Controllers will be used in each equipment room where major or more than two pieces of equipment are being controlled. The use of AAC devices for critical or main system equipment will not be permitted.

M. All points associated with a given mechanical system (i.e., an air handling unit) will be controlled from a single Building Controller or point expansion panels from the respective master. (i.e., remote motor control centers). All expansion modules shall be located in the building controller enclosure or an attached enclosure within line of sight of the controlled equipment. No points from a given mechanical system may be distributed among multiple panels - points must be run back to a single Building Controller dedicated to that mechanical system. Closed-loop control of Chillers, Heat Recovery Chillers and Boilers must never depend upon network communications. All inputs, set points, program sequences, and outputs for any single DDC control loop shall reside in the same Building Controller. VFD closed-loop control may use networked variables to adjust loop setpoints only. Closed-loop control air handling and air terminal (e.g. VAVs and CAVs) control may depend on network communications if the transfer occurs only in the building network segment, each controller sending or receiving data is connected directly to a BAS manage Juniper switch, and no equipment damage occurs if the network transfer fails. Loops shall be programmed to prevent wind up of the loop output when the loop is not in use.

N. Air Handlers and Roof Top Unit control panels shall have local indicator LED lights per the below drawing to provide a visual status of the unit safeties.



7"X3" CUSTOM BLACK PHENOLIC LABEL WITH WHITE TEXT SHALL BE LOCATED ON PANEL FACE TO SHOW STATUS OF SAFETY DEVICES.

2.03 BUILDING CONTROLLER RESIDENT SOFTWARE FEATURES

A. General:

1. All necessary software to form a complete operating system as described in this specification shall be provided.

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

3. Point naming convention shall use the Brick schema. See https://brickschema.org.. If Appendix A does not cover the name required please submit name for approval by OSU Project Manager.

   Point names for Siemens controllers shall use this format:

   OSU Building Number-System Name-Point Description. Example: 302 AHU2 Supply Air Temperature. Do not use periods between sections and minimize abbreviations.

B. Control Software Description:

1. The Building Controllers shall have the ability to perform any or all of the following pre-tested control algorithms:

   a. Two-position control

   b. Proportional control

   c. Proportional plus integral control

   d. Proportional, integral, plus derivative control

2. Control software shall include a provision for limiting the number of times that each piece of equipment may be cycled within any one-hour period.

3. The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. This feature shall be resident in all Binary Output objects. The use of custom programming to prevent an excessive demand on start-up shall not be required.

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

C. All programs shall be executed automatically without the need for operator intervention and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the Sequence of Operations. Building Controllers shall have the ability to perform any or all of the following energy management routines:

1. Time-of-day scheduling

2. 365 day Calendar-based scheduling

3. Holiday scheduling

4. Temporary schedule overrides
5. Start-Stop Time Optimization
6. Automatic Daylight Savings Time Switch over
7. Night setback control
8. Enthalpy switch over (economizer)
9. Peak demand limiting
10. Temperature-compensated duty cycling
11. Fan speed/ control
12. Heating/cooling interlock
13. Cold deck reset
14. Hot deck reset
15. Hot water reset
16. Chilled water reset
17. Condenser water reset
18. Chiller sequencing
19. Chiller load monitoring

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

1. It shall be possible to use any of the following in a custom process:
    a. Any system measured point data or status
    b. Any calculated data
    c. Any results from other processes
    d. User-defined constants
    e. Arithmetic functions (+, -, *, /, square root, exponential, etc.)
    f. Boolean logic operators (and/or, exclusive or, etc.)
    g. On-delay/off-delay/one-shot timers
2. Custom processes may be triggered based on any combination of the following:
    h. Time interval
    i. Time-of-day
    j. Date

k. Other processes

l. Time programming

m. Events (e.g., point alarms)

3. A single process shall be able to incorporate measured or calculated data from any and all other controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other controllers on the network.

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

5. The custom control programming feature shall be compiled and documented via English language descriptors. These descriptors (comment lines) shall be viewable from local operator I/O devices to facilitate troubleshooting.

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

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

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

3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs.

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

a. Each Building Controller shall be capable of storing ~~all~~ custom alarm messaging text for each alarm. The alarm text shall be unique and user defined; custom text shall be available for all BACnet alarms and shall reside in the BC, not in an OWS or PC. Non-Delta controllers shall use the local subnet BBMD for custom alarm messaging. Alarm messages shall be in this format: Building Name-Equipment Name-Issue-University entity to notify of the issue.

b. Alarms shall have ability to be acknowledged from the local operator I/O device, (once the problem is resolved).

5. Alarms shall be created only if they require an operator to take an action. The BAS contractor shall submit a complete alarm list with the controls submittal package. BAS

contractor will submit a finalized alarm list in as-built documentation. The list will show the alarm Event Enrollment number, description, cause of the alarm and diagnostic steps to resolve the alarm.

6. All Air Handling Unit controllers shall minimally have the following alarms:

EV	Description
900	Low Limit Thermostat Alarm
901	Supply Fan Status Critical
902	Return Fan Status Critical

F. A variety of historical data collection utilities shall be provided for manual or automatic sampling, storing and displaying system data for points as specified in the I/O summary.

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

   a. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controller. Two methods of collection shall be allowed: either by a pre-defined time interval, or upon a pre-defined change of value. Sample intervals of 1 second to 7 days shall be provided. Each Building Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing a minimum of 50,000 data samples + 1500 samples per connected Advanced Application Controller (i.e., VAV) if it cannot store trend logs.

2. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either; user-defined interval, manual command, or automatically when the trend buffers are full. Furthermore, the workstation shall notify the end-user if the hard drive capacity is low or if the database size is excessive. The OWS shall use a standard MSDE or SQL database handler for all trend log management. All trend data shall be available to all BACnet OWSs and for use in 3rd party personal computer applications. File format type to be comma delineated.

3. Building Controllers shall also provide high resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary. Provide capability to view or print trend and tuning reports.

   a. The Loop object shall display the most recent historical data of its own performance. It shall illustrate the number of setpoint crossings and the maximum and average deviation from setpoint.

   b. Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

G. Building Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary.

1. The totalization routine shall have a sampling resolution of one minute or less.

2. The user shall have the ability to define a warning limit for run-time totalization. Unique, user-specified messages shall be generated when the limit is reached.

H. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and digital pulse input type points as specified in the point I/O summary.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., kWh, gallons, BTU, tons, etc.).

2. The totalization routine shall have a sampling resolution of one minute or less.

3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

I. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for points as specified in the point I/O summary.

1. The event totalization feature shall be able to store the records associated with a minimum of 9,999.9 events before reset.

2. The user shall have the ability to define a warning limit. Unique, user-specified messages, up to 200 characters, shall be generated when the limit is reached.

J. Advanced Application Controllers:

1. Each Building Controller shall be able to extend its performance and capacity through the use of remote Advanced Application Controllers. Each Advanced Application Controller shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each Advanced Application Controller shall be a microprocessor-based, 16-bit or better, multi-tasking, real-time digital control processor. Provide for control of terminal equipment including, but not limited to, the following:

   a. VAV Boxes

   b. Heat pumps

   c. Fan coils, Uni vents

   d. Laboratory Air Supply, Exhaust and Fume Hoods

   e. Other terminal equipment or monitoring

2. Advanced Application Controllers must comply with Section 2.03, items A through I, and must be peer-to-peer devices. Advanced Application Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide a hand/off/automatic switch for each digital output for manual override capability. Switches shall be mounted either within the controller's key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides. In addition, each switch position shall be supervised in order to inform the system that automatic control has been overridden. Switches will only be required for non-terminal applications or where controllers are readily accessible (not required for VAVs, Heat pumps, etc. that are above ceilings or inaccessible). All inputs and outputs shall be of the Universal type, allowing for additional system flexibility. A minimum of 12 global points (i.e. chilled water temperature, hot water temperature, etc.) must be able to be accessed through the Advanced Application Controller. If global point access is unavailable with the Advanced Application then a Building Controller must be furnished.

3. Each Advanced Application Controller shall support its own real-time operating system. Provide a time clock with battery backup to allow for stand-alone operation in the event that communication with its Building Controller is lost and to insure protection during power outages. In the event that the AAC does not support a real time clock (RTC) function and it is being used on critical or system level equipment as mentioned in section 2.03 J.1 then a Building Controller supporting RTC functionality shall be used in its place. AAC devices without RTC functionality will be permitted for use on terminal or unitary equipment such as VAV boxes (except for laboratories), fan coils, heat pumps, unit ventilators and auxiliary monitoring and control.

4. Provide each Advanced Application 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 under capacitor backup (lithium or rechargeable battery backup will not be permitted). Advanced Application Controllers must be fully programmable with a minimum of 200 lines of code available for custom programming. All programs shall be field-customized to meet the user's exact control strategy requirements. Advanced Application Controllers utilizing pre-packaged or canned programs shall not be acceptable. As an alternative, provide Building Controllers for all central equipment in order to meet custom control strategy requirements.

5. Programming of Advanced Application Controllers shall utilize the same programming language and code as used by Building Controllers to maximize system flexibility and ease of use. Should the system controller utilize a different control language, provide a Building Controller to meet the specified functionality.

6. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.

7. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.

8. Advanced Application Controllers that lose communication with master panels, and/or lose control due to a single sensor failure, are not acceptable.

9. At all Advanced Application Controllers include a hardwired, concealed and secured, RJ-11 or RJ-45 jack for use by the Portable Operators Workstation. The local operator, using the Portable Operators Workstation, shall plug into this jack, and shall perform all monitoring, control, and programming of sequences for any and all building-wide points and sequences while standing at any Advanced Application Controller.

10. At all Advanced Application Controllers, include the point database of the following minimum building-wide system data:

    i. Building Primary Hot Water Return and Supply Temperatures

    j. Building Primary Chilled Water Return and Supply Temperatures

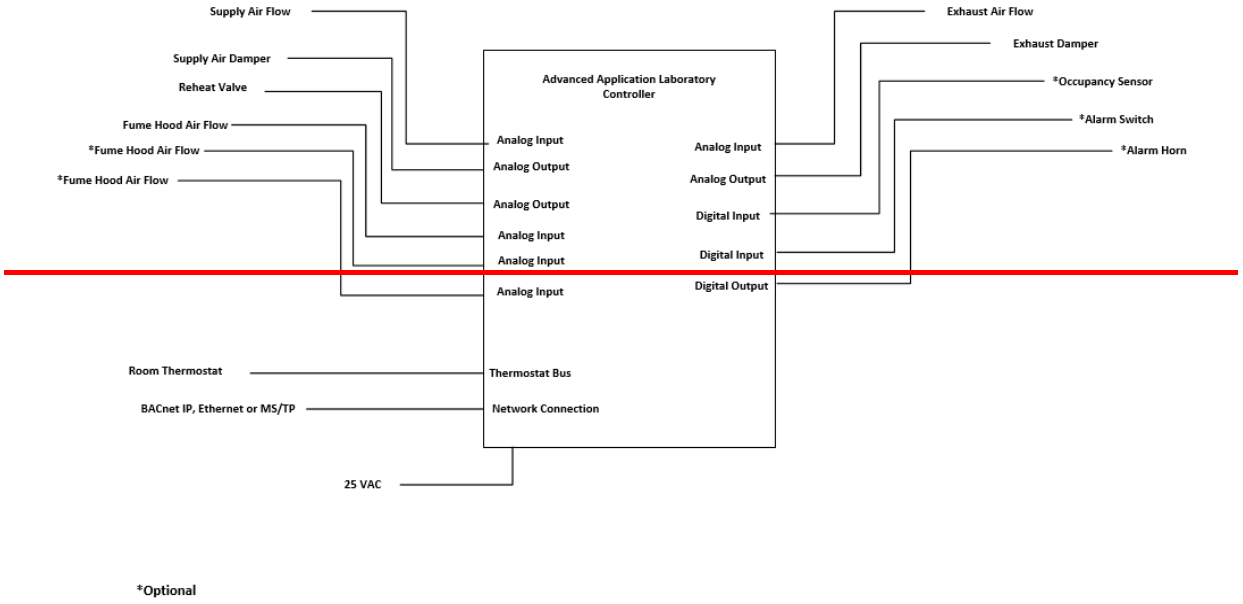
    k. Building Common Outside Air Temperature

    l. Database for 10 other building-wide points, as field selected by OSU.

    m. All VAV boxes including but not limited to dual duct boxes, mixing boxes, fan powered shall include a discharge air sensor.

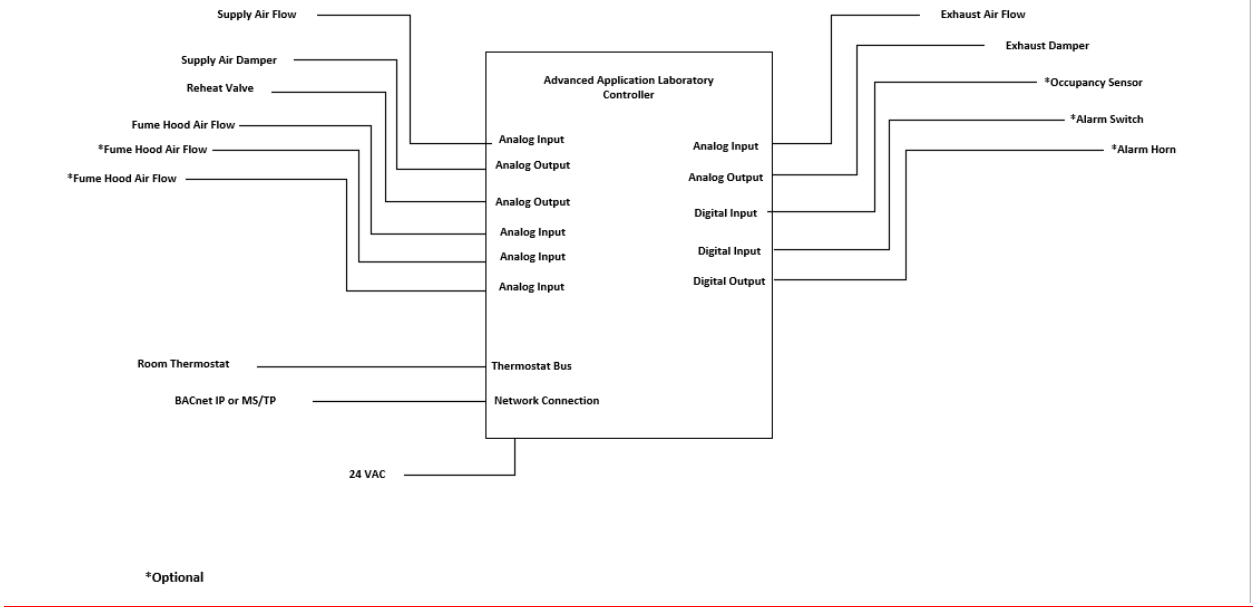
11. Advanced Application Controllers (AAC) or Building Controllers (BC) shall be used to control laboratory HVAC processes. Each laboratory shall use a single AAC/BC to control airflows, reheat valve(s) and monitor fume hood airflows. Airflow sensors, including the fume hood(s), shall be hard-wired analog inputs on the AAC/BC. Supply and exhaust damper controls and reheat valves shall be hard-wired to analog outputs on the AAC/BC. See Figure 2 below for an example. Laboratory AACs/BCs shall not be dependent in any way on a network connection (i.e. Ethernet, RS-485, proprietary, etc.) to function outside of the local thermostat.

Laboratory Controller Example with 1 or more Fume Hoods
Figure 2



*Optional

Laboratory Controller Example with 1 or more Fume Hoods
Figure 2



*Optional

K. Building Lighting Control Systems shall be integrated via BACnet into the BAS network. Lighting schedules shall be presented as BACnet Schedule objects in the University's Delta enteliWEB server. The lighting system schedule shall be editable from the enteliWeb server. The status of lighting controllers and their relays shall be visible in the enteliWeb server. A floor plan graphic will be created for each building floor showing the status of each lighting relay in EnteliWeb.

1. Lighting systems that utilize wireless communication shall not be utilized unless preapproved by the FOD Building Automation Director during the design phase of a project.

2. Room level lighting and shade controls shall be integrated into the room level building automation controller.

3. Lighting and shade control system front ends shall not utilize cloud-based systems or communications without preapproval by the FOD Building Automation Director during the design phase of a project. Cellular based communication solutions shall not be used.

4. Controllers solely supporting lighting maybe Application Specific Controllers (ASC) but must have editable schedules as shown in BACnet PIC Statement provided with the submittal.

5. Lighting Control workstations (Windows 10)/server (Windows 2022) need to be approved by the BAS shop, the hardware case needs to be two post Rack Mountable, and the BAS shop requires that hardware meet the recommended specs for the Operating System being used, and that the hardware, Operating System, Lighting Control Software to be provided by project.

~~5.~~6. Lighting controls vendor must supply firmware, application software updates and telephone or email technical support at no cost to the University for the life of the lighting control system.

~~6.~~7. Approved Vendors: Distech (nLight Eclypse), Leviton (Greenmax), Lutron (Quantum View), Delta Controls or approved equal. FOD-BAS has final authority if an approved equal meets specification.

2.04 PORTABLE OPERATOR'S TERMINAL (POT)

A. On request, provide One (1) portable operator terminal (POT). The POT shall be a laptop configuration and plug directly into any control panel. Provide the BACnet BAS software as required to provide complete functionality for viewing, modifying, restoring, and archiving of all data (including custom programs). The software used to setup and configure the BAS controls shall be the same software provided to the University at no additional expense.

B. Functionality of the portable operator's terminal connected at any controller:

1. Access all controllers on the network.

2. Backup and/or restore DDC Controller databases for all system panels, not just the DDC Controller connected thereto.

3. Display all point, selected point and alarm point summaries.

4. Display trending and totalization information.

5. Add, modify and/or delete any existing or new system point.

6. Command, change setpoint, enable/disable any system point.

7. Program and load custom control sequences as well as standard energy management programs.

C. Connection of a POT to a distributed control processor shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

D. Portable operator terminal access to controller shall be password-controlled.

E. Portable operator terminal minimum hardware and performance criteria shall be as referenced in Appendix A.1.

2.05 WORKSTATION OPERATOR INTERFACE SOFTWARE

A. Basic Interface Description

1. Operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:

a. Graphical viewing and control of environment

b. Scheduling and override of building operations

d. Definition and construction of dynamic and animated color graphic displays

e. Editing, programming, storage and downloading of controller databases

2. Provide a graphical user interface, which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device. All graphics shall be created in Delta enteliVIZ HTML 5 Designer.

a. Provide functionality such that all operations can also be performed using the keyboard as a backup interface device.

b. Provide additional capability that allows at least 10 special function keys to perform often-used operations.

3. The software shall provide multi-tasking operating system such that alarm notification occurs while user is running other applications such as Word or Excel; trend data uploads occur in the background while other applications are running. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows[a] or similar industry standard software that supports concurrent viewing and controlling of systems operations.

a. Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows: (Vector based graphics)

1). Dynamic and animated color graphics and graphic control
2). Alarm management coordinated with section 2.04.E.
3). Time-of-day scheduling
4). Trend data definition and presentation
5). Graphic definition
6). Graphic construction

b. If the software is unable to display several different types of displays at the same time, the BAS contractor shall provide at least two operator workstations.

4. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities. Privileges shall be customizable for each operator; the main menu shall reflect the privileges upon log on showing only the applications appropriate for the operator.

   a. Customizable such that operators can monitor, command, or edit an application or group of points. An operator can be defined with privileges for access to a building, group or buildings, or areas (labs--point names with the designation "lab"), by application: the operator has monitor, command, and edit capability for time of day schedules and calendars (only) for the entire campus: or by function: the operator (i.e. security guard) has ability to view/monitor all areas of the campus and receive alarms, etc.

   b. A minimum of 50 unique passwords, including user initials, shall be supported.

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

   d. The system shall automatically generate a report of log-on/log-off time and system activity for each user.

   e. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line as well as have the capability to generate a report of log-on, log-off time, parameters modified, and system activity for each user.

5. Software shall allow the operator to perform commands including, but not limited to, the following:

   a. Start-up or shutdown selected equipment

   b. Adjust setpoints

   c. Add/modify/delete time programming

   d. Enable/disable process execution

   e. Lock/unlock alarm reporting for points

   f. Enable/disable totalization for points

   g. Enable/disable trending for points

   h. Override PID loop setpoints

   i. Enter temporary override schedules

   j. Define holiday schedules

   k. Change time/date

   l. Automatic daylight savings time adjustments

   m. Enter/modify analog alarm limits

n. Enter/modify analog warning limits

o. View limits

p. Enable/disable demand limiting for each meter

q. Enable/disable duty cycle for each load

r. Operator shall have ability to schedule reports to print at a pre-specified time and frequency and directed to displays, printers, disk or emails. The reports shall be capable of querying all BACnet devices for all BACnet data and shall be available in industry standard formats such as Acrobat, Microsoft Word, Microsoft Excel and Crystal Reports.

1) Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups or for the entire BACnet network without restriction due to the hardware configuration of the building automation system. At a minimum, the report function shall provide all required BACnet data for the previously identified BACnet objects in section 2.00 J.

B. Scheduling

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum:

a. BACnet schedules

b. BACnet calendars

2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.

3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone, unless custom programming is used to enable/disable the points. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Zone thermostats shall be programmed to allow a 2-hour temporary unoccupied override by pressing a button on the thermostat. Thermostats shall give a visual feedback to the user as to what mode they are in.

4. Monthly calendars, until the year 2090, shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

5. Occupancy schedules for Air Handling Units (AHU) should avoid starting and stopping the units. Lower static pressures and wider temperature set point dead bands should be utilized during unoccupied time periods to reduce energy consumption. In cases where the AHU has zone level Digital Controls, the setback schedules shall be done at the zone level.

C. Collection and Analysis of Historical Data

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting. In addition, the BAS system shall automatically trend and archive all alarms and user activity (no exceptions).

2. Trend data report graphics shall be provided to allow the user to view all trended point data. The BAS system shall employ the use of Multiple Trend-Logs which may be customized to include up to 8 individual singe trends in one viewable and printable format. Provide additional functionality to allow any trended data to be transferred easily to Microsoft Office, Excel ®. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A maximum of 8 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

    a. Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

    b. Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time, the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

4. All new Building (BC) and Lab (AAC) controllers are required to have the following points trended:

    a. Analog Inputs (AI) and Outputs (AO): 300 15-minute samples.

    b. Binary Inputs (BI), Outputs (BO) and Binary Variables (BV): 300 samples on Change of Variable (COV).

    c. Analog Variables (AV) that change frequently, such as setpoints: 300 15-minute samples.

    d. Multi-state Variables (MV): 300 samples on Change of Variable (COV).

    Room level AACs with limited memory shall trend the same points, but limit samples to 100 per trend log.

5. New buildings or building renovation projects where the HVAC controls are upgraded must provide a Delta Coppercube and licensing for the University's Kaizen building analytics software. The Kaizen license period shall be for 10 years. The following formula shall be used to calculate the number of Kaizen trend logs to license:

   (Number of Building/System controllers X 50) + (number of AACs X 30) + (number of 3rd party BACnet interfaces X 25)

   If a building controls system exceeds 50,000 BACnet objects, an additional Coppercube will be supplied for each additional 50,000 BACnet objects or part thereof.

   Smaller projects with less than 1000 trend logs required shall check with FOD-BAS to see if an existing Coppercube can be upgraded to a larger license instead of providing a new Coppercube.

D. Dynamic Color Graphic Displays

1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, room level terminal unit equipment shall be provided by the BAS contractor as indicated in the point I/O summary of this specification to optimize system performance analysis and speed alarm recognition. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

2. Dynamic temperature values, humidity values, flow values, percent load, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

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

4. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays. Delta enteliVIZ HTML 5 graphics shall be used.

   a. The BAS contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

   b. The graphic package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:

      1) Define symbols
      2) Position and size symbols
      3) Define background screens
      4) Define connecting lines and curves
      5) Locate, orient and size descriptive text
      6) Define and display colors for all elements
      7) Establish correlation between symbols or text and associated system points or other displays
      8) Ability to import scanned images and CAD drawings in Autodesk ®, DWG format.

c. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points that aids the operator in the analysis of the facility.

1) To accomplish this, the user shall be able to build graphic displays that include point data from multiple controllers.

d. The main graphic page for a building shall have an HTML hyperlink to a PDF file of the network riser diagram(s) for the building. Each system level graphic shall have an HTML hyperlink to a PDF file of the system Sequence of Operation and point to point wiring diagrams.

5. Dynamic system status graphic of the site-specific architecture showing status of system hardware, including quantity and address of networks, field panels, terminal equipment controllers, and printers.

6. The BAS contractor shall employ the use of accurate floor plans as part of the overall graphics package. The floor plans shall illustrate the location of room sensors and equipment. In addition, the floor plans shall utilize a thermographic scheme to instantly alert the end user of hot and cold areas. The thermograph shall illustrate and automatically intensify the red and blue gradient fills for each area, as to indicate the severity of the overheating or overcooling problem.

7. Any graphical point that is “in hand” or overridden in the controller shall show up as the inverse of its normal color.

8. All graphics shall be loaded on the University’s Delta enteliWEB server prior to start-up and commissioning of new DDC systems. Each point/dynamic object on all graphics shall be verified during point-to-point checkout of the DDC controller. Graphic verification shall be documented.

E. System Configuration and Definition:

1. All temperature and equipment control strategies and energy management routines shall be definable and fully programmable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

a. Add/delete/modify stand-alone Building Controllers

b. Add/delete/modify stand-alone Advanced Application Controllers

c. Add/delete/modify operator workstations

d. Add/delete/modify Application Specific Controllers, if used

e. Add/delete/modify points of any type and all associated point parameters and tuning constants

f. Add/delete/modify alarm reporting definition for points

g. Add/delete/modify control loops

h. Add/delete/modify energy management applications

i. Add/delete/modify time and calendar-based programming

j. Add/delete/modify totalization for points

k. Add/delete/modify historical data trending for points

l. Add/delete/modify custom control processes

m. Add/delete/modify any and all graphic displays, symbols and cross-reference to point data

n. Add/delete/modify dial-up telecommunication definition

o. Add/delete/modify all operator passwords

p. Add/delete/modify alarm messages

3. Definition of operator device characteristics, any controller's individual points, applications and control sequences shall be performed using instructive prompting software.

a. All custom programming language must be line sequential, English text with a real time compiler. The operator shall be able to view all live data within the program with no exceptions. The use of secondary software or manual intervention shall not be required.

b. If programming must be done with the PC workstation off-line, the BAS contractor shall provide at least 2 operator workstations.

c. Inputs and outputs for any process shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

d. Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate controller. Similarly, changes made at any Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

e. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed. The help menus shall be readily accessible by selecting an icon or by pressing a function button on the keyboard.

2.07 FIELD DEVICES

A. Temperature Sensors: Each temperature sensor shall match the requirements of the associated temperature controller and shall be based upon 10-K Type-3 thermistors. Each sensor shall be designed for the appropriate application (i.e., duct, immersion, etc.) and be provided with all necessary installation accessories. Ranges shall be selected to the middle of the control range. Temperature sensors must have a minimum accuracy of +/- 0.5 deg F or .5 % of scale; whichever will provide the least error in measurement.

1. Electronic: A modulating solid state sensor with built-in detector, with continuous voltage or current output. Each sensor shall have individual setpoint adjustment. Input voltage shall be 24 VAC or less. Sensors shall be of matching type to the input detectors and output drives or sequencers.

2. Thermostat guards shall be provided where specified, indicated on control diagrams, or indicated on floor plans. Guards shall be firmly attached to wall and thermostat cover shall be visible through the guard. All room sensors in public areas will have concealed setpoint adjustments.

3. All room sensors in classroom, office, or common spaces will have exposed set point adjustments locked to provide adjustment between 68 degrees and 72 degrees only.

4. Install thermostats and sensors at 4'-6" AFF to bottom unless otherwise noted on Architectural Drawings. Coordinate installation with the work of other trades before any rough-ins are made. Thermostats shall have a built in button to allow the user to override occupancy schedules during non-business hours.

5. Duct Sensors: DDC duct sensors shall match the requirements of the associated controller incorporating an electrical signal to insure exact and proportional relationship between the measured variable and the transmitted signal. Static pressure sensors shall be mounted in temperature control panels with connecting sensor lines in hard copper. Where a device is used for sensing of Mixed Air Temperature or Preheat applications and the duct area is in excess of 24 square feet the instrument shall incorporate a capillary averaging element with a minimum length of 96 inches or a suitable array of duct sensors wired as a single input. Averaging sensors shall be used on any duct application where duct area exceeds 24 square feet.

6. Provide temperature sensors as required to meet the sequence of operation; in addition, provide temperature sensors in the following locations: return air, mixed air, coil ~~and~~ discharge air sections, and supply air temperature if not required by the sequence of operation.

7. Wireless sensors are NOT permitted unless it has been submitted in writing for pre-approval to the OSU Project Manager.

B. Humidity Sensors: The relative humidity transmitter monitors and transmits changes in humidity, accurate to +/- 2 % RH. Operating range shall be 0 to 99% RH.

C. Pressure Sensors: Duct static pressure analog sensors shall be high accuracy +/-1% of range suitable for the low pressures and selected for at least 50% over range Sensors shall have industry standard 4-20 mA output and zero end span adjustments. Sensors that are installed remote of the mechanical space shall have their location denoted on the as-built drawings.

D. Control Dampers (Multiple Blade Dampers): Automatic dampers furnished by the BAS Contractor shall be single blade or multiple blades as applicable. All dampers shall be sized to the application by the manufacturer using methods similar to control valve sizing. Dampers shall be installed by the HVAC Contractor under the supervision of the BAS Contractor. All dampers furnished by air handling unit manufacturers shall meet the requirements listed in this section. Manufacturer's catalog information shall be de-rated 50 percent for application to provide positioning of the dampers. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the HVAC Contractor. All damper frames shall be constructed of extruded aluminum hat channel with a 0.125" minimum wall thickness and shall have flanges for duct mounting. Damper blades shall not exceed 6 inches width. All blades shall be airfoil type construction and will be equal to Ruskin RCD 50 control dampers with blade and jamb seals. Blades shall be suitable for high velocity performance. All damper bearings shall be

made of molded synthetic. Bushings that turn in the bearings shall be oil impregnated sintered metal. Dampers hung with blades mounted vertically shall be provided with thrust bearings. Butyl rubber seals shall be installed along the top and bottom of the frame and neoprene along each blade edge. Independent, self-compensating, stainless steel end seals shall be installed to ensure minimum leakage between blade ends and damper frame. Seals shall provide a tight closing low leakage damper. Damper sections shall not exceed 48" in length or 16 sq. ft. Openings that require multiple damper sections shall be jack shafted together where appropriate. . All dampers in modulating applications shall have opposed blades unless otherwise specified by the A/E for air mixing applications. Dampers in two position services shall have parallel blades. Where sequence requires, submittals shall include damper sizes and leakage characteristics. Leakage shall not exceed 3 cfm/sq. ft. at 1" of static pressure and shall be AMCA licensed as a Class 1A damper.

1. Control dampers will be sized by the BAS Contractor to the inside of the duct or duct liner whichever is smaller. Sizing of dampers to duct size and the subsequent cutting back of insulation to make dampers fit is unacceptable.

2. Control dampers used for outside air or exhaust air applications will be installed a minimum of 6" away from wall penetrations to allow for external mounting of their respective damper motors. Jack shafting in these applications will only be allowed to prevent having to mount motors in the outside airstream. When internal damper motor mounting is required the sheet metal contractor shall provide access panels at each motor location to allow for ease of service.

E. Damper Operators: Operators shall be electronic, spring return, low voltage (24VAC), and shall be properly sized so as to stroke the damper smoothly and efficiently throughout its range. Actuator responses shall be linear in response to sensed load.

1. Electronic damper motors for terminal boxes will be provided by the temperature control contractor and shipped to the terminal box manufacturer for mounting. Mounting charges shall be the responsibility of the terminal box manufacturer.

2. Damper operators on outside air intake/exhaust shall be spring return closed.

3. VAV Terminal Boxes using internal or proprietary actuators are unacceptable.

4. Modulating electronic damper operators shall provide an analog position feedback signal to the system controller.

5. Damper operators that are 2-position (i.e. open/closed) shall be provided with safety limit switches interlocked to fan motor starters to prevent equipment damage from under/over pressurization and open/closed status contacts back to the DDC controller.

F. Automatic Control Valves: All valves sized greater than 2 ½" or steam applications shall be pneumatic. All valves shall be equipped with throttling plugs and removable composition discs and shall be manufactured by Siemens, Belimo, or Johnson Controls. All valves are to be sized by the Control Contractor and shall submit pressure drop calculations and guarantee sufficient size to meet the requirements of the equipment being served. Valve operators shall be of such design so as to provide adequate operating power for valve positioning. BLX positioners are prohibited.

1. Reheat valves controlled by AACs in VAV terminal applications shall utilize electronic actuation and shall fail normally closed (capacitor or spring driven failsafe). All reheat valves serving Laboratories and/or Vivarium's (animal) rooms shall be electronic actuation and include spring return, to fail normally closed. Reheat control shall be an analog output signal from the AAC.

2. Three-way Valves: Three-way valves are to be of the three port mixing arrangement, designed expressly for mixing of two inlets and providing a common outlet. The use of reverse piped diverting valves shall not be acceptable. The Temperature Control Contractor will assist the HVAC Contractor in providing guidance as to the correct method of piping of all three-way valves. It is the responsibility of the HVAC contactor to evaluate the contract drawings for proper verification.

3. Butterfly valves for air handling unit coil control are unacceptable. If high GPM requirements dictate the valve size to be greater than 6", then Temperature Control contractor shall provide two control valves for the application, and the HVAC Contractor shall install the two control valves, for parallel and/or sequenced operation. Chilled water valves shall fail in the closed position unless otherwise directed by the A/E.

4. For all fan systems with separate pre-heat and separate 2nd heating coil. The pre-heat coil shall fail normally open, shall include separate analog output AO point for control, and separate analog input AI point for low-limit pre-heat discharge control. The separate 2nd heating coil shall fail normally closed, shall include separate analog output AO point, and separate analog input AI point for low-limit heating control.

5. For all fan systems with a single hot water coil, the coil shall fail normally open (i.e. AHUs, Fan coils Unit ventilators, UHs, CUHs, etc.)

6. Pressure drop through modulating control valves shall not exceed 7 psi and should be matched to the coil pressure drop whenever possible. Control valves for 2-position applications shall be line sized.

7. All valves for steam applications shall fail normally closed on loss of power or compressed air pressure.

G Air Volume Measurement: Provide Ebtron or approved equal air flow measuring system including microprocessor panel and air flow measuring sensor struts as required to measure outside air intake flow as denoted on the Drawings.

1. DDC air flow measuring system shall have a velocity range from 350 to 6000 ft./min. with duct measurement accuracy (including repeatability, zero offset, and temperature compensation) of plus or minus 0.5 percent.

2. Pilot tube arrays and differential pressure arrays are not acceptable.

3. The air flow measurement stations shall include a digital LCD display that illustrates the actual CFM, not FPM or other variables.

H Smoke Detectors shall be furnished by the electrical contractor and installed by the HVAC contractor. The electrical contractor will provide the necessary interlock wiring for life safety functions.

I Air Static and Velocity Pressure Transmitter: The pressure transmitter shall be used for measuring duct static or velocity pressure in variable air volume fan systems. Location of down duct static sensors shall be provided in the as-built drawings.

J Low Limit Detection Thermostat: Low limit detection thermostats equal to Siemens 134-1511 shall be of the vapor tension capillary type having a sensing element a minimum of 20 feet in length. These thermostats shall be of the manual reset type. The elements shall be complete with necessary fittings to permit installation in the duct so as to sense the correct discharge temperatures. One low limit detection thermostat will be installed for every 24 square feet of protected area and arranged so as to stop their respective units and close the outside air dampers in the event discharge temperatures fall below 38 degrees F. The normally closed

contact shall be wired to the fan circuit and the normally open contact (close on alarm) shall be wired to a DDC input. One common circuit is suitable for multiple thermostats on a single AHU coil area.

K Electric Thermostats: Heavy-duty snap action type with key operators rated at 10 FLA at 120 RIAC contacts suitable for the intended service. Provide manual selector switches as required in the sequence of operation.

L Fan and Pump Proof: Proof points for air handling unit fans, exhaust fans and pumps will be accomplished through the use of current sensing relays at the motor control center or motor starters. Current sensing relays shall be split-core design, for installation over any single power lead. Current sensing relays shall include field adjustable set screw for amperage setpoint adjustment and shall include integral LED status light to locally indicate the 'on' and 'off' condition. Where possible, the LED status light shall be visible outside of VFDs, cabinets, enclosures and junction boxes to allow the operator to see the status of the unit. Combination relay and current status sensors shall not be use.

M Variable Frequency Drives: The Variable Frequency Drives (VFDs) shall be BACnet MS/TP compatible and interfaced with the FOD-BAS BACnet network. It is the responsibility of the BAS contractor to coordinate with the HVAC contractor to ensure that the proper drive is ordered with the appropriate native BACnet communications card (no gateways i.e. protocol router/converter are allowed). Additionally, the BAS contractor will ensure that VFDs are not directly connected to a major mechanical system controller (i.e. AHU, MAU). The use of combination relay/current transformer is prohibited. Relays shall be mounted exterior of the VFD so LED indicators can be seen without opening the VFD. VFDs shall be provided with a bypass starter.

Required hardwired I/O points for VFDs:

1. VFD Start/Stop
2. VFD Speed Command
3. VFD Speed Feedback

Approved Vendors: ABB, Yaskawa and Delta.

N. Electro-pneumatic (EP) transducers: EP transducers shall have the ability to be powered by 24 VAC or 24 VDC. EP transducer shall have field selectable inputs for 0-5 VDC, 0-10 VDC or 4-20 mA signals. The EP transducer shall have a field selectable output range of 0-20 or 3-15 PSI. The EP transducer shall have < 1% deviation from full scale for Repeatability, Linearity and Hysteresis. The EP transducer shall not consume air when in a steady state. "Poppet" valve style EP transducers are prohibited in occupied spaces, above the ceilings of occupied spaces, and wherever noise could be an issue. They are acceptable for mechanical room applications.

Approved devices: Kele UCP-722 series.

O. Non Delta, Siemens, or ALC controllers (i.e., those used on packaged Chillers, Boilers, and etc.) shall not be directly connected to a major mechanical system controller. A BACnet MS/TP router (i.e. Delta ~~DSM-RTR~~ eBMGR-2 or approved equal) should be used to connect them to the Building Automation network.

P. Carbon Dioxide (CO2) sensors: Shall use non-dispersive infrared (NDIR) technology. Units shall be self-calibrating. Measuring accuracy shall be < (+/-50 ppm + 2% of measured value). CO2 sensors used for Demand Control Ventilation shall be hard wired back to the AHU controller.

Q. Occupancy Sensors: Shall be ceiling mounted type. Sensor shall use both passive infrared and ultrasonic diffusion technologies to detect occupancy. Sensors shall provide an isolated relay for

BAS integration. Sensor unoccupied time delay shall be adjustable between 5- and 30-minutes utilizing DIP switches.

Approved Device: Legrand DT-300. Substitutions shall be reviewed and approved by FOD-BAS.

R. Magnetic Flow Meters: Flow meters used for leak detection on central plant provided heating hot water and chilled water systems shall match the flow meter used for energy consumption. Leak detection meter must meet DIV 33 standards. Other flow applications shall use an Onicon F-3500 Insertion magnetic flow meter or approved equal.

S. Fume Hood Monitors: Monitors shall be an Accutrol T-APM-10 or approved equal. Flow rate from monitor must be hardwired to the laboratory room controller using a 0-10v/4-20ma signal.

2.08 LABELING

A. Provide labels for all field devices including sensors, transducers, thermostats, and relays. Exception: Room temperature and/or humidity sensors shall not be labeled.

B. Labels shall be black laminated plastic with white letters and adhesive backing or screw fasteners. Labels shall be located adjacent to device and permanently affixed to device mounting surface. Labels for sensors in pipes may be secured using chain around the sensor well.

C. Labels shall include system virtual/pseudo point name as well as English language name of device being controlled or specific condition being sensed.

D. Identify all control wiring at each end with a wire tags or labels machine print (no hand written).

E. Identify and label all control transformers by indicating all devices they power.

F. All 120 VAC panel power sources shall have labels in panels for electrical panel and breaker number.

PART 3EXECUTION

3.01 SEQUENCE OF OPERATION

A. Sequences of Operation (SOO) shall utilize the appropriate sequence in ASHRAE Guideline 36-2021 where applicable.
   1. Economizer mode shall use the dry bulb method described in ASHRAE Guideline 36-2021. Economizer mode should disable above 65 degrees OAT and enable at 63 degrees OAT where applicable.
   2. Sequences should not lock off chilled or hot water pumps when a command failure is detected.

3.02 ON-SITE TESTING

A. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The installer shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Upon completion of the work, contact the third party commissioning agent that the system is ready for final tests and commissioning. If there is no commissioning agent, contact the OSU Project Manager, and Architect/Engineer to inform them that the system is ready for final tests and commissioning. Commissioning shall be performed on all systems in BOTH heating and cooling seasons.

B. At the time of final inspection, this Contractor shall be represented by a person with the proper authority, who shall demonstrate, as directed by the commissioning agent or the A/E, that his work fully complies with the purpose and intent of the Specifications and Drawings. Labor, services, instruments, and tools necessary for demonstrations and tests shall be provided by the Contractor.

C. The Contractor shall test and adjust each instrument specialty and equipment furnished by him, prior to final acceptance. The Contractor shall demonstrate, for approval by the A/E, subsystems operate as coordinated and properly functioning, integrated system including the graphics, alarms and trending.

D. The Contractor shall furnish labor to provide adjustments and incidentals necessary to obtain the desired and intended results.

E. The Contractor shall turn over a printed copy and electronic copy of the completed and debugged operating software to OSU Construction Manager at the conclusion of the one year warranty.

3.03 SERVICE AND GUARANTEE

A. General Requirements: Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after completion of successful commissioning. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work.

B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates (including all firmware updates), transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.

C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. University shall be advised in writing of the name of the designated service representative, and of any changes in personnel.

D. Systems Modifications: Provide any recommendations for system modification in writing to University. Do not make any system modifications, including operating parameters and control settings, without prior approval of the OSU Project Manager. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.

E. Software: Provide all software updates and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the OSU Project Manager, and shall be incorporated into the operations and maintenance manuals, and software documentation.

F. As-Builds: Submit 1 complete sets of drawings to the OSU Project Manager electronically following OSU's Project Closeout Standards and showing the kind of control equipment for each of the various systems and their functions, along with indications on the drawing of all original setpoints and calibration values, and setup parameters, and sequence of operation of the automation system together with a complete brochure describing the equipment and their functions and operation. Include all application software documentation (actual programs or their job-specific flow charts) with DDC system.

1. Manufacturer's Product Data:

    a. All equipment components

2. Shop Drawings:

   a. System wiring diagrams with sequence of operation for each system as specified.

   b. Submit manufacturer's product information on all hardware items along with descriptive literature for all software programs to show compliance with specifications.

   c. System configuration diagram showing all panel types and locations as well as communications network layout and workstations.

   d. Floor plan diagram showing VAV/CAV/Lab controller locations, network connection routing and location of power supply for the VAV/CAV/Lab controllers.

Where installation procedures, or any part thereof, are required to be in accord with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Associate prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

3.04 TRAINING

A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 7:00 a.m. to 3:30 p.m. weekdays as follows:

B. Provide 8 hours of training for FOD Building Automation Department personnel. Training shall include:

1. Explanation of drawings, operations and maintenance manuals

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

3. Software, peripherals and panel communication procedures.

4. DDC Controller and AAC operation/function

5. Operator control functions including graphic generation and field panel programming

6. Operation of portable operator's terminal

7. Explanation of adjustment, calibration and replacement procedures

C. Provide up to 32 hours of additional training at the request of the OSU Project Manager for a period of one year from final completion of the project.

D. Since the University may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the University requires such training, it will be contracted at a later date. Provide description of available local and factory customer training.

PART 4 APPENDICES

Appendix A.1:

The minimum hardware requirements for the Portable Operator Terminal (POT) are as follows:

Intel i7 or better processor 16 GB RAM

1 serial port or "USB to Serial Adapter (e.g. US232R-10-BULK powered by FTDI Chip)"

512 GB Solid State Hard Drive or larger

15.4" display with Nvidia GPU

2X USB 3.0 Ports

DVD/CD-RW ROM Drive

Windows 10 Professional or later operating system (A/E verify these requirements with OSU Project Manager)

Integrated keyboard and pointing device

2 battery packs, 110 VAC adapter/charger

Carrying Case

Three-year limited warranty

Proprietary Software Key(s)

Operating System restore software including any Proprietary Software

Appendix A.2

Steam Desuperheater Control:

Provide a modular controller with associated input/output modules and touch-screen display mounted in a panel located in an area not subjected to high temperature or relative humidity. (Modular controller shall be Delta EnteliBUS eBMGR-TCH, or equivalent by an approved equivalent manufacturer.) Desuperheater control valve shall be as described in Division 23 for medium pressure steam service and shall have electro-pneumatic positioner and Class V shutoff. Provide high temperature sensor and transmitter.

Sensor:

Sensor Type	1000 Ohm +/- 0.1% @ 32 F
Temperature Coefficient	0.00375 Ohm/Ohm/Degree C
Sensitivity	2.1 Ohm/F @ 32 F
Measurement Range	-58 F to 932 F
Probe Material	304 Stainless Steel
Wiring Terminations	Two-wire nickel coated stranded copper, 24 inch long 22 AWG fiberglass insulated
Warranty	3 years
Model Number	S241HC (Minco, or equivalent)

Transmitter:

Supply Voltage	8.5 – 35 VDC unregulated
Sensor Input	1000 Ohm platinum 0.00375 Ohm/Ohm/Degree C
Measurement Range	0 F to 800 F
Signal Output	4 – 20 mA

Maximum Output Impedance	775 Ohm +/- 0.1% @ 24 VDC min
Accuracy	Calibration accuracy +/- 0.05% of span
Operating Temperature	-58 F to 160 F
Well Operating Pressure	3000 PSIG max
Well Material	304 Stainless Steel
Warranty	3 years
Model Number	TT111H-0800 (Minco, or equivalent)

Provide the following inputs and outputs:

Desuperheater Control Valve	Analog Output
Desuperheater Pump 1 Status	Binary Input
Desuperheater Pump 2 Status	Binary Input
Desuperheated Steam Temperature	Analog Input

Desuperheater control valve shall modulate to maintain steam temperature at 15 F above saturation temperature. Provide alarm for high temperature and pump failure.

Desuperheater pump package will be controlled by its own microprocessor controller.

END OF FOD APPENDIX A-FOD