INSTRUCTIONS TO PROFESSIONAL:

1. Parts 1, 2A, 2B and 3 of this PSU BAS Guide specification must only be altered by notation (i.e. deleted text with ~~strikethrough~~ and additional text with underline). To turn Track Changes ON using Word2010: "Review" Ribbon Tab, select Track Changes /Track Changes. To set Options, select Track Changes /Track Changes Options. Set options as: Inserted Text=Underline, Deleted Text=Strikethrough, Changed Format=Bold, Changed Lines=Outside border. Set all Color=By author. Word2013 is similar.

2. NOTE FOR CONSULTANT and Project Note (project-specific) and highlighted Text, are intended to make it easier for the Design Professional to Edit this BAS Guide Spec to be Project-specific. If you have Feedback, please send an Email to Tom Ertsgaard, tse3@psu.edu.
3. Begin the Construction Specification Document that uses this Guide Specification with the INDEX.

4. The Consultant should include Figure 1, Figure 2 and Figure 3 at the end of this Specification, as applicable. These figures indicate the BAS architecture, including connecting to the existing campus BACnet BAS at PSU University Park and 3rd party digital interfaces (i.e. Chillers, RTU's, VFD's, Lighting Control, or Electrical Monitoring).

5. Leave the following Note ("For Construction Document Review, Design Submittal") as part of the Review Submittal, to aid any Reviewer to understand WHY there are strikeouts and underlines. Also, leave any "REVIEWER NOTE" placed in this Guide Spec, for the Mark-up version provided for PSU Review.

6. Provide the 25 55 00 Specification section to the PSU Physical Plant BAS Group at final design review in electronic format (attached to an email, OR via CD).

7. AFTER comments are received from PSU and incorporated, the strikeouts and underlines should be removed, and the REVIEWER NOTEs deleted, before the spec is issued for Bidding. Also, page-breaks will need attention in the final version. Formatting may also need attention.

8. Before PRINTING this BAS Guide Specification, check that "Hidden Text" will NOT be printed. In Word2010: At File/ Options/ Display, Hidden-Text needs to remain UNCHECKED. Word 2013 is the same.

9. Provide the 25 55 00 Specification section as it went out for Bidding-purposes, in electronic form (attached to an email, OR via CD) for PSU Physical Plant BAS Group Reference.

10. Provide all submittals for PSU Physical Plant BAS Group review to:
    Bob Mulhollem, Manager of Facility Automation Services (FAS), REM26@psu.edu, 814-863-7220.

CO-ORDINATION NOTE to the Professional:

PART 4 (Sequences of Operation) includes BAS Sequences and Requirements that MUST be CO-ORDINATED with other parts of the MECHANICAL specifications, as well as the ELECTRICAL Specifications. The Designer responsible for BAS needs to be sure to co-ordinate with the Designer responsible for LIGHTING, ELECTRICAL SERVICE, EMERGENCY SYSTEMS and OEM or 3rd party digital interfaces.

WHAT's been done since JUN2014 Web-release:

Highlighted CHANGES with THIS Revision (OCT2015):

1. Typos & minor edits.
2. Miscellaneous clarifications.
3. Environmental Systems changed to Facility Automation Services
4. Revised BACnet ASHRAE Standard 135-2010 to 135-2012
5. 1.8 BAS Intent Meetings
   a) broke-out from "Submittals" section, to clarify. This requirement is not a 'Submittal', and is preliminary to the BAS Shop Drawings.
   b) EDITS made within this relocated section
6. 1.9 B. BAS Shop Drawings
   a) minor re-arranging and EDITS
   b) 4 paper copies no longer required; only e-file submissions
7. Part # changed for the 8-port Managed Ethernet-switch. Edits at 2A.1 A. 1.
8. Clarified where mini-switch needs installed for Technician-access. Edits at 2A.1 A. 2.
9. 2A.1 ADDED Ethernet home-runs
10. 2A.2 ADDED that all 3rd-party Devices must support ability to change the BACnet port
11. 2A.2 ADDED mention of process for outside-vendor Access to BAS-network
12. 2A.3 ADDED that a Device to act as BBMD is required in every Building
13. ADDED Valve Types in 2A.11
14. 2A.13 SETRA Low Airflow sensor replaced EBTRON Bleed Sensor
15. Part 3 – EXECUTION: portions ADDED mainly to emphasize the seriousness of Contractor's activities involving the BAS-network
16. ADDED Valve Application Tables in Part 3
17. COV for Fan air temperatures changed from 5 to 2 degrees. See EDIT at 3.13 B. 5.
18. 3.16 ADDED 7-day Trend Logs after corrections made
19. 3.17 TRAINING: ADDED "Vendor-specific" BAS Product Training
20. Part 4 ADDED: ELECTRICAL Requirements (or Reference to Div 26 Guide Specs)
21. Figure 3 Updated

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PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions of the Contract, General Conduct of the Work and Special Requirements, and Division 1 Specification Sections, apply to this Section.

1.2 OVERVIEW

A. This document contains the specification and input/output summaries for the Building Automation System (BAS) for the **## INSERT NAME OF PROJECT HERE (and check location)##** at University Park campus. The system architecture shall utilize intelligent distributed control modules, located at each site, which communicate over a local controller network. The BAS shall provide Direct Digital Control (DDC), monitored and adjusted by the University's Automated Logic WebCTRL, Delta Controls enteliWEB or Siemens Desigo software at University Park, all via Microsoft Internet-Explorer, the thin-client user interface. This BAS for the air conditioning, heating and ventilating systems shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.

B. Contractor Alert: Many aspects of the installation and implementation of this project require approval by the University's Physical Plant BAS Group before the BAS installation shall proceed.

1.3 RELATED SECTIONS

A. Specification sections where Others will install appurtenances to accommodate control devices provided by the CSC (i.e. thermowells for Temperature Sensors).

1. Section ## ## ## INSERT #s for this Project
2. Section ## ## ## INSERT #s for this Project

B. Specifications where Equipment is purchased by Others, that will have BAS controllers provided by CSC to be installed at the factory (factory-installed Controls, i.e. VAV boxes, etc.)

1. Section ## ## ## INSERT #s for this Project
2. Section ## ## ## INSERT #s for this Project

******NOTE FOR CONSULTANT: In the section below, reference EACH system by specification number that requires an Interface ("integration gateway module") to the BAS [possibly RTU(s), Chiller(s), VFD(s), Lighting Controls, and/or Electrical Monitoring]****The interface is to be supplied by the equipment OEM, not the CSC. The Consultant shall also include a specification in the applicable equipment section for the interface by the OEM.**

C. 3rd-Party Interfacing is required on this project according to the following Specification sections. Figure 1 thru Figure 3, included at the end of this specification shows the interdependence of the interface to the BAS, so Vendor understands how the communications-networking needs to function.

1. Section 23 xx xx – Roof Top Unit(s)

2. Section 23 xx xx – Chiller(s)
3. Section xx xx xx – Variable Frequency Drive(s)
4. Section 26 xx xx – Lighting Controls
5. Section 26 xx xx – Electrical Monitoring
6. Section xxxxx - OTHER

1.4 REFERENCES

A. ANSI/ASHRAE 135-2012: BACnet™ - A Data Communication Protocol for Building Automation Systems: This shall include the Standard and all published Addenda. Refer to www.bacnet.org for published Addenda.

1.5 DEFINITIONS

A. **Application Controller**, for this specification, must be an AAC (Advanced Application Controller). These would be used on Primary Equipment and Terminal Equipment. (Refer to para. 2A.4 of this specification. ASC's (Application Specific Controllers) are not acceptable products, except with specific approval on a per project basis from the OPP FAS group.

B. **BAS** refers to the Building Automation System. (In the past, this may have been referred to as CCS, Central Control System, EMS, Energy Management System, or ATC, Automatic Temperature Control.)

C. **Critical Space** refers to a space that is being backed-up by redundant utilities and/or redundant HVAC system(s) (i.e. Animal Rooms, Temperature-critical research, etc.).

D. **CSC** refers to the Control System Contractor. The CSC is the Contractor responsible for the implementation of this Section of the Specifications.

E. **Enhanced Zone Sensor** refers to a Room Sensor with Set-point Adjustment and Occupancy Override.

F. Equipment Interface refers to a gateway as described below.

G. **Gateway** refers to the interface (hardware and/or software) to provide seamless integration by non-BAS equipment manufacturers. Refer to paragraph 2A.2 "BAS Interfacing with 3rd-Party Sub-systems".

H. **I/O** refers to Input/Output. Thus, "I/O device" means "Input/Output device".

I. **IP** refers to the Internet Protocol.

J. **Night Lighting** refers to non-emergency exterior lights mounted to the building.

K. **OEM** stands for Original Equipment Manufacturer, and refers to the manufacturer of the equipment being provided that includes a microprocessor based building sub-system [RTU(s), Chiller(s), VFD(s), Lighting Controls, and/or Electrical Monitoring] for this Project.

L. **Object Table**(s) refer(s) to the detailed listing(s) of BACnet objects and the functional requirements using the various operator interfaces for the system. In the past, this/these may have been referred to as "Points List(s)" and "I/O Summary".

M. **On-line** refers to accessibility via the thin-client user interface.

N. **OSPF** refers to Open Shortest Path First, which is a routing protocol for Internet Protocol (IP) networks.

O. **Primary Equipment** refers to Heating, Cooling and/or Air Moving SOURCE equipment. This includes HW System (pumps, HX, valves, sensors, etc.), CHW System (pumps, Chiller, Tower, valves, sensors, etc.), ACFs, RTUs, HRUs, etc. This does NOT include Terminal Equipment (see separate definition).

P. **Terminal Equipment** refers to Heating, Cooling and/or Air Moving equipment connected to Primary Equipment and directly serving a Conditioned Zone in the Building. This includes FCUs, CUHs, VAVs, FTR, etc. This definition is separate from Primary Equipment (see separate definition).

Q. **Thin-client User Interface** refers to the software program Microsoft Internet Explorer.

R. **TNS** refers to Penn State's Telecommunications and Networking Services at The Pennsylvania State University.

S. **OWS** refers to an Operator Work Station, also seen as Operator Workstation.

T. "**University's Physical Plant BAS Group**" refers to University employees designated by the Office of Physical Plant (OPP) Energy & Engineering Division, and Facility Automation Services (FAS).

1.6 MANUFACTURERS

******NOTE FOR CONSULTANT: The Design Professional shall determine, in consultation with PSU, whether this project will be competitively bid or be a proprietary project to blend with an existing system. The Professional shall then edit this following paragraph and Paragraph 1.10 accordingly. When using the PSU BAS GUIDE SPEC for Projects at non-University Park campuses, it WILL need edited for Vendor names as they may differ from the list below. Pay attention to the installer name, as this WILL also change from UP to non-UP projects. Please contact the PSU BAS Group if there is any Question concerning which vendors or installers to list for any project.******

A. Automated Logic Corporation (ALC), as installed by ALC Pennsylvania branch offices, located in Pittsburgh, Harrisburg or State College.

B. Delta Controls (Delta), as installed by Conexus, Inc. located in Lebanon, PA. At their discretion, Conexus may partner with Building Control Integrators (BCI) from Columbus, OH.

C. Siemens Building Technologies (Apogee hardware and Desigo Software only), as installed by Siemens Harrisburg branch office.

D. No other Manufacturers or installers are allowed.

1.7 SCOPE OF WORK

A. This specification is using the OCT2015 version of the PSU BAS Guide Specification. Some of the revisions since the JUN2014 version will affect the Scope of Work. The CSC must carefully review this entire Specification Section 25 55 00 for changes.

B. Control System Contractor's (CSC) Responsibilities:

1. The CSC shall furnish and install all necessary hardware, wiring, pneumatic tubing, computing equipment and software required to provide a complete and functional system

necessary to perform the design intent given in the sequences of operation, and as defined in this specification.

2. The CSC is fully responsible for coordinating the work required of the OEM when there is a 3rd-party sub-system provided in the project.
3. All costs associated with the work of this Section shall be included in the CSC's contract.
4. The CSC shall coordinate the CSC's work with other trades.

C. System Requirements

1. All material and equipment used shall be standard components, regularly manufactured, available, and not custom designed especially for this project. All systems and components, except site specific software, shall have previously been thoroughly tested and proven in actual use prior to installation on this project.
2. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
3. Controllers used for primary and terminal equipment (all equipment) shall be fully programmable. Application Specific Controllers are not acceptable.
4. All functions required of a controller, either by this specification or in the sequence of control provided for the project, must be performed entirely within that controller.
5. The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

D. Equipment

1. System Hardware
   a. The CSC shall provide the following:
      1) Operator workstation(s), when necessary.
      2) All control modules.
      3) All relays, switches, sensing devices, indicating devices, and transducers required to perform the functions listed in Object Table(s).
      4) All monitoring and control wiring and air tubing.

****** PROJECT NOTE, for the Consultant ******
Include the following item, if applicable. This may not be a project requirement on "small" projects. Please contact the BAS Group if there is any Question.

REVIEWER NOTE
Verify that Section 2A.2 and the Equipment Spec Sections also have clear language that matches.

      5) The CSC shall connect to (physical wiring and/or via programming) the integration gateway module(s) and software provided by the OEM, to interface with the following third party equipment: **[possibly RTU(s), Chiller(s), VFD(s), Lighting Controls, and/or Electrical Monitoring]**
         (a) Equipment type-1
         (b) Equipment type-2
         (c) Equipment type-3

2. System Software and Firmware

   a. The CSC shall provide all software identified in this specification. The database required for implementation of these specifications shall be provided by the CSC, including point descriptor, alarm limits, calibration variables, on-line graphics, reports and point summaries. The CSC shall provide and create the system using the latest software release at the time of Shop Drawing approval.

   b. All programming tools shall be provided as part of the system. CSC shall provide any system upgrades released during the warranty period free of charge to the University.

   c. The CSC shall provide and install the latest firmware upgrades for all hardware devices as of the date of substantial completion for the project

   d. Software-license(s): All required software licenses for this project shall be provided. See Specification Section Part 2B for additional information.

E. Object Table(s)

1. The system as specified shall monitor, control, and calculate all of the points/objects and perform all the functions as listed in sequences of operation and as shown in control diagrams in this specification.

2. All objects, including Application Controller level objects, shall be exposed as BACnet Objects.

F. Codes and Regulations

1. All electrical equipment and material and its installation (including programming) shall conform to the current requirements of the following authorities:

   a. Occupational Safety and Health Act (OSHA)
   b. National Electric Code (NEC), 2008
   c. International Fire Code, 2009
   d. International Mechanical Code, 2009
   e. International Energy Conservation Code, 2009
   f. International Fuel Gas Code, 2009
   g. International Building Code, 2009
   h. International Existing Building Code, 2009
   i. International Plumbing Code, 2009

2. All distributed, application controllers supplied shall be in compliance with the following listings and standards:

   a. UL916 for Open Energy Management

   b. CE Electro Magnetic Compatibility

   c. BACnet Testing Lab (BTL) listed.

3. The control system manufacturer shall have quality control procedures for design and manufacture of environmental control systems for precise control and comfort, indoor air quality, HVAC plant operation, energy savings and preventative maintenance.

4. Where two or more codes conflict, the most restrictive shall apply. Nothing in this specification or related documentation shall be construed to permit work not conforming to applicable codes.

G. Building Ethernet Connection Cabling: The building Ethernet shall be provided by the University (cooperation between Physical Plant and TNS), at the Building Telecommunications closet(s), and a Network Switch is provided and installed by Physical Plant personnel at this location. The campus fiber shall be terminated at the network switch in the Telecommunications closet by University personnel. The CSC shall provide CAT-5e or CAT-6 cabling between Global Building Controller(s)/Router(s) and the Building Telecommunications Closet(s). The CSC shall provide repeaters between Global Building Controllers /Routers and the network switch as required. Final CAT-5e or CAT-6 Connection terminations shall be by the CSC and shall be coordinated with the University's Physical Plant BAS Group.

H. Major Systems Cabling: The CSC shall provide CAT-5e or CAT-6 cabling between the Global Building Controller location and each location of an Air Handler, Heating System, and/or Chilled Water System Panel. All terminations shall be completed by the CSC.

I. The CSC shall provide all object mapping and programming and shall coordinate object naming conventions and network map requirements with the University's Physical Plant BAS Group. The naming convention shall be submitted with the BAS Shop Drawings for review and approval by the University's Physical Plant BAS Group.

J. The CSC shall provide dedicated power circuit(s) from a Normal/Emergency Standby-Optional power panel for all control panels handling network, building or primary equipment and for control panels serving emergency and/or critical equipment, locations or points.

K. The CSC shall provide a UPS for all Global Building Controller/Routers, repeaters and Application Controllers serving emergency and/or critical equipment, locations or points.

L. The CSC shall provide router and software to route BACnet messages over the existing Campus Ethernet infrastructure using BACnet standard Annex J routing (BACnet over IP). The existing Campus Ethernet infrastructure has multiple subnets and is capable of routing IP messages.

M. Refer to the Figure(s) at the end of this Section for a graphical indication of the Scope of Work, as it relates to the campus infrastructure and OEM equipment.

1.8 BAS Intent Meetings:

A. Purpose of BAS Intent Meetings: The GOAL of these Meetings is to be proactive about having the Controls Design, including the Programming Logic, to be consistent with the INTENT of the Systems (a "system" involves Equipment and Sequence of Operation). The Design Intent is best understood by the Design Engineer, and the PSU Engineering Services Engineer responsible for Reviewing and guiding the Project. Text language can often be interpreted in different ways. By having face-to-face discussions, mis-interpretations should be able to be avoided early in the Construction-process.

B. Format of Meetings:

1. There shall be at least two (2) Meetings, but not less than the number of Meetings that are required to adequately cover the BAS Intent. This will depend on the size of this Project.

a. The first BAS Intent Meeting shall be scheduled by the CSC and conducted by the Owner, and shall be held prior to the CSC starting the BAS Shop Drawings Submittal. PSU (Engineer and BAS Group) will review the Project-specific Sequences of Operation and provide Updates as appropriate. The CSC shall contact the PSU Project Manager with at least 10-days advance notice for scheduling this Meeting.

b. The second (and additional) BAS Intent Meeting(s) shall be scheduled and conducted by the CSC, during the course of Shop Drawings development and Programming, to verify that everything is "on-track" according to the BAS Intent (defined by Designer & Owner). The intent is to avoid any need for re-Programming by the CSC. The CSC shall schedule the Meeting(s) with at least 10-days advance notice.

C. Meeting Logistics:

1. The CSC shall be responsible for requesting and coordinating the meetings. The meetings shall be held at OPP Conference Room 148F or other suitable location with overhead projection capabilities. It is desirable to be able to mark up the overhead projection so that all attendees have an immediate record of decisions reached at the meeting.

D. Meeting Attendance:

1. Required attendance:

a. The Project's Mechanical Design Engineer (the person responsible for, and knowledgeable-about, the Sequences of Operation)

b. PSU Engineering Services Engineer(s)

c. PSU BAS Group representative

d. Applications Engineer for the CSC (Control System Contractor)

e. Programmer /Logic-developer for the CSC

2. Optional attendance:

a. the Project's CM (Construction Manager), or Mechanical Contractor, representative

b. Project Manager for the CSC

c. the Project's Cx-provider

d. PSU Cx Services representative

e. PSU Project Management representative

E. Meeting Materials (2nd and Subsequent Meetings):

1. The following materials shall be presented at the BAS intent meetings and shall include at a minimum:

a. Include a "watermark" on each Sheet, with "Preliminary"

b. Cover Sheet /Title Sheet with the Project Name, PSU Project Number and date of this meeting on the sheet. If the BAS Shop Drawings Submittal will be completed in multiple Parts, include a Legend that will

1) List all of the Parts of a Complete Submittal

2) Indicate <u>which</u> Part of the Complete Submittal the e-file represents

c. Index and Legend.

d. Communications Riser to date, and Device Addressing Scheme

e. System Schematic, 1 for each System

f. Sequence of Operation, 1 for each System

g. Valve and Damper Schedules (complete as possible; not necessarily Final)

h. Product Data Sheets: This shall include at least a LIST of the Controllers and Devices to be used. The "list" could be a "combined BOM", and then submit Product Data Sheets for just the new or not-common Devices. (The BAS Shop Drawings Submittal (for Approval) will still include Product Data Sheets for ALL the Materials on the Project, as these are important for future reference)

2. The CSC shall be prepared to show the logic (to date) representing the sequences of operation on the wall via overhead presentation. All participants will discuss the logic and agree or offer advice for the CSC's use in finalizing the logic.

1.9 SUBMITTALS

A. Submit under provisions of Division 1.

B. BAS Shop Drawings: The Building Number and PSU Project Reference Number shall be in the title block on each page of the Shop Drawings Submittal. All controls drawings shall be B-size (11" x 17" sheet), and shall be completed and provided using Visio, or AutoCAD.

1. If needed, contact the University's Physical Plant BAS Group for an example or template, or additional instructions.

2. Provide a Notification via email, to Bob Mulhollem, rem26@psu.edu, when the BAS Shop Drawings and/or associated spreadsheets are provided to the Project Contacts.

3. Device Addressing Scheme: Install controllers implementing an addressing scheme consistent with the Penn State Standard for Device Instance numbering. Contact FAS Representative, for a Blank-Form of the BAS DEVICE TABLE. The CSC shall complete the Form as much as possible, and return to FAS Group for Device Instance-numbers and IP addresses. The Device Instance addressing scheme shall be submitted, reviewed and approved by the University's Physical Plant BAS Group prior to implementation.

4. Ethernet Addressing: Complete a spreadsheet for Ethernet Addressing. Contact FAS Representative, for a Blank-Form of the BAS DEVICE TABLE. The CSC shall complete the Form as much as possible, and return to FAS Group for Device Instance-numbers and IP addresses. The Ethernet Addressing shall be submitted, reviewed and approved by the University's Physical Plant BAS Group prior to implementation.

5. Equipment Numbering: Acronyms used for equipment installed for this project shall follow the "Equipment Identifier Prefix Acronym" listing prepared by the University's Office of Physical Plant and available on the PSU Design Standards website. The numbering assigned to equipment installed for this project shall sequentially follow the numbering of existing equipment of the same type in the same building. The equipment numbering scheme shall be submitted, reviewed and approved by the University's Physical Plant BAS Group prior to implementation.

6. Shop Drawings shall include:

a. Cover Sheet /Title Sheet: Attached to the Front of all Submittal Sheets, this shall include a minimum of: PSU Project Name; Project Location; PSU Project Number, Building Number; CSC Contractor Name, Address, Phone Number(s); Project Engineer Name; Mechanical Contractor Name; Submission Date; Date and Name of the Project Construction Documents used to create the Submittal. When resubmitted at the end of the Project for Record Documentation, they shall be marked as "RECORD DRAWINGS" and the current Date shall be added.

b. Index: The first sheet of the Shop Drawings shall be an Index of all sheets in the set.

c. Legend: A description of symbols and acronyms used shall be provided at the beginning of the set of Shop Drawings.

d. Each unique controlled system or piece of equipment shall include the following items (described above):

   1) System Schematic (required for Design Intent Meeting)

   2) Sequence of Operation (required for Design Intent Meeting)

   3) Point-to-point Wiring Details

   4) Bill of Material

   5) Configuration Details

   6) On-line Graphic (sample)

e. Communications Riser Spreadsheet (required for Design Intent Meeting): A spreadsheet shall be submitted indicating the layout of the network including the order of the nodes and each node's current communication status. The spreadsheet shall include the following information: a network node number, equipment description, controller part number, network address and BACnet instance number.

   1) Alternatively, riser diagrams for renovations and/or expansions to an existing BAS shall be developed using the existing communications riser diagram available from the University's Physical Plant BAS Group.

   2) A single-page riser diagram depicting the system architecture shall include room locations and addressing for each controller, as well as the current communication status of each controller. Include a Bill of Material for all equipment in this diagram but not included with the unique controlled systems.

f. BAS Device Table: A complete table for each and every controller and device on the BAS-network, installed per this project, shall be included in the BAS Shop Drawings Submittal. Request a Template for this BAS Device Table from the FAS representative. See 1.9 B. 3. & 4. ABOVE. BAS Device Table shall include the following:

   1) The University Campus location where the equipment and controller will be installed

   2) The official University building inventory number where the equipment and controller will be installed

   3) The building name where the equipment and controller will be installed

   4) The BACnet device instance of the controller.

5) The BACnet network instance that the controller shall reside on.
6) The UDP port that is being utilized by any device on the BACnet/IP network
7) The manufacturer's name of the controller
8) The manufacturer's model number of the controller
9) The manufacturer's model number of the controller
10) The network media type that the controller resides on

g. Systems Summary Spreadsheet: The Shop Drawings and Record Drawings shall include a table listing each piece of equipment, the area(s) served by each piece of equipment, and the air flow values for each piece of equipment. Minimum and maximum values for both heating and cooling shall be listed, when applicable.

h. Object Table: The Object Table shall be submitted at the end of the construction period but before PSU is requested to witness the Acceptance Test and again with the RECORD DRAWINGS. The Object Table shall include all I/O points, all Alarm points and all Trend points. This information may be combined with the System Summary Spreadsheet required above. Information on each point shall include the following:

1) Point type
2) Point description
3) Point name
4) Object instance number
5) Alarm limits, if applicable
6) Whether or not a Trend is Enabled on point
7) What Trend is triggered on, if applicable
8) Whether or not Trend historian (archive) is enabled on point
9) Event Category and Event Template assigned to point
10) Event parameters
11) Failure modes for control functions to be performed in case of failure

i. Valve Schedule: The Valve Schedule(s) shall be submitted using the Template provided by PSU, and shall be reviewed and approved by the Professional prior to installation of any Valve. The document "Valve Schedule_Template.xls" is available on the PSU Design Standards website.

j. Damper Schedule: The Damper Schedule(s) shall be reviewed and approved by the Professional prior to installation of any Damper.

k. UPS locations (as applies, only on Projects with emergency and /or critical equipment, locations or points identified in the Construction Documents for the Project).

l. Floor Plans: Drawings shall include the proposed location of all field devices and the routing of the communications cabling.

m. System Schematic: Drawings shall include a single-line representation of the equipment being controlled, including all field devices required for properly controlling equipment and implementing the sequences of operation for this project. As an example, a chilled water system may require a schematic to show the relationship of the condenser system to the chilled system, especially if some components wouldn't make sense if shown only on one system or the other.

n. Sequence of Operation: Drawings shall include Sequences of Operation for each piece of equipment with a unique configuration. The sequences shall be written in English text in such a way as to clearly convey how the design sequence of operation has been implemented by the controls design included in this Submittal. The design sequence of operation is that which is provided in the specification for this project as provided by the Professional. A simple duplication of the design sequence of operation provided in the specification for this project is not acceptable. The Sequences of Operation shall follow the outline below for a pattern of form and content. Each device that is referred to shall have the Device Tag identified in parentheses.

1) Title (appropriate to the Equipment included)

2) General (include set points, schedule, etc.)

3) Modes of operation

a) Unoccupied

(1) Heating

(2) Cooling

b) Occupied

(1) Heating

(2) Cooling

4) Interlocks (i.e. Fume hoods, exhaust fans, etc.)

5) Safeties (i.e. Freeze protection, smoke detector, etc.)

o. Point-to-point Wiring Details: Drawings shall include point-to-point wiring details and must show all field devices, start-stop arrangement for each piece of equipment, equipment interlocks, controllers, panel devices, wiring terminal numbers and any special information (i.e. shielding requirements) for properly controlling equipment and implementing the required sequences of operation.

p. Bill of Material: Drawings shall include a bill of the material necessary and used for properly controlling equipment and implementing the required sequences of operation. RECORD DRAWINGS shall include the Valves and Dampers installed.

q. Configuration Details: Drawings shall include programming and parameter setup information necessary for each controller used to properly control equipment and implement the required sequence of operation.

7. The Product Data Sheets for all BAS Materials on the Project will be submitted at the same time as the above mentioned BAS Shop Drawings in a separate binder. These are to include the manufacturers' standard published data with the specific project items well noted on the submission, as these are important for future reference.

8. BAS shop drawings and product data sheets shall be submitted to and approved by the Professional and the University's Physical Plant BAS Group before any aspect of the BAS installation shall proceed. Therefore, shop drawings must be submitted in time for the Professional and the University's Physical Plant BAS Group review so that all installations can be completed per the project's completion schedule. A minimum of Ten (10) working days shall be allowed for the Professional and the University's Physical Plant BAS Group to review submittals.

9. Two (2) sets of marked up shop drawings or "record drawings to date" shall be submitted to the Cx Agent and University for use during the acceptance test. These sets do not require final approval prior to acceptance testing.

10. Record Drawings shall be created after the final system checkout, by modifying and adding to the Shop Drawings. Record Drawings shall show exact installation. Record Drawings will be acknowledged in writing by the Professional and the University's Physical Plant BAS Group after the final checkout of the system. The system will not be considered complete until the Record Drawings have received their final approval. The CSC shall deliver four sets of Record Drawings to the University's Project Manager and an electronic set to the University's Physical Plant BAS Group.

C. Air Flow Monitoring Station (AFMS) Product Data Sheets
   1. Submit product data sheets and technical Installation, Operation and Maintenance Manual for thermal dispersion airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.

D. As soon as Submittals are prepared, an electronic version shall be provided simultaneously with the mailing of the paper copies to the Project Contractor-chain.. The electronic version shall be transmitted via e-mail, to expedite the approval process. Provide Submittal in electronic format to: Bob Mulhollem, Manager of Facility Automation Services, REM26@psu.edu, 814-863-7220.

E. Construction Schedule of CSC's milestones:

   1. The CSC shall submit to the University's Project Management a detailed schedule, identifying expected dates for the following activities. The schedule shall be coordinated with all other Contractors and shall be submitted within 90 days after the notice to proceed. The schedule shall include, but shall not be limited to, the following milestones:

      a. submit BAS Shop Drawings Submittal, and associated hardware and software documentation, for review and approval by the Design Engineer and the University's Physical Plant BAS Group;
      b. submit copy of construction mark-up set for review and use in commissioning;
      c. notify the University's Project Management and Physical Plant BAS Group, in writing, of system completion and preparations for acceptance testing;
      d. submit approved Record drawings, and complete revisions to the initial set of online graphics;

F. Operating and Maintenance Manuals

   1. Operating and Maintenance (O&M) manuals for the system shall include the following categories: Workstation User's Manual and Project Engineering

Handbook. Project specific manuals shall include detailed information describing the specific installation.

a. Workstation User's Manual shall contain as a minimum:

(1) System overview.
(2) Networking architecture.
(3) The object tables.
(4) A detailed sequence of operation describing exactly how the Consultant's sequences of operation were implemented.
(5) A print out of the complete logical programming.
(6) Established setpoints and schedules.
(7) Summary of trend objects.
(8) User manuals for the 'third party' software

b. Project Engineering Manual shall contain as a minimum:

(1) System architecture overview
(2) Product Data Sheets, for BAS and HVAC control items.
(3) Wiring diagrams for all controllers and field hardware
(4) Installation, mounting and connection details for all field hardware and accessories
(5) Commissioning and setup parameters for all field hardware
(6) Maintenance procedures, including final tuning and calibration parameters.
(7) Spare parts list.

G. Provide complete description and documentation of any proprietary services, equipment and/or objects.

1. Provide a complete description of the proprietary service, equipment or object, including it's function and how information is to be relayed from the service, equipment or object to the Building Automation System.

2. This information shall be submitted with the BAS Shop drawings to be reviewed and approved in the same manner.

1.10 COORDINATION WITH OTHER CONTRACTORS

****** PROJECT NOTE, for the Consultant ******
Paragraph "A" below is required if the Project is NOT New Construction. If there is no existing building, this does not need to be included. Please contact the BAS Group if there is any Question.
Coordinate with Part 3 WIRING DEMOLITION

A. When the Project involves removal and/or demolition of existing BAS Panel(s) and/or BAS cables (wire or fiber):

1. Contact the PSU Project Manager and OPP BAS Group to coordinate the disconnection of the equipment from the active CCS network, and
2. All wiring and tubing abandoned by the work of the CSC, during the course of completing this Project, shall be removed in total.
3. All Controllers, Panels and Devices abandoned by the work of the CSC, during the course of completing this Project, shall be removed in total. The PSU OPP BAS Group shall determine whether these devices shall be retained by PSU or

disposed of by the CSC. Contact: Gary Persing, FAS CCS Supervisor, GLP11@psu.edu, 814-863-8149. Also see Paragraph 3.4

4. Contact the Project Manager and the Area Services Supervisor to coordinate the placement of removed equipment into an inventory of Spare Parts.

B. The CSC shall review the installation of all controlled systems such as air handling equipment, duct work, piping, pumps, chillers, fans, and similar equipment for the purpose of providing the appropriate installing contractor correct information for wells, relays, panels, access panels, and similar appurtenances required for the control system. Such information shall include physical size, proper location and orientation, and accessibility requirements.

C. The CSC shall coordinate the installation of all control devices, and shall ensure that supporting work by others such as installation of thermometer wells, pressure taps, orifice plates and flanges, access panels, electronic transducers, and other items required are included. The CSC shall schedule and coordinate the work to ensure that the items are installed in the proper manner at the appropriate time.

****** PROJECT NOTE, for the Consultant ******
Design Professional needs to make sure the Mechanical Section 23 05 19 includes Pressure and Temperature test plugs (P/T ports) that are required adjacent to all electronic pressure and temperature BAS sensors in hydronic systems (for testing/calibration purposes).

D. The CSC shall coordinate the Pressure and Temperature test plugs (P/T ports) that are required adjacent to all electronic pressure and temperature BAS sensors in hydronic systems (for testing/calibration purposes). Pressure and Temperature test plugs are installed by others per Section 23 05 19.

****** PROJECT NOTE, for the Consultant ******
Design Professional, in consultation with PSU, needs to determine whether this project will be competitively bid or be a proprietary project to blend with an existing system in an Existing Building. The Professional shall then edit the following paragraph (1.10) and Paragraph 1.6 accordingly.

ALSO, the Design Professional must EDIT Paragraph 1.10 below, to Delete either A. or B. depending on the location of this Project.

1.11 CONTRACTOR (CSC) EXPERIENCE AND PERFORMANCE

A. University Park Projects

1. The University requires a BAS that is installed, programmed, commissioned, and serviced by an experienced CSC. To insure the University of proper BAS service and support, the CSC shall be only those as listed in Specification Section 1.6 above. None other are acceptable.

B. Non University Park Projects

1. The University requires a BAS that is installed, programmed, commissioned, and serviced by an experienced CSC. To insure the University of proper BAS service

and support, the CSC shall be the authorized distributor of the BAS manufacturer for the local area and if requested by the University shall supply proof thereof. In view of this, the CSC shall have installed a minimum of five BASs of the same type and size as the BAS herein specified and shall provide job names, a brief description of the scope of each BAS job, and a point of contact for each job. The actual, local CSC or BAS branch office, rather than the BAS manufacturer, will provide this information.

2. The CSC shall have a local office or representative within the state of Pennsylvania, staffed with factory trained engineers, fully capable of providing instruction, routine maintenance, and emergency maintenance service on all system components. The CSC shall be responsible for replacement of: the controllers with current job software, printer, PC(s), sensors, and devices at all times for a period of not less than 1 year following project completion, and shall guarantee replacement and software reprogramming of a system in need of repair, within a 24 hour period after notification from the University. In the case of an after-hours emergency, the CSC shall provide after-hours emergency services which will, upon notification of an emergency situation, result in CSC personnel being on-site within four hours if necessary.

3. The CSC must have an acceptable performance record with the University. The performance record of the CSC will be subject to an annual review by the University's Physical Plant BAS Group.

1.12 WARRANTY & SERVICE

A. Provide warranty under provisions of Division 1.

B. Provide all services, materials and equipment necessary for the successful operation of this system for a period of one year. In addition, provide two (2) semi-annual visits for testing and evaluating the performance of the networked equipment installed per this specification. One visit shall be during the cooling season and one visit shall be during the heating season. Provide a written report after each visit is complete. Coordinate service visits through the University's Physical Plant BAS Group. This service visit shall include, but not be limited to, the following:

1. Check calibration and re-calibrate if needed instrumentation sensors for air flow, liquid flow, pressure, humidity, temperature, and transducers. Written records shall be kept indicating the performance of such calibrations along with pertinent data.

2. Check the operation of dampers and damper actuators to assure no lock up has occurred and stroke is proper. Written records shall be kept indicating the performance of such calibrations along with pertinent data.

3. Check the overall system field operations by performing an all-points review (by hard copy or by documenting all-point inquiries). Verify that all monitoring and command points are valid and active.

4. Written records shall be kept indicating the performance of such exercises.

C. If a problem develops at any time during the warranty/service period, the CSC shall monitor and log the affected BAS point/object for the remainder of the warranty/service period. "A problem" in the above statement will refer to an incident in which any of the following occur:

1. An alarm occurs due to defective control system components or improper installation or programming.
2. Overall performance of the system is compromised due to defective control components or improper installation or programming.
3. Major recalibration (by greater than 5 times the catalogued accuracy) is required for a sensor during one of the service visits.

D. The CSC shall provide any system software and firmware upgrades released during the Building-turnover period, free of charge to the University.

---- End of PART 1 ----------

PART 2A PRODUCTS, HARDWARE

2A.1 NETWORKING/COMMUNICATIONS

A. The design of the hardware and software shall network existing operator workstations at the PSU Campus with new Global Building Controllers /Routers provided under this Section. The network shall be implemented via the Campus shared Ethernet system. The campus shared Ethernet backbone uses IP communication protocol.

****** PROJECT NOTE, for the Consultant ******
For this project, include the following item (begins with "Ethernet switch"). This may not be a project requirement on "small" projects. Please contact the BAS Group if there is any Question.

1. Ethernet Switch: For this project, the CSC shall provide an Ethernet switch in the same panel with the Global Building Controller /Router, to connect the Global Building Controller to the campus shared Ethernet backbone. This hardware shall be an 8-port 10/100 Mbps Ethernet-switch with DIN-rail mount; Contemporary Controls Model EISK8M-100T or Equivalent.

2. Technician-access: An Ethernet mini-switch (EISK8M-100T) is required where there is not reliable wireless-connectivity; including ALL Basement and Penthouse MER(s). A single RTU with BAS Control Panel mounted in a service-corridor is considered a MER for meeting the intent of this requirement.

B. Ethernet Home-runs: Each Ethernet-connection shall be a home-run back to the nearest (within 300 Meters) Telecom Closet. The location shall be included on the Riser Diagram in the Set of BAS Shop Drawings. The network design will NOT include daisy-chaining Ethernet-connections. Also see Part 3.4 B. for "Network cabling" installation details.

C. All network parameters must be assigned and approved by the University's Physical Plant BAS Group prior to implementation.

D. The system must be fully BACnet™ compliant at the time of installation. This means that the system must use BACnet™ as the native communication protocol between workstations or servers on the network.

E. The BACnet communication protocol is the required protocol for all tiers of the network.

2A.2 BAS INTERFACING WITH 3RD-PARTY SUB-SYSTEMS

A. General: The CSC shall be responsible for connecting all sub-systems to the BAS via native BACnet interface (provided by the equipment OEM), or if not native BACnet, a sub-system shall be integrated via a gateway that converts the proprietary protocol to the BACnet protocol. Sub-systems include RTU(s), VFD(s), Chiller(s), Lighting Controls and/or Electrical Monitoring provided as part of this project (refer to Figure 1 thru Figure 3 at the end of this specification section and related specification sections). These sub-systems shall be controlled, monitored and programmed through the Graphical User Interface (GUI) software of the BAS.

B. All devices must support the BACnet port (i.e. 47808. 47807, …) to be changed.

******NOTE FOR CONSULTANT: Coordination of these requirements by other contractors is required in any Section specifying OEM electrical/mechanical sub-systems with interoperability integrated into the BAS.******

C. Gateway: The gateway(s), required for the sub-system(s), shall be provided by the equipment OEM. The gateway(s) is(are) further specified below:

1. The gateway Submittal shall be provided by the OEM to the CSC to be included with the BAS Shop Drawings Submittal, for review and approval by the University's Physical Plant BAS Group.

2. All system information specified in the sequence of operation and related documents shall be available to the BAS. Read and write capability, as indicated by an object table provided by the OEM, shall be provided to the mechanical and electrical equipment indicated and be available to the BAS system. The OEM shall provide to the CSC, a table of gateway objects and their functionality, including normal operating limits (i.e. High and Low Oil Temperature Limits from a Chiller control panel). The equipment OEM will expose all available objects as BACnet objects for use by CSC.

3. OEMs shall bid a fully BACnet compliant device to facilitate interoperability between OEM electrical/mechanical sub-systems and the BACnet BAS or provide the necessary gateway to integrate into the web-based BACnet BAS using the BACnet protocol.

   a. The OEM shall provide any software or hardware required to access or modify any electrical/mechanical subsystems (i.e. RTUs, VFD, Chillers, Lighting Controls and/or Electrical Monitoring).
   b. Typical gateway requirements for projects include: A BACnet interface to the chiller manufacturer's product(s), a BACnet interface to the lighting controls manufacturer's product(s), a BACnet interface to the VFD manufacturer's product(s), a BACnet interface to the electrical monitoring manufacturer's product(s) (Square D or Cutler-Hammer), a BACnet interface to the lab equipment manufacturer's product(s).

D. A Modbus interface may be used only when a BACnet interface is not available from the equipment OEM. If the equipment manufacturer does not have this capability, they shall contact the authorized representative of the CSC for assistance and shall include in their equipment price any necessary hardware and/or software obtained from the CSC to comply with this section. Cost alone is not an acceptable reason for not providing a BACnet interface.

E. OEM Configuration Tools and Licenses: Configuration Tools, and all software licenses, required to configure all OEM controllers installed on this project, shall be provided.

F. When an outside-vendor requires access to the PSU BAS-network, permissions paperwork must be submitted to, and approved by, the OPP BAS Group. Contact: Tom Walker, FAS Network Supervisor, TEW17@psu.edu, 814-867-4753, to receive the Forms that need completed..

2A.3 GLOBAL BUILDING CONTROLLER /ROUTER

A. Acceptable Products:

1. ALC: LGR Ethernet Router

2. Delta Controls: DSM, DSC and eBCON Ethernet Router

3. Siemens Apogee: PXC Ethernet Router

B. GENERAL - Global Building Controller /Router

1. The Global Building Controller /Router shall be a microprocessor based communications device. One of the functions of the Global Building Controller /Router is to provide a communications gateway between a controller network and an IP Ethernet network. The Global Building Controller /Router shall communicate via IP and be connected to the PSU campus Ethernet infrastructure. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification. Controller networks shall use the BACnet protocol.

2. For PSU's OSPF routed Network (new, beginning Q4 of 2015) each Building must have it's own sub-net and requires that at least one Device in the Building must be able to act as a BBMD. If not already existing, the CSC shall provide this BBMD capable Device.

3. The Global Building Controller /Router shall support a network of at least 90 controllers, but no more than 60 controllers may be placed on any network so that adequate future capacity is reserved for the University.

4. The Global Building Controller /Router shall provide a port which can be connected to Operator Workstations, portable computers, or modems.

5. Global Building Controller /Router shall provide full arbitration between multiple users, whether they are communicating through the same or different Global Building Controller /Routers.

6. The Global Building Controller /Router shall be responsible for routing global information from the various controller networks which may be installed throughout a building.

7. The Global Building Controller /Router shall not contain a mechanical hard-drive.

8. The CSC shall not use 100% of the manufacturers' published object count or resources of the Global Building Controller. At least 20% of the published rating shall be reserved for future use by PSU.

9. The Global Building Controller shall not be used as both a major or critical system controller and router. Each major or critical system shall have a dedicated controller(s) that are not also tasked to route system information for the network.

10. There shall be no routers placed on the arcnet or MS/TP networks except for the purpose of integration with third party interfaces to mechanical and electrical equipment.

C. Memory: Each Global Building Controller /Router shall have sufficient memory to support its own operating system and databases including:

1. Control processes

2. Energy Management Applications

3. Alarm Management
4. Historical/Trend Data for 100% of all physical I/O for all programs in any controller connected to the Global Building Controller, at a minimum of 500 samples per Trend. If trend data is collected and stored at the local controller level, the requirements for memory at the Global Building Controller may be reduced accordingly.
5. Maintenance Support Applications
6. Custom Processes
7. Operator I/O

D. Expandability: The system shall be modular in nature, and shall permit easy expansion through the addition of software applications, workstation hardware, application controllers, sensors, and actuators.

E. Integrated On-Line Diagnostics: Each Global Building Controller /Router shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The Global Building Controller /Router shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each Global Building Controller /Router, and shall not require the connection of an operator I/O device.

F. Surge and Transient Protection: Isolation shall be provided at all network terminations, as well as all field point terminations to suppress induced voltage. Isolation levels shall be sufficiently high as to allow all signal wiring to be run in the same conduit as high voltage wiring where acceptable by electrical code.

G. Powerfail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all Global Building Controllers /Routers to prevent the loss of database or operating system software. Non-Volatile memory shall be incorporated for all critical Global Building Controller /Router configuration data, and battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.

1. Upon restoration of normal power, the Global Building Controller /Router shall automatically resume full operation without manual intervention.
2. Should Global Building Controller /Router memory be lost for any reason, the user shall have the capability of reloading the Global Building Controller /Router via the Local Area Network (LAN).

H. Communications:

1. The controller network shall use BACnet™ as its native communication protocol. The communication between controllers shall be ARCNET or MS/TP at least 76.8 Kbps.
2. The Global Building Controller /Router shall utilize FLASH memory, battery backed RAM or firmware which shall allow for operating system updates to be performed remotely via TCP/IP or UDP/IP.

I. UPS: Uninterruptible Power Supply(s) is(are) required for the Global Building Controller(s), repeater(s) and/or Application Controllers (on primary or terminal equipment) that serve or monitor emergency and/or critical equipment, locations or points.

2A.4 APPLICATION CONTROLLERS

A. Acceptable Products:

1. ALC: ME-line, SE-Line, and ZN-Line Controllers.

2. Delta Controls: Ebcon, DSC, DAC, DVC and DZNT line of controllers.

3. Siemens Apogee: PXC and PXC Compact line of controllers. PTEC controllers are not acceptable.

B. GENERAL - Application Controllers

1. Application controllers must use BACnet™ as the native communication protocol between controllers.

2. Each Application Controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output, minimum 8 bit A to D conversion, and include voltage transient and lightning protection devices. Firmware revisions to the module must be able to be made from the local workstation, portable operator terminals or from remote locations over modems or LANs.

3. The Application Controllers for Primary Equipment shall be expandable to the specified I/O point requirements. Each controller shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. The controller, in conjunction with the expansion modules, shall act as one application controller.

4. Each Application Controllers shall be fully programmable and shall permit all point data, algorithms and application software within the controllers to be customized as required by this specification and the approved sequence of operation.

5. Each Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/write-able nonvolatile flash memory within the controller and will be able to upload/download to/from the Operator Workstation. Firmware revisions, application programs and program modifications to the controller shall be capable of being performed over the Wide Area Network (WAN).

6. Each Application Controller shall be configured on the workstation/server software as a BACnet™ device. All of the points shall be configured as BACnet objects. Each controller shall include self-test diagnostics which allow the controller to automatically relay to the Global Building Controller /Router any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.

7. Each Application Controller should be capable of performing event notification (alarming).

8. Each Application Controller should be capable of scheduling, either by using an on-board real-time clock or by receiving the time from the Global Building Controller. If time is received from the Global Building controller, the Application Controller must be able to retain the time during a break in communication so that the Application Controller can move from unoccupied to occupied mode appropriately until such time that communication with the Global Building Controller is restored.
9. Each Application Controller shall contain both software and firmware to perform full DDC PID control loops.
10. Each Application Controller shall contain a port for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.
11. If being installed outdoors, the Application Controllers shall be capable of being mounted directly in or on the equipment located outdoors. The Application Controllers shall be capable of proper operation in an ambient temperature environment of -20 degrees F to + 150 degrees F.
12. Input-Output Processing:
    a. Digital outputs shall be relays or triacs, 24VAC or VDC minimum. Each output shall be configurable as normally open or normally closed.
    b. Universal inputs shall be capable of, 0-20mA, dry contact, and 0-5VDC, 2-10VDC or 0-10VDC.
    c. Analog output shall be electronic, voltage mode 0-10VDC, 2-10VDC or current mode 4-20mA.
    d. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy indicator.
    e. Analog pneumatic outputs shall be 0-20psi. Each pneumatic output shall have a feedback transducer to be used in the system for any software programming needs. The feedback transducer shall measure the actual psi output value and not a calculated value. An LED shall indicate the state of each output.
    f. All programming sequences shall be stored in non-volatile memory. All programming tools shall be provided as part of the system. Provide documentation of all programming including configuration files.
13. Each Application Controller shall be able to support various types of zone temperature sensors, such as temperature sensor only, temperature sensor with built-in local override switch, with setpoint adjustment switch, temperature sensor with CO2 monitor or temperature sensor with occupancy switch.
14. Each Application Controller for VAV application shall have a built-in air flow transducer for accurate air flow measurement in order to provide the Pressure Independent VAV operation. If the transducer is not integral to the controller, the controller/transducer assembly shall be factory tested and approved for the intended use.

15. Each Application Controller for VAV applications shall have an integral direct coupled electronic actuator. If the actuator is not integral to the controller, the controller/actuator assembly shall be factory tested and approved for the intended use. The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque. The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly. The actuator shall not require any limit switches, and shall be electronically protected against overload. When reaching the damper or actuator end position, the actuator shall automatically stop. The gears shall be manually disengaged with a button on the assembly cover. The position of the actuator shall be indicated by a visual pointer. The assembly shall have an anti-rotational strap.

16. Each Application Controller shall have LED indication for visual status of communication and power.

17. Astronomical Time: Astronomic capability shall allow the system to calculate sunrise and sunset times based on geographical location, and incorporate Daylight Savings Time, for dusk-to-dawn control or dusk-to-time control. This is required in any Application Controller with I/O for the Exterior lighting circuit(s). The Application Controller may receive this value from the Global Building Controller and fail to a "safe" position (ie., lights fail on) upon a loss of communication from the Global Building Controller.

18. In the event of a loss of communication, the Application Controller shall control from its resident schedule and control program which maintains the assigned space temperature and airflow values, appropriate for the time of day and occupied/unoccupied status until communication is restored.

19. UPS: Uninterruptible Power Supply(s) is(are) required for any Application Controller (on primary or terminal equipment) that monitors or serves emergency and/or critical equipment, locations or points.

20. Primary Equipment shall be controlled using one Application Controller. A single controller with adequate Input/Output and resource capacity shall be used for a single piece of equipment as opposed to using two or more smaller controllers to house the programs for one piece of equipment. All exceptions must be pre-approved by OPP FAS on a per project basis.

21. Each Application Controller shall be used to control only one piece of Primary Equipment. Some Terminal Equipment may be controlled from the same application controller as Primary Equipment if it is associated and of a minor nature. The intent is to not lose multiple pieces of Primary Equipment if one application controller fails.

22. Each Application Controller for Primary Equipment shall contain the following as Spare I/O:

    a. Minimum of: (3) Spare Universal Inputs (or 2-DIs and 1-AI), (1) Spare AO, and (2) Spare DOs.
    b. In addition to the Minimum, the Application Controller shall have 10% Spare I/O, of each type; UI (or DI and AI), AO and DO.

24. Each Application Controller for Primary or Terminal Equipment shall have spare memory resources available for future programmatic changes or additions by the University.

****** PROJECT NOTE, for the Consultant ******
For this project, include the following item (begins with "For this project"). This will not be a project requirement on all projects. Please let the BAS Group representative know if there will be LAB CONTROLS on this Project. Please contact the Project Manager or the BAS Group if there is any Question.

2A.5 LAB CONTROLS

A. For this project, the CSC shall provide the following equipment for Lab Controls, including duct-mounted boxes and DDC controllers.

B. It is the intent that any type of air-control box or valve will be controlled by the Controllers manufactured, designed, installed and programmed by the CSC.

****** PROJECT NOTE, for the Consultant ******
For PROJECTS AT A COMMONWEALTH CAMPUS ONLY
The Consultant shall determine if an Operator Work Station and/or a Laptop (or Tablet PC) is to be required on this project. Projects at University Park will NOT include an Operator Work Station or laptop computer and the following paragraph shall be deleted. Most projects at Commonwealth Campuses WILL include an Operator Work Station or Laptop Computer. For any projects that DO require an Operator Work Station or Laptop Computer, the Consultant will include the following paragraph. Paragraph 1.7 shall also be edited accordingly. This may not be a project requirement on "small" projects. Please contact the BAS Group if there is any Question.

2A.6 LAPTOP (or Tablet) COMPUTER(S)

A. For this project, the CSC shall provide [one] [two] Laptop or Tablet Computer(s) to the University's ITS Group at the Commonwealth Campus prior to the start of the Acceptance Testing (reference subsection 3.11 - ACCEPTANCE OF COMPLETED BAS INSTALLATION).

B. Provide a new laptop computer with the control system software and database as part of the project. Computer, in original packaging, is to be delivered to the University's ITS Group at the Commonwealth Campus via the Project Contractor-chain and the University's Project Management in Commonwealth Services.

C. Provide an Allowance of $1500 per Laptop or Tablet PC, at time of Bidding.

D. At time of Purchase, contact PSU ITS group at the Commonwealth Campus for the minimum specifications of the Laptop to be provided. Cost over-runs or under-runs shall be handled via Change-Order via the Project Contractor-chain and the University's Project Management in Commonwealth Services.

2A.7 FIELD HARDWARE/INSTRUMENTATION

A. Input Devices - General Requirements

1. Temperature sensors shall be of the type and have accuracy ratings as indicated and/or required for the application and shall permit accuracy rating of within 1% of the temperature range of their intended use.

2. Sensors used for mixed air application shall be the averaging type and have an accuracy of ± 1 degrees F.
3. Outside air temperature sensors shall have a minimum range of -52 degrees F to 152 degrees F and an accuracy of within ± 1 degrees F in this temperature range.
4. Room temperature sensors shall have an accuracy, of ± 1.0 degrees F in the range of 32 degrees F to 96 degrees F.
5. Chilled water and condenser water sensors shall have an accuracy of ± 0.25 degrees F in their range of application.
6. Hot water temperature sensors shall have an accuracy of ± 0.75 degrees F over the range of their application.
7. Temperature-differential measurement shall use a matched set of sensors.

****** PROJECT NOTE, for the Consultant ******
For this project, EDIT the following paragraphs for Sensors, Thermostats, Valve and Damper Actuators and Control Valves. Contact the Project Manager or the BAS Group if there is any Question.

2A.8 SENSORS

A. AIR FLOW MEASUREMENT STATIONS (AFMS-x): See separate paragraph. These are considered more than just a “sensor”.

B. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

1. Thermistor temperature sensors as follows:

a. Accuracy: Plus or minus 0.5 deg F (0.3 deg C) at calibration point.

b. Wire: Twisted, shielded-pair cable.

c. Insertion Elements in Ducts: Single point, 18 inches (20 cm)long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (1 sq. m).

d. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required.

e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).

f. Room Sensors: With Set-point Adjustment and Occupancy Override (Enhanced Zone Sensor), except when placed in Public Spaces. Sensors that must be installed on exterior walls shall include insulating bases. Refer to Part 3 for Execution requirements.

g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.

h. Room Temperature Security Sensors: Stainless-steel cover plate with insulated back and security screws.

2. Resistance Temperature Detectors: Platinum.
   a. Accuracy: Plus or minus 0.2 percent at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Insertion Elements in Ducts: Single point, 18 inches (20 cm)long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (1 sq. m).
   d. Averaging Elements in Ducts: Minimum 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (1 sq. m); length as required. Total length: 5 ft (1.5m) per 10 ft^2 (1 m^2) of duct cross-section.
   e. Mixed Air Temperature (MAT) shall be an averaging-type sensor, minimum 20ft length. For a Coil more than 20 ft^2, provide 1 ft (3 m) of sensing element for each 1 ft^2 (1 m^2) of downstream face area of the mixing plenum.
   f. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
   g. Room Sensors: With Set-point Adjustment and Occupancy Override, except when placed in Public Spaces. Sensors that must be installed on exterior walls shall include insulating bases.
   h. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   i. Room Temperature Security Sensors: Stainless-steel cover plate with insulated back and security screws.
3. Humidity Sensors: Bulk polymer sensor element.
   a. Accuracy: 5 percent full range with linear output.
   b. Another standard span for room sensors below is 20 to 90 percent relative humidity with 2 percent accuracy.
   c. Room Sensors: With cover matching room thermostats, span of 25 to 90 percent relative humidity.
   d. Duct and Outside-Air Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
4. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0 to 0.25 inch wg (0 to 62 Pa).
   d. Duct Static-Pressure Range: 0 to 5 inches wg (0 to 1243 Pa).
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.

C. Equipment operation sensors as follows:

1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 inches wg (0 to 1243 Pa).
2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa).
3. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.

D. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to 0 to 20 psig (0 to 138 kPa).

E. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless-steel or bronze paddle. For chilled-water applications, provide vaporproof type.

F. Carbon-Monoxide Detectors: Single or multichannel, dual-level detectors, using solid-state sensors with 3-year minimum life, maximum 15-minute sensor replacement, suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C), calibrated for 50 and 100 ppm, with maximum 120-second response time to 100-ppm carbon monoxide.

G. Carbon-Dioxide Sensor and Transmitter: Single detectors, using solid-state infrared sensors, suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C), calibrated for 0 to 2 percent, with continuous or averaged reading, 4 to 20 mA output, and wall or duct mounted.

H. Ceiling-mounted Room Sensor: When application requires this, these sensors shall be 10k Type2 Thermistor with 0-5vdc signal, by Veris Industries, http://www.veris.com/docs/datasheets/tc_ts_d.pdf

I. Occupancy Sensor: These sensors shall have passive dual technology (PDT) and internal relay option. Provide Sensorswitch Model WV-PDT-16-R sensors with WV-BR ceiling mounting brackets. The power source is 24 VAC/VDC, and shall be provided by the BAS controller. This is a stocked-item at OPP Stores, and can be furnished by Laface & McGovern, Altoona Office; contact Dan Cowen, 814-944-6373.

2A.9 THERMOSTATS

A. Combination Thermostat and Fan Switches: Line-voltage thermostat with two-, three-, or four-position, push-button or lever-operated fan switch.

1. Label switches "FAN ON-OFF," "FAN HIGH-LOW-OFF," "FAN HIGH-MED-LOW-OFF." Provide unit for mounting on two-gang switch box.

B. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, integral manual on-off-auto selector switch.

1. Equip thermostats, which control electric heating loads directly, with off position on dial wired to break ungrounded conductors.
2. Dead Band: Maximum 2 deg F (1 deg C).

C. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature, with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.

2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit, adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches, with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

D. Room thermostat located on exterior walls: Shall include insulating base.

E. Electric Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet (6 m). For a Coil more than 20 ft^2, provide 1 ft (3 m) of sensing element for each 1 ft^2 (1 m^2) of coil area.

2A.10 VALVE AND DAMPER ACTUATORS

A. Electronic direct-coupled actuation shall be provided.

B. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The fastening clamp assembly shall be of a 'V' bolt design with associated 'V' shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a 'V' clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Single bolt or screw type fasteners are not acceptable.

C. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

D. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are acceptable for valves larger than 4”.

E. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation.

F. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA analog control input and provide a 2 to 10VDC or 4 to 20mA operating range.

G. Actuators capable of accepting a pulse width modulating or three-point floating control signal are acceptable for specific uses only and shall require review and approval by PSU BAS and Engineering. Typically, these uses would be fin tube radiation control valves or small re-heat control valves.

H. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 10VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC

power shall not require more than 10VA. Actuators operating on 230VAC shall not require more than 11VA.

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

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

K. Actuators shall be provided with a 3 foot cable and ½ inch conduit fitting.

L. Actuators shall be Underwriters Laboratories Standard 873 listed and Canadian Standards Association Class 4813 02 certified as meeting correct safety requirements and recognized industry standards.

M. Actuators shall be designed for a minimum of 100,000 full stroke cycles and 1,000,000 part cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of start-up, per Start-up Report or Cx documentation.

N. Actuators motors shall be brushless type.

O. Manufacturer shall be ISO9001 certified.

2A.11 CONTROL VALVES

******NOTE FOR CONSULTANT: The Design Professional shall determine, in consultation with PSU, which types of Valves will be used on this Project. The Professional shall then edit this Section and Part 3, Section 3.6 accordingly.**
Listings in the Tables of specific valve types and their features do not imply acceptability for a given application unless specifically stated. Also refer to other applicable PSU specification sections and standards for selection determination of either pressure independent or pressure dependent type of valves.****

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Where “approved equal” is used, this means full technical Submittal information must be reviewed and approved by PSU BAS and Engineering representatives.

C. Refer to tables below for acceptable valve selection options for specific applications. CSC shall follow Project specific details provided by the Design Professional.

All control valves, including but not limited to, those provided as part of other equipment systems specified in other specification sections shall also meet all the requirements of this specification section.

D. Globe Valves

1. NPS 2 (DN 50) and Smaller: Bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.

2. Globe Valves NPS 2-1/2 (DN 65) and Larger: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.

3. Hydronic system globe valves shall have the following characteristics:

a. Rating: Class 125 for service at 125 psig (862 kPa) and 250 deg F (121 deg C) operating conditions.

b. Internal Construction: Replaceable plugs and seats of stainless steel or brass.

1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.

2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

c. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate.

d. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.

E. High Performance Segmented V-Ball Control Valves:

1. Construction: Carbon steel body, hardened stainless steel V-notch ball and shaft, low friction bearings and a TFM 1700 ball seat. Seats and stem packing shall be field replaceable. Control valves shall be rated ANSI Class VI leakage rate, -20 F to 400 F temperature range and maximum 250 PSI allowable shutoff pressure.
2. Valves shall be applicable for HVAC temperature control with water, steam and percentage glycol water mixes. Segmented V-notch ball valves shall have 90 degree rotation, minimum 200:1 range-ability (turn-down), with equal percentage control characteristic.
3. Valve sizes and connections:
   a. Face to Face Dimension: ASME B16.10
   b. 1”, 1-1/2” & 2” shall be ANSI Class 150/300 multi-rated and have Universal End Connections for use with MPT or ANSI Class 150/300 wafer connections.
   c. 2-1/2” and greater shall have ANSI Class 150 or 300 flanges as required by application.
4. Select valve Cv for acceptable range of control authority with least pressure drop for each application.
5. Operators shall close valves against pump shutoff head.
6. Acceptable Manufacturers:
   a. Belimo, VB V Ball series
   b. DeZurik, VPB
   c. Fisher, Vee-Ball
   d. Flow-Tek, V-Control
   e. KTM, Single V Control Ball
   f. Valve Solutions, Series V

F. Pressure Independent Characterized Ball Control Valves:

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (PICCV) or approved equal.
2. The modulating control valves shall be pressure independent.
3. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic. The flow shall not vary more than +/- 5% due to system pressure fluctuations across the valve with a minimum of 5 PSID and maximum of 50 PSID across the valve.

4. Provide means for pressure differential measurement either across orifice or valve to be used for flow verification.
5. Forged or cast (for larger sizes) brass body nickel plated rated at no less than 400 PSI, chrome plated brass ball and stem, female NPT union ends, dual EPDM lubricated O-rings and TEFZEL characterizing disc.
6. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSI.
7. The control valve shall require no maintenance and shall not include replaceable cartridges.
8. All actuators shall be electronically programmed by use of a handheld programming device or external computer software. Programming using actuator mounted switches or multi-turn actuators are NOT acceptable. Actuators for two-position ½'-1" pressure independent control valves shall fail in place and have a mechanical device inserted between the valve and the actuator for the adjustment of flow.
9. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base.
10. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
11. The use of pressure independent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

G. Pressure Dependent Characterized Ball Control Valves (1/2" - 2"):

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (CCV) or approved equal.
2. The modulating control valves shall be pressure dependent.
3. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic.
4. Forged brass body, nickel plated rated at no less than 400 PSI and 250 F, stainless steel ball and stem, female NPT union ends, Teflon PTFE seats,and EDPM seat 0-rings, dual EPDM lubricated O-rings at stem and TEFZEL or stainless steel characterizing disc.
5. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSI and 50 PSI differential.
6. The control valve shall require no maintenance and shall not include replaceable cartridges.
7. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base.
8. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
9. The use of multiple pressure dependent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

H. Pressure Dependent Characterized Ball Control Valves (2-1/2" - 6"):

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (CCV) or approved equal.

2. The modulating control valves shall be pressure dependent.
3. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic.
4. Cast iron body, rated at no less than 175 PSI and 250 F, stainless steel ball and stem, female NPT union ends, Teflon PTFE seats,and EDPM seat 0-rings, dual EPDM lubricated O-rings at stem and stainless steel characterizing disc.
5. Combination of actuator and valve shall provide a minimum close-off pressure rating of 100 PSI and 50 PSI differential.
6. The control valve shall require no maintenance and shall not include replaceable cartridges.
7. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base.
8. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
9. The use of multiple pressure dependent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

I. Pressure Dependent High Temperature Characterized Ball Control Valves:

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (B2HT) or approved equal.
2. The modulating control valves (can be used as on/off per application schedule) shall be pressure dependent.
3. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic.
4. Forged brass body, rated at no less than 400 PSI and 260 F water and 250 F steam, stainless steel ball and stem, female NPT union ends, Teflon PTFE seats,and Vitron seat 0-rings, dual EPDM lubricated O-rings at stem and TEFZEL characterizing disc.
5. Maximum inlet steam pressure 15 PSI.
6. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSI.
7. The control valve shall require no maintenance and shall not include replaceable cartridges.
8. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base.
9. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
10. The use of multiple pressure dependent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

J. Electronic Pressure Independent Control Valves:

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (ePIV) or approved equal.
2. The modulating control valves shall be pressure independent.
3. The control valves shall accurately control the flow from 0 to 100% full rated flow with an equal percentage flow characteristic.

4. Valves shall be capable of maintaining constant flow regardless of system pressure fluctuations.
5. Brass body, nickel plated or cast iron for larger sizes, rated at no less than 250 PSI (sizes up to 2 inch, ANSI 125 Class B for larger sizes) and 250 F water, stainless steel ball and stem, Teflon PTFE seats,and dual EPDM lubricated O-rings at stem and TEFZEL (sizes up to 2 inch) and stainless steel (for larger sizes) characterizing disc.
6. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSI (sizes up to 2 inch) and 100 PSI (for larger sizes).
7. The control valve shall require no maintenance and shall not include replaceable cartridges.
8. The actuator shall be the same manufacturer as the valve.
9. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
10. The use of multiple pressure independent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

K. Pressure Dependent Butterfly Ball Control Valves:

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (HD) or approved equal.
2. The on/off control valves shall be pressure dependent.
3. Ductile iron body, ANSI 125 class rated at 250 F, stainless steel disc and shaft, EDPM seats and 0-rings,
4. Combination of actuator and valve shall provide a minimum close-off pressure rating of 200 PSI.
5. The control valve shall require no maintenance and shall not include replaceable cartridges.
6. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base.
7. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
8. The use of multiple pressure dependent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

L. Pressure Dependent High Performance Butterfly Ball Control Valves:

1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc. (150SHP) or approved equal.
2. The on/off control valves shall be pressure dependent.
3. Carbon steel full lug body, ANSI 150 class rated at 400 F, stainless steel disc and shaft, RTFE seats and TFE gland seal,
4. Combination of actuator and valve shall provide a minimum close-off pressure rating of 285 PSI.
5. The control valve shall require no maintenance and shall not include replaceable cartridges.

6. The actuator shall be the same manufacturer as the valve, integrally mounted to the valve at the factory via a single screw on a four-way DIN mounting-base.
7. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
8. The use of multiple pressure dependent valves piped in parallel to achieve the rated coil flow shall be permitted. Actuators shall be electronically programmed to permit sequencing the flow with a single control output point. The use of external devices to permit sequencing is NOT acceptable.

****** PROJECT NOTE, for the Consultant ******
For this project, include the following item as required. Be sure to Select, and appropriately EDIT the following, according to the requirements of PSU Engineering Services and PSU Design Standards. Contact the Project Manager if there are Questions during Design.

2A.12 COMBINATION AIR FLOW /TEMPERATURE MEASUREMENT STATION (AFMS):

A. Manufacturers:

1. EBTRON, Inc. Gold Series (basis of design)

B. General: For this project, the CSC shall provide thermal dispersion type, combination airflow and air temperature measurement devices where indicated on the drawings and/or control sequences. Each measuring device shall consist of multi-point sensor nodes in one or more probe assemblies with a maximum of sixteen sensor nodes per location, and a single remotely mounted 32-bit microprocessor-based transmitter for each measurement location. Airflow/Temperature measuring devices shall be UL Listed as an entire assembly. Devices in UL-labeled enclosures are not equivalent and are not acceptable without a UL Listing for Standard 873.

1. Design and installation shall use duct or plenum mounted devices to fullest extent possible.

2. Fan inlet sensors shall not be substituted for duct or plenum sensor probes.
   a. Exception: where conditions otherwise make duct/plenum installation impractical and justifications of exceptions are reviewed with University and manufacturer's authorized representative.
   b. Where fan inlet mounting is otherwise unavoidable, mounting styles shall be indicated on the plans as either "face mounting" or "throat mounting." Face mounting shall provide no mechanical fastening in the throat or on the surface of the inlet cone and shall be used on all performance-sensitive plenum-type or plug fans.

C. Sensor Assembly: Each sensing point shall independently determine the airflow rate and temperature at each node, which shall then be equally weighted in calculations by the transmitter prior to output as the cross-sectional average. No electronic components other than the sensor elements shall be located at the sensing node. Each ducted sensor probe shall have an integral, U.L. Listed, plenum rated cable. Cable jackets and conductor insulation shall be FEP, Teflon-FEP or Neoflon-FEP. Conductor insulation for

internal probe wiring shall be Kynar. Devices which average multiple non-linear variables are not acceptable. Pitot arrays are not acceptable. Devices using chip-in-glass, epoxy-coated or diode-case chip thermistors are not acceptable. Vortex-shedding devices are not acceptable.

1. Each independent airflow sensor shall have a sensor accuracy of +/-2% of Reading over the entire calibrated airflow range of 0 to 5,000 fpm (25.4 m/s for ducted or plenum mounted probes, or not less than 0 to 10,000 fpm (50.8 m/s) for fan inlet mounted sensors. All sensor nodes shall be wind tunnel calibrated to at least 16 air velocities against standards that are traceable to NIST.

2. Each independent temperature sensor shall have a calibrated accuracy of +/-0.14° F (0.08° C) over the entire operating temperature range of -20° F to 160° F (-28.9° C to 71° C).and be calibrated at 3 temperatures against standards that are traceable to NIST.
3. Devices whose accuracy is the combined and independent accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the calibrated range.

D. Transmitter: Each transmitter shall have a display capable of simultaneously displaying both airflow and temperature. Airflow rate shall be field configurable to be displayed as velocity or volumetric rates, selectable as IP or SI units. Each transmitter shall operate on 24 VAC and be fused and protected from over voltage, over current and power surges. All integrated circuitry shall be temperature rated as ‘industrial-grade’.

1. Each transmitter shall be capable of transmitting individual velocity and temperature measurements for every sensing point in an array for a single location. The traverse data from each independent sensor shall be available as part of the network data packet transmitted via the BACnet protocol.

2. Each transmitter shall be capable of communicating with other devices using at a minimum the following interface option:
   a. Combined linear airflow and temperature analog output signals and one RS-485 network interface. This shall include: Two field selectable 0-5VDC / 0-10VDC / 4-20mA (4-wire) outputs, fuse protected and electrically isolated from all other circuitry; plus one field selectable network protocol: BACnet-MS/TP or BACnet-ARCNET. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.

3. Transmitter shall include the following features: Enhanced Output Integration, Low Airflow Alarm functions for compliance with LEED Outdoor Air Delivery Monitoring credit and ASHRAE Standard 189.1 and a Field Calibration Wizard to simplify field setup for adjustments when desired.

2A.13 BI-DIRECTIONAL AIRFLOW SENSOR (Pressure Transducer Type):

A. SETRA Model MRG (Multi-Range General) Pressure Transducer (which replaces SETRA “Multi-Sense” DP Low Airflow Sensor)

B. General: For this project, the CSC shall provide the Setra MRG (Multi-Range General) Pressure Transducer, multi-configurable air DP sensor, (replaces Setra Model 260).

C. Each measuring device shall set to the lowest bi-directional pressure range of -0.5 to +0.5 Inches W.C.

D. Provide duct/plenum mounting kits as applicable.

2A.14 CONTROL PANEL 120-Volt ENCLOSED POWER SUPPLY

A. Each BAS Control Panel (including the Building Controller) shall have a "packaged" Power Supply in a separate enclosure, such that the BAS Control Panel door can be opened without exposure to the hazards of 120-Volt wiring connections (Arc-Flash hazard).

B. The CSC shall use the PSH Series by Functional Devices, Inc. The specific Model will vary with specific power requirements at that Control Panel. An Approved Equal is acceptable.

****** PROJECT NOTE, for the Consultant ******
For this project, the Consultant should specify WHERE a UPS is to be installed. All critical equipment, locations and monitoring points shall be served from a control panel that is backed up by a UPS. Provide a list here, a schedule on the drawings or show on the floor plans. Contact the PSU OPP BAS Group if there are Questions during Design.

2A.15 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS is required to be installed to provide Uninterrupted Power to every level of Controller(s) serving emergency and/or critical equipment, locations or points.

B. When a UPS is required it shall be an Eaton (MGE/Cutler Hammer), model PULSL1000T or approved equal.
   1. Tower or mini-tower model, 1000 VA capacity, with an LCD screen. It shall be equipped with software for remote supervision.
   2. The UPS shall be a true UPS meaning the inverter shall be active at all times, not just on a loss of input power.
   3. UPS output shall be configured for four (4) 5-15R outlets.
   4. Batteries shall be sealed, maintenance-free type.
   5. UPS shall have a two year warranty on the assembly, including batteries.
   6. IP network management shall be built in or if done via an optional card, included in the supplied hardware.
   7. Provide UPS status outputs via relay contacts and an emergency stop.
   8. For ease of service, the UPS shall be a plug in type and not hard wired.
   9. A limited access outlet is needed to keep the UPS powered in an environment where someone may be in need of an outlet (See Part 3).

C. A UPS shall be used on the following BAS Panels:

   1. The Consultant is to insert a list of locations here, provide a schedule on drawings, or show locations on the floor plans.

D. The fewest quantity of UPS devices is preferred. Contact the BAS Group if the 1000 VA capacity is the limiting factor to having fewer UPS devices. Contact: Bob Krasinski, FAS Support Supervisor, RRK2@psu.edu, 814-865-7870.

---- End of PART 2A ----------

PART 2B PRODUCTS, SOFTWARE

2B.1 SYSTEM SOFTWARE OVERVIEW

A. Acceptable Products:

1. Automated Logic Corporation: Eikon and WebCTRL.
2. Delta Controls, Inc.: enteliWEB, (makes use of ORCAview and ORCAweb)
3. Siemens Building Technologies: Desigo (and related tools)

**** PROJECT NOTE, for the Consultant ****

The Consultant must contact the BAS Group prior to issuing the specification to discuss where and by whom the software will be hosted and whether any additional simultaneous users should be added This is true for UP and non-UP projects alike.

B. The CSC shall provide all software required for operation of the BAS system specified herein. All functionality described herein shall be regarded as a minimum. The following are minimum requirements and shall be turned over to PSU before the installed system will be accepted by PSU.

1. An additional Software Server License shall be provided for each additional server that this project requires whether the server is provided by the project or by PSU.
2. Completed database, and an electronic copy of the Back-up file.
3. Configuration of all controller and operator workstation application programs to provide the sequence of operation indicated.
4. An electronic copy of each and every Controller program installed in all Primary Equipment, Terminal Equipment, or other programmable controllers for the Project. File-names shall include Equipment Tag and Date in MMDDYYYY format.
5. All Configuration Tools, and all software licenses, required to configure all controllers installed on this project. This includes the highest-level software tools that the CSC uses to install and commission/start-up the Controllers included in this Project.

2B.2 SYSTEM CONFIGURATION

A. Database Creation and Modification. All changes shall be done utilizing standard procedures. The system shall allow changes to be made either at the local site through a portable computer or central workstation.

B. The system shall permit the operator to individually and globally perform, as a minimum, the following:

1. Add and delete points/objects
2. Modify point parameters
3. Create and modify control sequences and programs
4. Reconfigure application programs

C. All data points/objects within the database shall be completely accessible as independent or dependent variables for custom programming, calculation, interlocking, or manipulation.

D. The University shall be provided with a software account that has unlimited privileges for the entire site installation.

2B.3 APPLICATION PROGRAMMING

A. The system software shall include Logic Programming for all DDC control algorithms resident in individual control modules. This programming may be completed using Graphical Logic Blocks or line code utilizing either PPCL or GCL+.

B. The clarity of the programming sequence must be such that the user has the ability to verify that system programming meets the specifications. The programming must be done in segments, (such as OA control, start/stop control, etc.) for each section of the sequence of operation. The programming must be documented and labeled to provide the user with an understandable and exact representation of each segment of the sequence of operation and for ease of troubleshooting.

C. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs, either individually or globally. The programming language shall have the following features, at a minimum:

1. The language shall be Graphical or English language oriented, and allow for free-form programming (i.e., not column-oriented or "fill in the blanks").
2. A full-screen character editor/programming environment shall be provided. The editor shall be cursor/mouse-driven and allow the user to insert, add, modify, and delete custom programming code. It also shall incorporate features such as cut/paste and find.
3. The programming language shall allow independently executing program modules to be developed.
4. The editor/programming environment shall have a debugging capability that shall provide error messages for syntax and execution errors.
5. The programming language shall support conditional statements (IF/THEN/ELSE/ELSE-IF) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
6. The programming language shall support floating-point arithmetic using the following operators: +, -, /, x, square root, and x-to-the-y-power. The following mathematical functions also shall be provided: natural log, log, trigonometric functions (sine, cosine, etc.), absolute value, and minimum/maximum value from a list of values.
7. The programming language shall have predefined variables that represent time of day, day of the week, month of the year, and the date. Other predefined variables shall provide elapsed time in seconds, minutes, hours, and days. These elapsed time variables shall be able to be reset by the language so that interval-timing functions can be stopped and started within a program. Values from all of the above variables shall be readable by the language so that they can be used in a program for such purposes as IF/THEN comparisons, calculations, etc.
8. The language shall be able to read the values of the variables and use them in programming statement logic, comparisons, and calculations.

2B.4 DIRECT DIGITAL CONTROL SOFTWARE

A. The system shall continuously perform DDC functions at the local control module in a stand-alone mode. The operator shall be able to design and modify the control loops to meet the requirements of the system being operated. The operators shall use system provided output for tuning of PID loops.

B. Each local control module shall perform the following functions:

1. Identify and report alarm condition
2. Execute all application programs indicated on the Object Table(s)
3. Execute DDC algorithms

C. It is preferred that each local control module should be able to trend and store data.

1. It is acceptable to trend and store data in the Global Building Controller instead of the Local Control Module.

D. In the event of a control module power failure, all points/objects under its control shall move to the failure mode as indicated on the Object Table(s). All DDC software for this feature shall reside in the respective control module.

1. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory.
2. Power failure at any control module shall be reported at the Operator Workstation.
3. The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

2B.5 SOFTWARE USER INTERFACE

A. The on-line graphics, scheduling, and events shall be created using the Automated Logic WebCTRL, Delta Controls enteliWEB or Siemens Desigo software.

B. All of the system objects, schedules, and events shall be represented as BACnet objects by the CSC.

C. Events (Alarms):

1. The CSC shall provide all alarm event notification and alarm events messages for objects on the object table provided to and approved by the University's Physical Plant BAS Group.

2. Alarm event notification, alarm event messages, and event routing shall be in accordance with the existing PSU standards.

D. On-line Graphics:

1. The on-line graphics shall be provided by an approved Automated Logic Corporation branch or dealer, an approved Delta Controls dealer or an approved Siemens Branch Office. .
2. Equipment Graphic:
   a. All controlled equipment (Mechanical, Electrical, Primary, Terminal, etc.) shall have a representative equipment graphic.
   b. The latest version of the BAS vendor's animated graphics software shall be used to its fullest extent in the creation of the equipment graphics. Fans, dampers, coils, pumps, etc. shall be rendered as animated graphics.
   c. Hypertext links to the cooling source and heating source of each piece of equipment shall be defined on the graphic.
   d. Object in alarm condition shall be shown red and signify "Alarm" on the graphic.

e. The device communication status shall be displayed on all equipment on-line graphics.
f. The program run state shall be displayed on all equipment on-line graphics.
g. An on-line text description of the Sequence of Operation shall be provided as separate graphics screen(s) for each unique mechanical system.

3. System Summary Graphics:
   a. Each integrated building-wide system or combination of systems, and each central plant system, shall have a separate graphic that accurately represents the relative order/arrangement of equipment and components as installed, and shows the inter-relationships and inter-dependence between key components of each system and combination of systems.
      1) Example-1: when multiple pieces of mechanical equipment within a "system" are intended to operate in series or parallel, with a duty/standby or lead/lag sequence of operation.
      2) Example-2: when primary equipment supply units and zone/terminal distribution units have associated exhaust fans that are linked for overall pressure control, or airflow control.
      3) Example-3: chiller "plants" shall schematically show key components of the main system, including multiple chillers, cooling towers, pumps, isolation and temperature/flow control valves and interconnected piping. Include summary of connected load equipment cooling requests.
      4) Example-4: heating "plants" shall schematically show key components of the main system, including multiple boilers, combustion air dampers, fuel gas valves, pumps, isolation and temperature/flow control valves and interconnected piping. Include summary of connected load equipment heating requests.

4. Logic Programming:
   a. All equipment shall have an interactive link on the equipment graphic page that links to the logic programming. The programming logic shall be shown with real-time values, accessible via the standard thin-client user interface program Microsoft Internet Explorer preferred;
   b. A vendor-supplied toolset that allows the University to view the logic programming with real time values will be acceptable, but is not preferred.

5. Communications Riser Spreadsheet:
   a. A spreadsheet shall be submitted indicating the layout of the network including the order of the nodes and each node's current communication status. The spreadsheet shall include the following information: a network node number, equipment description, controller part number, network address and BACnet instance number.
   b. Alternatively, riser diagrams for renovations and/or expansions to an existing BAS shall be developed using the existing communications riser diagram available from the University's Physical Plant BAS Group.
      1) A single-page riser diagram depicting the system architecture shall include room locations and addressing for each controller, as well as the current communication status of each controller. Include a Bill of Material for all equipment in this diagram but not included with the unique controlled systems.

6. Area Served/Equipment graphic

   a. The CSC shall provide a Floor Plan graphic representing the spaces served by each piece of Primary Equipment (Air systems, and Heating-only systems) The Floor Plan graphic will include the Room Numbers of the Spaces being served, and the Spaces shall be color-shaded to indicate they are served by the noted Primary Equipment.
   b. Floor Plans shall dynamically update to visually depict the Zone alarm (event) status of the Spaces being served, just as with the Floor Plan dynamic thermo-graphics.
   c. If the Primary Equipment serves Spaces on several Floors, the Area Served/Equipment graphic will be comprised of portions of several Floor Plans.
   d. This Area Served**/**Equipment graphic will be available from the Equipment graphic and from the Floor Plan dynamic thermo-graphic (as described below) that represents the difference between Zone Temperature and Zone Set-Point.

7. Floor Plan dynamic thermo-graphics.

   a. All floors in the building shall have a graphic screen.
   b. Equipment locations and space temperatures shall be displayed on the floor plan graphic.
   c. Hypertext links to the room controller parameters shall be defined by clicking on the room location the controller serves.
   d. Hypertext links to equipment parameters shall be defined by clicking on the equipment location on the floor plan.
   e. Dynamic thermo-graphics shall be defined for each Zone controller to visually depict the Zone alarm (event) status of the room(s). The color-coding is defined below.
      1) If the actual space temperature is in the dead band between the heating setpoint and the cooling setpoint, the color displayed shall be green for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
      2) If the space temperature rises above the cooling setpoint, the color shall change to yellow. Upon further rise beyond the cooling setpoint plus an offset, the color shall change to orange. Upon further rise beyond the cooling setpoint plus the yellow band offset, plus the orange band offset, the color shall change to red indicating unacceptable high temperature conditions. At this point an alarm shall be generated to notify the operator.
      3) When space temperature falls below the heating setpoint, the color shall change to light blue. Upon further temperature decrease below the heating setpoint minus an offset, the color shall change to dark blue. Upon further space temperature decrease below the heating setpoint minus the light blue band offset minus the dark blue band offset the color shall change to red indicating unacceptable low temperature conditions. At this point an alarm shall be generated to notify the operator.

8. Two submissions of online Graphics are required. So as not to delay the turnover of the project, The CSC shall provide and install the on-line graphics in two steps as follows:
   a. Initial set of online graphics (systems and dynamic thermo-graphic floorplans), shall be ready for use by the Cx-provider before verification of Inputs and Outputs.
   b. Complete revisions to the initial set of online graphics, at the same time as submitting Record BAS Shop Drawings

9. All graphics screens shall be reviewed, coordinated and approved by the University's Physical Plant BAS Group prior to implementation.

E. Equipment Occupancy Scheduling:

1. All equipment occupied/unoccupied scheduling shall be accomplished via a BACnet BV that is controlled by a BACnet schedule.
2. The CSC shall provide a BACnet BV for all VAVs, FCUs, Air Handlers, Exhaust equipment to be implemented in schedules. It is the University's goal to schedule all terminal equipment and allow the call for starts to turn on the up-line equipment.
3. The CSC shall coordinate equipment schedules between the University Project Management and the University customer.
4. The system shall allow the operator to designate any combination of equipment to form a group that can be scheduled with a single operator command through the mouse interface at the workstation.
   a. Any designated group shall have the capability to be a member of another group.
   b. The operator shall be able to make all schedule additions, modifications and deletions using the mouse and appropriate dialog boxes. In addition, the operator shall have the capability to edit all schedules and then download any or all schedule changes to the control modules with a single operator command through the mouse interface.
   c. The operator shall be able to view a forecast of schedules for instant overview of facilities schedules. Schedule forecast shall include indication of all types of schedules, i.e. normal, holiday and override.

F. The following applications software, per "programs" in System Points/Objects List(s), shall be provided for the purposes of 1) emergency utility demand limiting and 2) optimizing energy consumption while maintaining occupant comfort:

1. Emergency Utility Demand Limiting Strategies
   a. Install controllers implementing a demand-limiting strategy consistent with the Sequences of Operation Guideline available at "Enterprise Utility Management System (EUMS) Equipment Control Strategies", on the PSU Design Standards website. The demand-limiting strategies shall be submitted, reviewed and approved by the University's Physical Plant BAS Group prior to implementation.

2. Time Scheduling
   a. The system shall be capable of scheduling by individually controlled equipment and groups of individually controlled equipment. Each schedule

shall provide beginning and ending dates and times (hours:minutes). The CSC shall provide a BACnet BV for scheduling by the CSC.

3. Reset (Source Temperature Optimization (STO))

   a. The system shall automatically perform source optimization for all air handling units, chillers and boilers in response to the needs of other downstream pieces of equipment, by increasing or decreasing supply temperature setpoints, i.e. chilled water, discharge air, etc. using University defined parameters. In addition to optimization, the STO capability shall also provide for starting and stopping primary mechanical equipment based on zone occupancy and/or zone load conditions.

   b. The STO program will allow setpoints for various equipment in the heating/cooling chain to be reset between an University defined maximum and a minimum setpoint based on the actual requirements of the building zones. The actual setpoint shall be calculated based on the number of heating or cooling requests which are currently being received from the equipment or zones served. Once every update period, the STO program surveys the network to see if any piece of equipment requires any additional heating or cooling from its source.

   c. As an example, a VAV air handler is the source of cold air for a number of VAV boxes. Assume that the STO program for the air handler has the following parameters established for it by the University's Physical Plant BAS Group:

      1) Optimized setpoint description: Initial setpoint 60.00, Max. setpoint 65.00, Min. setpoint 55.00. Every 2.0 minutes, trim by 0.25 and respond by -0.50 but no more than 2.0 . Every two minutes, the STO program will total up all of the requests and calculate a new setpoint:. New setpoint = prev setpoint + 'trim by' + ('respond by' x no. of req.). Assuming four requests were received and the previous setpoint was 57.00 degrees, the new setpoint would be: New setpoint = 57.00 + 0.25 + (-0.50 x 4) = 55.25 Deg F
      2) If the number of requests received multiplied times the 'respond by' value is greater than the 'but no more than' value, the 'but no more than' value is used inside the parenthesis in the above calculation.

4. Set Back /Set Up (Day/Night Setback (DNS))

   a. The system shall allow the space temperature to drift down or up within a preset (adjustable) unoccupied temperature range. The heating or cooling shall be activated upon reaching either end of the DNS range and shall remain activated until the space temperature returns to the DNS range.

   b. The system shall be capable of closing all outside air and exhaust air dampers during the unoccupied period, except for 100% outside air units.

   c. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room in the building if full DDC control is not being effected.

   d. User shall be able to define, modify or delete the following parameters:

1) DNS setpoint temperature(s)
2) Temperature band for night heating operation
3) Period when the DNS is to be activated

5. Timed Local Override (TLO)

a. The system shall have TLO input points/objects which permit the occupants to request an override of equipment which has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact), wind-up timer, or ON/OFF switches as detailed in the Object Table(s).

b. If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse and the total maximum ON time permitted. Override time already entered shall be canceled by the occupant at the input point. If a wind-up timer is used the equipment will stay in override mode until the timer expires. Year to date, month-to-date and current day override history shall be maintained for each TLO input point. History data shall be accessible by the operator at any time and shall be capable of being automatically stored on hard disk and/or printed on a daily basis.

6. Space Temperature Control (STC)

a. There shall be two independently-adjustable space temperature setpoints, one for cooling and one for heating, separated by a dead band. Only one of the two setpoints shall be operative at any time. The cooling setpoint is operative if the actual space temperature has more recently been equal to or greater than the cooling setpoint. The heating setpoint is operative if the actual space temperature has more recently been equal to or less than the heating setpoint. There are two modes of operation for the setpoints, one for the occupied mode (example: heating = 72 degrees F, cooling = 76 degrees F and one for the unoccupied mode (example: heating = 55 degrees, cooling = 90 degrees F). NOTE: it will no longer be acceptable to accomplish having a Heating Setpoint and a Cooling Setpoint by having a single mid-range setpoint with offsets.

b. The occupied/unoccupied modes may be scheduled by time, date, or day of week via a BACnet BV.

c. All setpoints and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.

d. The cooling and heating setpoints may be increased (decreased) under demand control conditions to reduce the cooling (heating) load on the building during the demand control period. Up to three levels of demand control strategy shall be provided. The operator may predefine the amount of setpoint increase or decrease for each of the three levels. Each space temperature sensor in the building may be programmed independently.

e. An optimum start-up program transitions from the unoccupied setpoints to the occupied setpoints. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).

f. A PID control loop, comparing the actual space temperature to its setpoint, shall modulate the dampers and heating coil valve or heating stages in sequence to achieve the setpoint target.

7. Historical Data and Trend Analysis: A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.

a. Continuous Point Histories: Global Building Controllers /Routers shall store Point History Files for all analog and binary inputs and outputs. The Point History routine shall continuously and automatically sample the value of all analog inputs at half hour intervals. Samples for all physical hardware input and output points shall be collected during the warranty period, to allow the user to immediately analyze equipment performance and all problem-related events. Point History Files for binary input or output points and analog output points shall be archived on the server workstation hard drive.

b. Control Loop Performance Trends: Global Building Controllers /Routers shall also provide high resolution sampling capability with an operator-adjustable resolution of 10-300 seconds in one-second increments for verification of control loop performance.

c. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assignable to user-definable trends for the purpose of collecting operator-specified performance data over extended periods of time. Sample intervals of 1 minute to 2 hours, in one-minute intervals, shall be provided. Each standalone Global Building Controller /Router shall have a dedicated buffer for trend data, and shall be capable of storing a minimum of 5000 data samples.

d. Data Storage and Archiving: Trend data shall be stored at the Global Building Controllers /Routers, and uploaded to hard disk storage when archival is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full. All trend data shall be available in disk file form for use in 3rd Party personal computer applications.

8. Runtime Totalization: Global Building Controllers /Routers shall automatically accumulate and store runtime hours for binary input and output points as specified.

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

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

9. Analog/Pulse Totalization: Global Building Controllers /Routers shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

   a. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g., KWH, gallons, KBTU, tons, etc.).

   b. The Totalization routine shall have a sampling resolution of one minute or less.

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

10. Event Totalization: Global Building Controllers /Routers 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.

   a. The Event Totalization feature shall be able to store the records associated with a minimum of 9,999,999 events before reset.

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

12. Alarm and Audit Logs

   a. The software shall automatically create audit and alarm logs.
      1) The audit log shall track all actions and changes that are made to the system by any operator.
      2) The alarm log shall keep a record of all alarms that have been generated, acknowledged, deleted, etc.

---- End of PART 2B ----------

PART 3 EXECUTION

3.1 NOTIFICATION

A. Prior to commencing work, the CSC shall contact the PSU Project Manager (PM) to determine the BAS Analyst assigned to this Project. The BAS Analyst will take care of informing the BAS Group of the Project and ensure BAS Group participation.

B. It is important that the CSC respect the PSU Campus BAS-network infrastructure. If controls work is executed in a thoughtful and conscientious way, time-consuming and costly network disruptions can be avoided and integration of the new systems can be implemented smoothly and efficiently.

3.2 EXAMINATION

A. Beginning of work means acceptance of existing conditions.

B. Verify that systems are complete and ensure that the systems are capable of being started and operated in a safe and normal condition before attempting to operate the BAS systems.

3.3 GENERAL INSTALLATION

A. Install equipment level and plumb.

B. Install software in control units and, as applicable, in laptop computer(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Connect and configure equipment and software to achieve sequence of operation specified.

3.4 WIRING DEMOLITION

A. The Demolition Contractor (sometimes not working for the CSC) needs to coordinate with the CSC prior to any demolition activities. Demolition activities should be planned to proceed in an orderly manner to minimize impact and disruption to the PSU Campus BAS-network infrastructure.

B. All wiring, tubing and panels abandoned by the work of the CSC, during the course of completing this Project, shall be removed in total. Contact the OPP BAS Group prior to removing any wiring or panels to make sure that the wiring/panel does not feed another panel that is still in use. Contact: Gary Persing, FAS CCS Supervisor, GLP11@psu.edu, 814-863-8149. Also see Paragraph 1.10 A. 3.

C. Controllers, Panels and Devices abandoned by the Scope of this Project, shall be retained by PSU Physical Plant Area Services. Area Services Technicians shall be given ten (10) days notice for them to remove these items.

3.5 WIRING INSTALLATION

A. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings and equipment details. Install electrical components and use electrical products complying with requirements of applicable Division 26 sections of these specifications.

B. Install Ethernet-cabling from Ethernet-connection at Control-device as a home-run back to the nearest (within 300 Meters) Telecom Closet. The location shall be included on the Riser Diagram in the Set of BAS Shop Drawings. The network design will NOT include daisy-chaining Ethernet-connections. Also, see 2A.1 B. for design details. Contact the

BAS Group if the nearest Telecom Closet is more than 300 Meters from the Control-device with an Ethernet-connection. Contact: Tom Walker, FAS Network Supervisor, TEW17@psu.edu, 814-867-4753.

C. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with requirements of applicable Specification Division 26 sections and all national, state, and local electrical codes. All the wiring shall be installed in accordance with the current National Electrical Code (NEC).

D. Provide wiring as required by functions as specified and as recommended by equipment manufacturers to serve specified control functions.

E. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the University's Physical Plant BAS Group's representative prior to rough-in.

F. The term "control wiring" is defined to include the providing of wire, conduit, and miscellaneous materials as required for mounting and connecting electric or electronic control devices in pilot circuits of contactors, starters, relays, etc., and wiring for valve and damper operators.

G. Install signal, communication, and fiber-optic cables according to Division 26 Section "Control/ Signal Transmission Media", and as follows:

1. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

2. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

H. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

I. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

J. Provide auxiliary pilot duty relays on motor starters as required for control function.

K. All exposed control wiring and control wiring in the mechanical, electrical, telephone, and similar rooms shall be installed in raceways. All other wiring shall be installed neatly and inconspicuously above ceilings.

L. Install exposed control wiring system in conduit for electric/electronic control systems. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. UL plenum-rated cable shall be provided when located in ceiling spaces. All control wiring shall be installed in a neat and workmanlike manner parallel to building lines with adequate support. Both conduit and plenum wiring shall be supported from or anchored to structural members. Conduit or plenum wiring supported from or anchored to piping, duct supports, the ceiling suspension system, is not acceptable. Wiring buried in slab-on-grade concrete or explosion-proof areas shall be in rigid metal conduit. Provide adequate strain relief for all field terminations.

M. Number-code or color-code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

3.6 CONTROL DEVICE INSTALLATION

A. All room sensors and thermostats shall be mounted so as to be accessible in accordance with ADA Guidelines, unless otherwise noted on the drawings. It is the CSC's responsibility for final coordination of the sensor/thermostat locations with the Professional and the University's Physical Plant BAS Group.

B. Enhanced Zone Sensors shall be installed only in private or semi-private Offices, and Conference Rooms. These shall not be installed in Public Spaces.

C. Provide averaging-type sensors in mixing plenums, and at hot and cold decks. Install averaging-type sensors in a serpentine manner vertically across the duct cross-section. Support each bend with a capillary clip.

D. Install low-limit duct thermostats (freezestats) in a serpentine manner horizontally across the face of coil. Provide 1 ft (3 m) of sensing element for each 1 ft^2 (1 m^2) of coil area.

E. Remote control devices not in local panels shall be accessible for adjustment and service below 7' above finished floor whenever possible.

F. Locate all temperature control devices wired under Division 26.

G. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

H. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

I. Local controllers shall be mounted at eye level for accessibility and service, and located within 50' of the system served, unless otherwise shown on the plans.

J. Freestanding enclosures and panels shall be supported on steel unistrut frames, or approved equal, and be securely anchored to the floor and be well braced.

K. Enclosures and panels mounted directly to the wall shall be provided with a minimum airspace of 1" between the enclosure and the wall.

L. A minimum of 3' working clearance shall be provided in front of all enclosures and panels; clearance shall be ensured to permit the enclosure door to open at least 90° from its closed position.

M. Mounting height shall be a maximum 6'-6" to the top of the enclosure.

N. Shall be suitable for use in environments having an ambient temperature range of 31°F to 104°F and a relative humidity of up to 95% noncondensing.

O. There shall be no pneumatic equipment or device installed in a Global Building Controller/Router enclosure. There shall be no equipment or device installed in a Global Building Controller/Router that is not a functional component of the campus system interface or building BAS system.

P. A padlocking hasp and staple or keyed cylinder shall be provided for each door.

Q. A field-installed, 14-gage galvanized steel drip shield shall be provided where enclosures and panels may be subjected to dripping water.

****** PROJECT NOTE, for the Consultant ******
For this project, EDIT the following Table for Control Valves.
Contact the Project Manager or the BAS Group if there is any Question.

3.7 CONTROL VALVE TABLES

A. See Table 1, Table 2 and Table 3 below, edited specific to the **## INSERT NAME OF PROJECT HERE (and check location)##** at University Park campus.

Table 1

Zone Terminal Valves						
Type	**Service**	**Normal Position**	**Fail Position**	**Control**	**Power**	**Notes**
Pressure Dependent						
Belimo B2 series CCV pressure dependent characterized control valves	Heating and cooling water or glycol mixtures	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Pressure Independent						
Belimo P2 and PICCV (larger sizes) series pressure independent characterized control valves	Heating and cooling water or glycol mixtures	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Steam						
Belimo B2 HT high temperature series characterized ball control valves	Steam heating (max 15.0 psi)	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.

Table 2

Air Handling Unit Valves						
Type	**Service**	**Normal Position**	**Fail Position**	**Control**	**Power**	**Notes**
Pressure Dependent						
Belimo B2 (1/2”-2”) and B6 (2-1/2”-6”) series CCV pressure dependent characterized control valves	Cooling chilled water or glycol mixtures	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
	Heating hot water or glycol mixtures (primary heating applications)	Normally closed (NC)	Spring return fail open	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
	Heating hot water or glycol mixtures (reheat only no heating duty)	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Pressure Independent						
Belimo PICCV series pressure independent characterized control valves	Cooling chilled water or glycol mixtures	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
	Heating hot water or glycol mixtures	Normally closed (NC)	Spring return fail open	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
	Heating hot water or glycol mixtures (reheat only no heating	Normally closed (NC)	Fail-in-place (FIP)	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.

	duty)					
Belimo P2 (1/2”-2”) and P6 (>2”) series electronic pressure independent characterized control valves	Same as above for Pressure Independent for specific application. Exception is that fail open is via electronic fail-safe actuators (note 8).					

Steam						
Belimo B2 HT (< or = 1”) high temperature series characterized ball control valves	Steam heating (max 15.0 psi)	Normally closed (NC)	Spring return fail open	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Belimo B2 VB (>1”) series high performance characterized V-port ball control valves	Steam heating (max 200.0 psi)	Normally closed (NC)	Spring return fail open	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Belimo B2 HT (< or = 1”) high temperature series characterized ball control valves	Steam humidification isolation valve	Normally closed (NC)	Spring return fail closed	On/off	24 VAC	See Note 6.
Belimo B2 VB (>2”) series high performance characterized V-port ball control valves	Steam humidification isolation valve	Normally closed (NC)	Spring return fail closed	On/off	24 VAC	See note 6.

Table 3

Heat Exchanger Valves						
Type	**Service**	**Normal Position**	**Fail Position**	**Control**	**Power**	**Notes**
Pressure Dependent (source side of HX)						
Belimo B2 (1/2”-2”) and B6 (2-1/2”-6”) series CCV pressure dependent characterized control valves	Cooling chilled water or glycol mixtures (note 8)	Normally closed (NC)	Spring return fail closed	2-10 VDC fully modulating	24 VAC	See Note 8.
	Heating hot water or glycol mixtures (primary heating applications)	Normally closed (NC)	Spring return fail closed	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Pressure Independent (source side of HX)						
Belimo PICCV series pressure independent characterized control valves	Cooling chilled water or glycol mixtures (note 8)	Normally closed (NC)	Spring return fail closed	2-10 VDC fully modulating	24 VAC	See Note 8.
	Heating hot water or glycol mixtures	Normally closed (NC)	Spring return fail closed	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Belimo P2 (1/2”-2”) and P6 (>2”) series electronic pressure independent characterized control valves	Same as above for Pressure Independent for specific application. Exception is that fail open is via electronic fail-safe actuators (note 8).					
Steam (source side of HX)						
Belimo B2 HT (< or = 1”) high temperature series characterized ball control valves	Steam heating (max 15.0 psi)	Normally closed (NC)	Spring return fail closed	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.
Belimo B2 VB (>1”) series high performance characterized V-port ball control valves	Steam heating (max 200.0 psi)	Normally closed (NC)	Spring return fail closed	2-10 VDC fully modulating	24 VAC	See Notes at the end of this Table.

Pressure Dependent (load side of HX)						
Belimo F6 150SHP series butterfly pressure dependent control valves	Heating water or glycol mixtures isolation valves	Normally closed (NC)	Spring return fail open	On/off	24 VAC	See Notes at the end of this Table.
Belimo B2 (1/2”-2”) and B6 (2-1/2”-6”) series CCV pressure dependent characterized control valves	Cooling chilled water or glycol mixtures isolation valves	Normally closed (NC)	Spring return fail open	On/off	24 VAC	See Notes at the end of this Table.
Belimo F6 (>6”) HD series butterfly pressure dependent control valves	Cooling chilled water or glycol mixtures isolation valves	Normally closed (NC)	Spring return fail open	On/off	24 VAC	See Notes at the end of this Table.

Notes (apply to Table 1, Table 2, and Table 3)**:**

1. Select valve CV for 3.0 psi pressure differential with the following exception that the CV shall be a minimum of 1.2. The basis for this standard is that the characterizing disc opening for those <1.2 CV are too small and raise the potential for flow restriction or total blockage in systems with less than ideal water quality conditions. Belimo also recommends that valves should be selected for a size no less than 2 nominal sizes of the installed pipe size.
2. Unless otherwise indicated, valves shall be typically normally closed (NC) fully modulating 2-10 VDC. Depending on the control application normally open (NO) and modulating with floating point control may be acceptable. These floating point and the normally closed exceptions require that exceptions shall be reviewed and approved by PSU BAS and Engineering prior to or during the DD (Design Development) phase. When the floating point option is accepted this does not also waive the requirement for brushless motors. Belimo TR actuators have motor brushes (in the floating point option) and are not acceptable.
3. There may be specific critical applications and/or those with freeze potential where fail-in-place (FIP) is indicated but spring return, fail open or closed should be considered. Design professional should have this issue reviewed and approved by PSU BAS and Engineering prior to or during the DD (Design Development) phase.
4. Freezestat controls shall be hard wired to de-energize 24 VAC power to valve actuator so that valve returns to fail position.
5. The Design Professional shall refer to HVAC systems design standards and specifications for guidance in determining whether system should be pressure independent or pressure dependent

type. Design Professional shall have this issue reviewed and approved by PSU BAS and Engineering prior to or during the DD (Design Development) phase.

6. Steam humidification isolation valve refers to an isolation valve of steam supply serving both humidification control valve and humidification distribution (in the airstream) steam jacketing.
7. Refer to control sequences for required 2-way (typical) and 3-way specific arrangements.
8. These applications do not include valves for campus chilled water service. These valves are typically specified in Utilities specification sections and standards.
9. For applications not listed above or applications where exceptions should be considered, these valve selections shall be presented by the Professional for review and approval by PSU BAS and Engineering prior to or during the DD (Design Development) phase.

3.8 INSTALLATION OF AIRFLOW MEASUREMENT DEVICES

A. Installation
   1. Install in accordance with manufacturer's placement instructions for optimum performance at the locations indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.

B. Adjusting
   1. Fan inlet mounted devices may be adjusted during start up and commissioning only after having been checked against known volumetric values (or against another like device measuring the same air volume) at two or more points of operations.
   2. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans. A written report shall be submitted to the consulting mechanical engineer prior to installation if any measurement locations do not meet the manufacturer's placement requirements.
   3. Field Installation: Install in accordance with manufacturer's placement instructions for optimum performance at the locations indicated on the plans. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.
   4. Adjustment: Duct and plenum devices shall not be adjusted without approval from the consulting mechanical engineer. Fan inlet mounted devices may be adjusted during start up and commissioning only after having been checked against known volumetric values (or against another like device measuring the same air volume) at two or more points of operation.
   5. Calibration of Terminal Units: The CSC shall cooperate with the TAB Contractor for completing the calibration of VAVs, etc.

3.9 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Ground equipment: Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.10 CONTROL POWER

A. Power supply for all control panels handling network, building or primary equipment and for control panels serving emergency and/or critical equipment, locations or points shall be connected via a dedicated BAS circuit to the building Normal/Emergency, Standby-Optional electrical panel. A grounding conductor shall be run from building service entrance panel ground bus. Conductor shall be insulated and isolated from other grounded conductors and building conduit system.

B. Provide power for Application Controllers and all associated control components from nearest applicable electrical control panel or as indicated on the electrical drawings—coordinate with Electrical Contractor.

C. Power for each control panel shall be provided through a switch (standard light switch) located inside the panel. A standard duplex receptacle shall also be provided inside the control panel. The receptacle shall be unswitched.

D. The Enclosed Power Supply, as specified in Part 2 of these specifications shall be installed according to the Manufacturer's instructions and located in the upper-left corner inside the BAS Control Panel.

1. When the control transformer is installed inside the control panel, the panel must be properly ventilated and all 120 volt wiring protected against Arc Flash Hazards.

2. If the control transformer must be installed outside of the control panel due to space constraints, then they will be attached to the top or side of the panel and all 120 volt wiring will be protected from Arc Flash Hazards.

3. All 120 volt wiring needs to be completely isolated so that maintenance personnel are only exposed to 50 volts or less while servicing the control system components.

3.11 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Uninterruptible Power Supply(s) shall supply power for the Global Building Controller(s), repeater(s) and/or Application Controllers that monitor or serve emergency and/or critical equipment, locations or points.

B. The dry-contacts for monitoring the UPS status shall be monitored by the BAS.

C. The UPS shall be equipped with a cord and plug and shall be plugged into a secure outlet. This outlet shall be connected via a dedicated BAS circuit to the building Normal/Emergency, Standby-Optional electrical panel, which may be the same outlet specified above, if applicable.

1. Do not hard wire the UPS.

D. Signage at the UPS Plug-in location shall include the Electrical Panel Name and Breaker # and shall say: "This outlet for UPS only."

E. If it is necessary to install the UPS where there is public access, the UPS, the outlet and the UPS plug shall be in a ventilated lockable enclosure. When installed in a space with restricted access (i.e., MER) the UPS, outlet and plug do not need to be in an enclosure.

F. The quantity of UPS devices on a Project shall be minimized to reduce future maintenance issues. The CSC may make suggestions for such to the Professional for consideration.

3.12 IDENTIFICATION

A. The CSC shall label each system device with a point address or other clearly identifiable notation inside the device cover. Labels shall be permanent, and method of labeling shall be approved by the University's Physical Plant BAS Group.

B. All control equipment shall be clearly identified by control shop drawing designation as follows:

1. Control valves and damper actuators: brass tags or engraved phenolic ("Bakelite") tags.

2. Other Remote Control Devices: Metal tags or laser printed, adhesive backed, metalized polyester film labels.

3. Control Enclosures and Panels: Engraved nameplate with panel number and system served.

C. Duct static-pressure sensors and piping differential-pressure sensors locations shall be:

1. indicated on the Installation Mark-up Drawings (kept on-site) for transfer of this information onto the As-Builts; and

2. identified on the BAS Floor Plan online graphic; and

3. identified in the building using a label on the nearest ceiling grid, or access-panel where concealed.

D. Geo-tree naming shall provide an equivalent description as provided on the floor plan graphic, plus the terminal unit type, sub-net number and Controller-address number (Example: Rm 102A Office VAV 01-20). If the VAV (or other Terminal Equipment) serves more than one space and has multiple Room Temperature sensors, all Rooms will be included, and the first Room will be the Room with the Master Sensor (Example: Rm 102 B, A, C Office VAV 01-20; where Rm 102B has the Master Sensor).

3.13 TRENDS

A. All input and output control and status points will have trends set-up and enabled. Each trend will store a minimum of 500 samples in the associated controller utilizing a first-in/first-out algorithm so that the oldest data is over-written as new data is stored. The controller will also be programmed for the capability of enabling historical trending on each trended point individually so that historical trending can be enabled on any point without enabling it on any other trended point.

B. All trends shall be programmed to be triggered according to the type of point, as follows:

1. All equipment start/stop control point trends will be triggered on the control point's change of state.
2. All equipment status point trends will be triggered on the status point's change of state.
3. All space-temperature and outside-air trends will be triggered on any change of value of 2 degrees Fahrenheit.
4. All space-humidity and outside-air-humidity trends will be triggered on any change of value of 5%.

5. All fan air temperature trends will be triggered on any change of value of 2 degrees Fahrenheit.
6. All water temperature trends will be triggered on any change of value of 3 degrees Fahrenheit.
7. All damper motor control point trends will be triggered on any change of value of 10% of its control range.
8. All air flow trends will be triggered on any change of value of 10% of its control range.
9. All valve control point trends will be triggered on any change of value of 10% of it's control range.
10. All VFD motor control point trends will be triggered on any change of value of 5% of its control range.
11. All fan air static pressure trends will be triggered on any change of value of .05 inches water column.
12. All water pressure trends will be triggered on any change of value of 3 psi.
13. All steam pressure trends will be triggered on any change of value of 2% of the steam pressure input range.

**** PROJECT NOTE, for the Consultant ****
The Consultant must contact the User Group prior to issuing the specification to discuss schedules and working hours. The appropriate Occupied/Unoccupied Schedules shall be furnished to the CSC in this specification section or on an appropriate schedule on the drawings.

3.14 SCHEDULES

A. A list of schedules to be implemented shall be reviewed and approved by the Professional. The list shall also include the schedule times (Occupied and Unoccupied) to be implemented.

3.15 BASIC SYSTEM REPORTS AND CUSTOM TRENDS

A. Basic System Reports shall be set-up, a minimum of one per System, that provide a Summary of values of the key Points in that System, at the same point-in-time ("snapshot"). Some Reports might require multiple "pages" for viewing. Contact the BAS Group for examples.

B. Reports shall be created using Microsoft Excel spreadsheets.

C. Basic System Reports for HVAC Systems Functional Performance & Diagnostics
   1. General Intent: To assess ongoing functional performance through continued monitoring and useful reporting through the BAS of the actual operating conditions of the controls and interactions of the HVAC systems. Coordinate and integrate building reporting requirements with campus EUMS to avoid duplication or omission of reporting requirements.
   2. Reports shall be initially set up by BAS vendor to be able to be manually or automatically run at user's option, and sent out periodically via email to user defined list to achieve the following goals:
      a. Verifying design intent and functional performance
      b. Diagnosing comfort and other space condition problems
      c. Alert users to inefficient or improper operation of equipment
      d. Maintaining persistence of energy savings

e. Demonstrating effects of poor maintenance or identifying when maintenance procedures are not followed
f. To provide data that can be further used in spreadsheets to assist in studying alternative strategies

3. Reports shall be organized according to the project specific applications. They shall include summaries of key setpoints, control status (optimized reset, auto vs. overridden) and actual controlled conditions.
   a. For example, reports shall provide, at a glance, a summary of the % cooling demand at all zone terminals, and corresponding cooling requests at zone level causing reset of Supply air temperature at AHU and unmet SAT setpoint at AHU level, causing DP reset at chilled water pump and/or chilled water supply temperature reset at chiller level.
   b. Example reports ("BAS Performance Reports.xlsx") in Excel spreadsheet format may be found on the OPP Design and Construction website at Division 25.
4. In general, include reports at each of the following levels and for each of the systems within those levels and key indicators that show interactions between systems:
   a. Zone Level Systems
      1). Thermal Comfort/Environmental Conditions
      2). Terminal Heating and Cooling Equipment
      3). Smoke & other distribution control dampers (position status)
      4). Other (as required)
   b. Primary Equipment and Central Plant Level Systems
      1). Air Handling Units
         a). Coil/Energy Transfer
         b). Ventilation and Pressurization: Supply, Return, Outside Air quantities
         c). Fan
      2). Auxiliary
         a). Pumps (chilled, condenser and hot water)
         b). Exhaust fans (General Purpose and Specific Purpose)
5. Primary Equipment and Central Plant Level Systems
   a. Cooling Plant Equipment
      1). Campus Chilled Water
      2). Chillers
      3). Cooling Towers
      4). Heat exchangers
   b. Heating Plant Equipment
      1). Boilers
      2). Heat Exchangers
   c. Decentralized Level Systems
      1). Packaged Unitary DX Equipment
      2). Heat Pumps
      3). Other (as required)

D. Custom Trends:
   1. The CSC shall provide a minimum of 10 Custom Trends, to be set-up by the CSC after the Cx-provider has begun Functional Performance Testing. These Custom Trends are in addition to the Trends for all input and output control and status points

noted above, and will mostly involve display of multiple trends in the same view (i.e. Trend Graph or Trend Study). The Cx-provider will provide 15-calendar-days advance notification of when the Custom Trends need to be completed.

3.16 ACCEPTANCE OF COMPLETED BAS INSTALLATION

A. Prior to the CSC requesting Acceptance, the CSC shall run Trend Logs on each component of the system(s) and correct any obvious errors. Then, after corrections are completed, run Trend Logs for seven (7) consecutive days. Submit these with the request for Acceptance Testing to be scheduled.

B. Upon completion of the installation, the CSC shall start up the system and perform all necessary calibration, testing, and debugging operations. An acceptance test shall be performed by the CSC in the presence of the University's Physical Plant BAS Group representative. Acceptance test shall be scheduled with at least 10 working days advance notice. The acceptance test shall be observed by at least one member from the University's Physical Plant BAS group.

C. Network Analysis Capture: Acceptance of the completed BAS installation includes verification of the proper equipment communication setup. This shall be accomplished by submitting a BACnet network analysis capture for a period of 5-minutes; fix any issues and re-sample. Submit the capture showing issues have been corrected. The capture files (in .TXT format) shall be submitted to the University's Physical Plant BAS group for Review and Approval. The Physical Plant BAS group Approval shall be received, and any identified problems shall be resolved before Acceptance Testing shall begin. Corporate assistance shall be requested and used as necessary to resolve any network-issues in a timely fashion.

D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove malfunctioning units, replace with new units, and retest.
2. Test and adjust controls and safeties.

E. Replace damaged or malfunctioning controls and equipment.

1. Start, test, and adjust control systems.
2. Demonstrate compliance with requirements, including calibration and testing, and control sequences.
3. Adjust, calibrate, and fine tune circuits and equipment to achieve sequence of operation specified.

F. The acceptance test shall include, but not be limited to:

1. The CSC shall submit a checklist of the objects for the test. The checklist shall be submitted to the University's Physical Plant BAS Group, and reviewed and approved by the University's Physical Plant BAS Group, prior to the test. The checklist shall include all objects that have event (alarm) routing defined.
2. The CSC and OEM manufacturer shall verify the proper operation of all input/outputs.

3. The CSC shall verify the proper event (alarm) routing to Physical Plant BAS operations center for all points on the main equipment and perform a spot check of the operations of ten percent of terminal units equipment.
4. The CSC shall verify that the software programs meet the design intent of the control sequences in the Construction Documents.
5. The CSC shall verify the proper operation of the system software on the operator workstation.
6. The CSC and the OEM manufacturer shall verify all inputs meet or exceed manufacturer's stated tolerances for accuracy.
7. The CSC shall verify that all on-line graphical displays of equipment accurately represent the real time state of the field equipment.
8. The CSC shall verify that all on-line displays of programming logic accurately represent the real time state of the field equipment.
9. The CSC shall verify the reliability of all communications of all field devices to the appropriate operator workstation located in the Physical Plant Building.
10. The test shall include all workstation/server level integration included in the scope of this project with the CSC and OEM manufacturers.
11. The test shall include functional verification of all interfaces and system integration required to meet the scope of this project.
12. Final acceptance shall include acceptance by the University's Physical Plant BAS Group.
13. The Acceptance Test shall be conducted with the CSC, OEM manufacturer, the Prime Contractor representative and a member of the University's Physical Plant BAS Group present.

G. Turnover of ALARMS to PSU BAS Operators:

1. Alarms being turned-over to PSU BAS Operators shall have been activated, tested for proper routing and determined to not be producing frequent and nuisance alarms.
2. It is expected that Alarms will not be turned-over to PSU BAS Operators until there is final acceptance of the completed BAS installation.

H. Acceptance: When the field test procedures have been successfully demonstrated to the University's Physical Plant BAS Group and the system performance is deemed satisfactory, the system parts will be accepted for beneficial use and placed under warranty. At this time, a "notice of completion" shall be issued by the University's project representative and the warranty period shall start.

I. All of the points which are alarmed shall be trended and archived from the time of installation through the end of the warranty period. All archived files will be readily accessible to the University's Physical Plant BAS Group.

J. Start-up and commission systems: Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

K. Provide any recommendation for system modification in writing to the University's Physical Plant BAS Group. Do not make any system modification, including operating parameters and control settings, without prior approval of the University's Physical Plant BAS Group.

L. Provide certificate stating that control system has been tested and adjusted for proper operation.

M. Project Record Documentation: After a successful acceptance testing, submit project record drawings of the completed project for final approval. After receiving final approval, supply four (or as specified in Division 1) complete project record sets (maximum ANSI "D" size), together with an electronic version on CD to the University's Project Management. The electronic version shall simultaneously be provided at the BAS Group's FTP site, and the University's Physical Plant BAS Group shall be notified. Notify Bob Mulhollem, Manager of Facility Automation Services, REM26@psu.edu, 863-7220.

N. Equipment Panel As-Built Drawings: After the above final approval, one set for the entire project shall be provided in the Building Controller Panel, and a paper-copy set of just the Drawings for that System shall be provided in each System Panel, and the University's Physical Plant BAS Group shall be notified. Notify Bob Mulhollem, Manager of Facility Automation Services, REM26@psu.edu, 863-7220.

3.17 TRAINING

A. The CSC shall provide a factory-trained instructor to give full instructions to designated personnel in the operation, maintenance, and programming of the system. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The training shall be specifically oriented to the system and interfacing equipment installed.

B. Project & Building-specific instructions shall include 2 parts, the "New BAS Equipment walk-through" and the "New BAS Equipment Classroom-Orientation" as outlined below:

1. New BAS Equipment "walk-through" sessions will be conducted by the PSU Technician that has been assisting with New Building (or Major Renovation) Commissioning. The CSC shall have a qualified representative attend and assist with this training session.
2. New BAS Equipment Classroom-Orientation: The CSC shall provide two (2) 3-hour Classroom-sessions for the University's Technical Service employees. This shall be an overhead/onscreen presentation of the online BAS interface and include showing how to access, and use, information about any portion of the new project's BAS.

   a. Handouts (20 copies) will include the construction mark-ups of the BAS Shop Drawing submittal, and shall be clearly noted on the Cover-page with "FOR TRAINING ONLY. (Date) DO NOT COPY", and shall be turned-over to the Training Coordinator at the end of the Classroom sessions. Alternate: A minimum of 5 Printed Handouts, and presentation using 2 projectors and 2 screens, including 1 projector and screen dedicated to displaying the BAS Shop Drawing Page being discussed.
   b. General - One session will be more general in nature for the Area Services and Weekend personnel who will be initial responders, dealing mostly with "Too Hot" or "Too Cold" calls.
   c. Technical – One session will be more technical, being oriented for the Central Services personnel that will need to troubleshoot more complex problems.
   d. Schedule Classroom-sessions with the University giving at least ten days advance notice. Provide an Agenda, to be approved by the University's Physical Plant BAS Group prior to scheduling Training. To schedule sessions, contact the Physical Plant Training Coordinator at 814/ 863-2340.

C. Vendor-specific BAS Product Training: The Contract for this Project shall provide a 5-day classroom training course, from the Company Training Catalog. This Training shall be provided during the period of installation, OR at the University's option, provided at a time following the installation period of the Contract for this Project.

1. This is not Project or Building-specific Training.

2. The 5-day classroom Training-course shall be taught by a factory-authorized Trainer to train the University's maintenance personnel on-site at The Penn Stater Conference Center (scheduled via OPP Training Coordinator), for at least twelve (12) University employees or Cx representative.

3. Train the University's maintenance personnel to adjust, operate, and maintain this vendor's control systems and components, including: procedures and schedules for starting and stopping, troubleshooting, servicing, Operation of portable operator's terminal and maintaining equipment and schedules.

4. Provide Operator Training on modification of data display, alarm and status descriptors, requesting data, executing commands, calibrating and adjusting devices, resetting default values, and requesting logs.

5. Provide a student binder with the classroom training course.

6. Schedule BAS Product Training session(s) with the University with at least thirty (30) days advance notice. Provide an Agenda, to be Approved by the University's Physical Plant BAS Group, prior to scheduling the Training. Contact: Bob Krasinski, FAS Support Supervisor, RRK2@psu.edu, 814-865-7870. To Schedule BAS Product Training, contact the Physical Plant Training Coordinator at 814/ 863-4455 (or 863-0379).

3.18 ADJUSTING AND CLEANING

A. Start-up: Start-up, test, and adjust electric control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

C. Final Adjustment: After completion of installation, adjust sensors, thermostats, control valves, motors, and similar equipment provided as work of this section. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.

----End of PART 3 ----

***** The following Parts are PROJECT SPECIFIC *****

*****MUST be Provided by the Professional*****

PART 4 SEQUENCES OF OPERATION

This Part shall include Sequences of Operation, Object Tables, and Control Diagrams. (Contact the University's Physical Plant BAS Group for Examples.)

TIPS for the DESIGN PROFESSIONAL:

1. Refer to the PSU Design Standards Website for 25 90 00 GUIDE SEQUENCES OF OPERATION (LINK: http://www.opp.psu.edu/planning-construction/design_and_construction_standards/division-25-integrated-automation/?searchterm=standard%20sequences%20of%20operation)

2. **CntlSpecBuilder** [https://www.ctrlspecbuilder.com/sb/welcome.nsf] is recommended as a starting-place if there is not a Guide Sequence already developed by PSU, for the particular System being proposed. See List of available Guide Sequences below. Contact BAS Group when Guide Sequences are needed by the Project Team, to receive all the latest versions. Contact: Bob Krasinski, FAS Support Supervisor, RRK2@psu.edu, 814-865-7870. Using **CntlSpecBuilder** should provide most of the needed elements (SoO, Object Table, Control Diagram) and get a Sequence of Operation more than 60% complete by selecting optional specifics. From that point, the Design Professional can further refine and "tweek" the Sequence for the Project-specific application, before Submitting for Design Review at 100% DD.

3. List of available Guide Sequences:
   (a) AHU Multi Zone
   (b) AHU Single Zone
   (c) Chem Treat Equip BLDG Logic
   (d) Chilled Water Systems
   (e) EUMS SoO and Symbols
   (f) Exhaust Fan
   (g) FCU
   (h) Hot Water Systems
   (i) Lighting
   (j) OAM Weather
   (k) Penn State BACnet Standard Scheme
   (l) VAV

4. Be sure to Review Part 3 – EXECUTION requirements of this BAS Guide Spec, to include the requirements of Enhanced Zone Sensors, averaging-type sensors and low-limit duct thermostats in the Mechanical Design documents.

5. Contact Glenn Lelko, PSU Mechanical Engineer, to co-ordinate the sizing & selection of the CHW Choke-valve. And CHW Meter.

6. Be sure to co-ordinate BAS Requirements in Systems by other Disciplines (i.e. Electrical, Plumbing, Elevators, etc.) with the appropriate Design Professional, and Specification Sections.

Some standard requirements, that are often neglected, include the following.

A. Multiple Sensors
Multiple Sensors are to be implemented when a piece of Terminal Equipment serves multiple-spaces, such that not more than 2 spaces are represented per one-sensor. Thus, a VAV serving 3 spaces will have 2 room-sensors networked together. The Sequence of Operation for the implementation of Multiple-sensors shall be clear that programming shall be selectable between using the High, Low or Average value for controlling the Terminal Equipment that serves the multiple-spaces. Mechanical Design documents shall indicate locations of "Master" verses "Slave" sensors.

B. Enhanced Zone Sensors (including Set-Point Adjustment, and Timed Local Override) shall be designed for only in private or semi-private Offices, and Conference Rooms. These shall not be installed in Public Spaces.

C. Outside Air Temperature Sensor (OAT) for Heating System: An OAT sensor shall be wired directly to the Heating System Controller, in ANY Project with a Heating System.

D. Outside Air Temperature Sensor (OAT) for Cooling System in a Project involving Equipment serving Critical Space(s): An OAT sensor shall be wired directly to the Cooling System Controller, in ANY Project with Cooling that serves Critical Space(s) (i.e. Animal Rooms, Temperature-critical research, etc.).

E. Weather Station:
The strategy at PSU-University Park is to have a small quantity of "weather stations", to best be able to maintain the high-quality sensors. Consult with the University's Physical Plant BAS Group if the Design Engineer has a potential need for a "weather station". This potential needs considered by the Designer on a Project-specific basis, related to requirements for control based on measurement of: OA Temperature, OA Humidity, OA Local-CO2 and Atmospheric–pressure. The Designer needs to determine where the Weather Station DATA would come from for this Project.

****** NOTE FOR CONSULTANT: Coordination of these requirements with the Design EE (Electrical Engineer) and appropriate ELECTRICAL Specification Section(s) is ESSENTIAL. ******

DEFINITIONS

Night Lighting – CCS (central control system) term for exterior lights mounted to the building and/or free standing walkway lights. These "Night" lights are usually controlled by the campus master photo cell. "Night" Lighting does not include exterior lighting for the roadway or parking, or egress lighting to the Public Way.

Site Lighting – CCS term for exterior lighting for the roadway or parking lots. These "Site" lights are usually controlled by the campus master photo cell. "Site" Lighting does not include exterior lights mounted to the building and/or free standing walkway lights, or egress lighting to the Public Way.

BUILDING MOUNTED "NIGHT" LIGHTING

1) Exterior Building Mounted Lighting Control – Control of exterior building mounted lighting shall match that of Site/Night Lighting Control, unless it is egress lighting.
2) Exterior Building Mounted Egress Lighting – Control of egress lighting shall be a local "fail safe" photocell by the EC (electrical contractor).

SITE (ROADWAY AND PARKING) & NIGHT (WALKWAY) LIGHTING

REFER TO Division 26 GUIDE SPECS /STANDARDS.

ELECTRICAL SERVICE ENTRANCE EQUIPMENT

REFER TO Division 26 GUIDE SPECS /STANDARDS.

- *CONFIRM with Design EE the required quantity of Points to include in this Project. Typically PSU wants one notification that any Breaker within a single piece of Power Distribution Equipment is in the "ARM" mode. If more than one Switchgear on the project has ARM, each Switchgear shall be monitored separately.*

EMERGENCY SYSTEMS

****** NOTE FOR CONSULTANT: Confirm with Design EE whether there is one or more ATS on the project. ATSs exist in many different applications, including where there is a connection to the Campus Emergency or Standby Cable, an Emergency Generator, a Fire Pump, Elevator(s) over 4 stories, or Emergency Standby HVAC equipment. ******

REFER TO Division 26 GUIDE SPECS /STANDARDS.

ENGINE GENERATOR(s)

****** NOTE FOR CONSULTANT: Confirm with Design EE whether there is an engine generator on the project. ******

REFER TO Division 26 GUIDE SPECS /STANDARDS.
And ADD the following:

3) Emergency Generator, Minimum Points to be Monitored:
The following points shall be hardwired from NC contacts of the Manufacturer-installed SPDT auxiliary contacts in the Emergency Generator Control Panel, to indicate:
   a) Generator Fault Status
   b) Low Fuel Level Status
   c) Fuel Tank Leak Detector Status
   d) Hand/Off/Auto switch position at generator control panel – Initiate Alarm when the switch is not in Auto position.
   e) Air Damper Status

(NOTE: per Paragraph 2A.4 B. 19. Application Controllers /UPS: the BAS Controller(s) with these I/O Points connected, are to be on Normal/Emergency Power and a UPS.)

4) Emergency Generator, Interface provided:
   a) On installations of Emergency Generators larger than 250KW, the Generator installation will provide a BACnet (preferred) or Modbus (allowed) digital interface. The CSC shall coordinate with the Generator and/or Interface Manufacturer to communicate with this Interface. The CSC shall provide all necessary programming.

----End of PART 4 ----

Figure 1: Building Automation System with Automated Logic Corporation product:

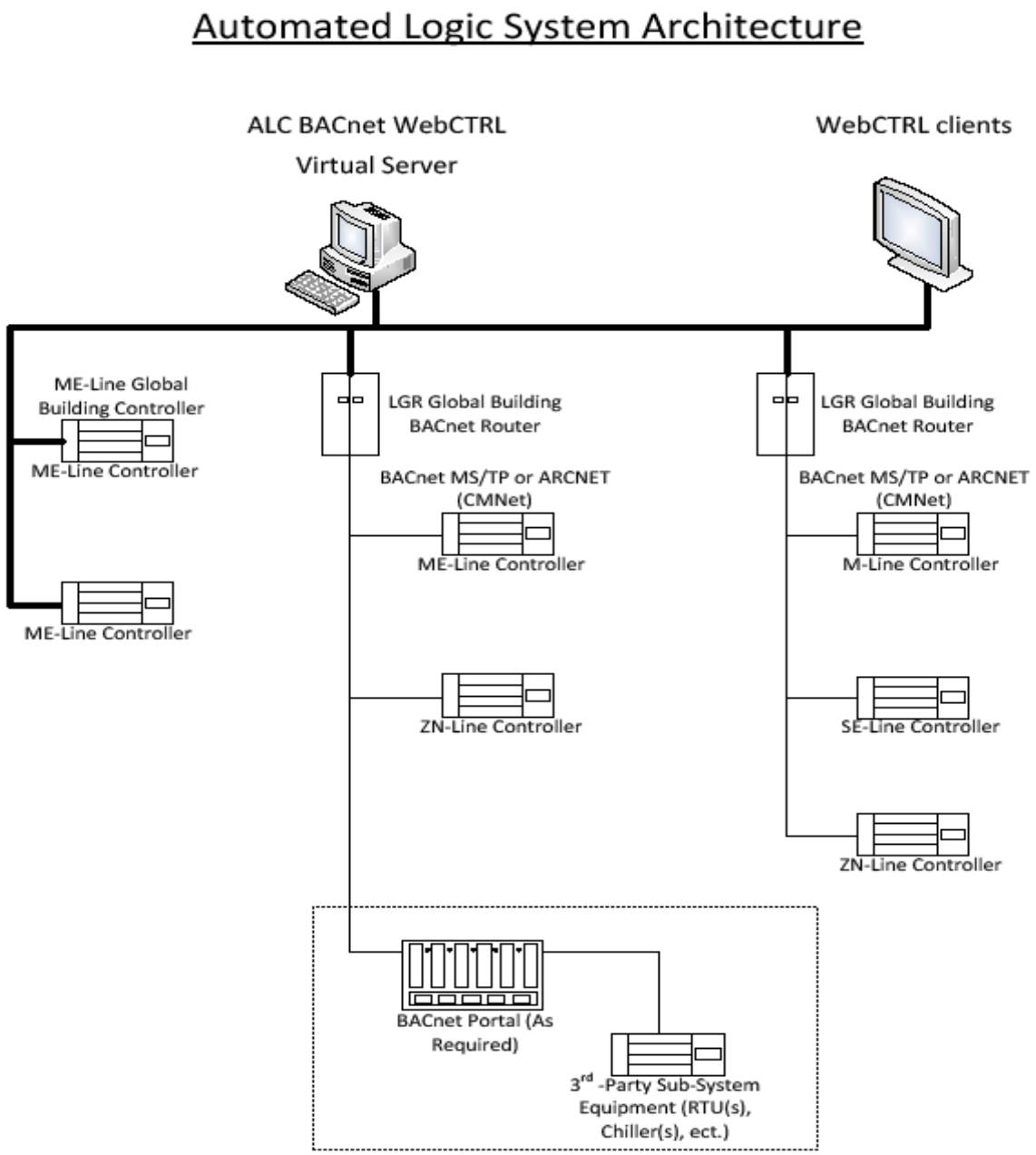


Figure 2: Building Automation System with Delta Controls product:

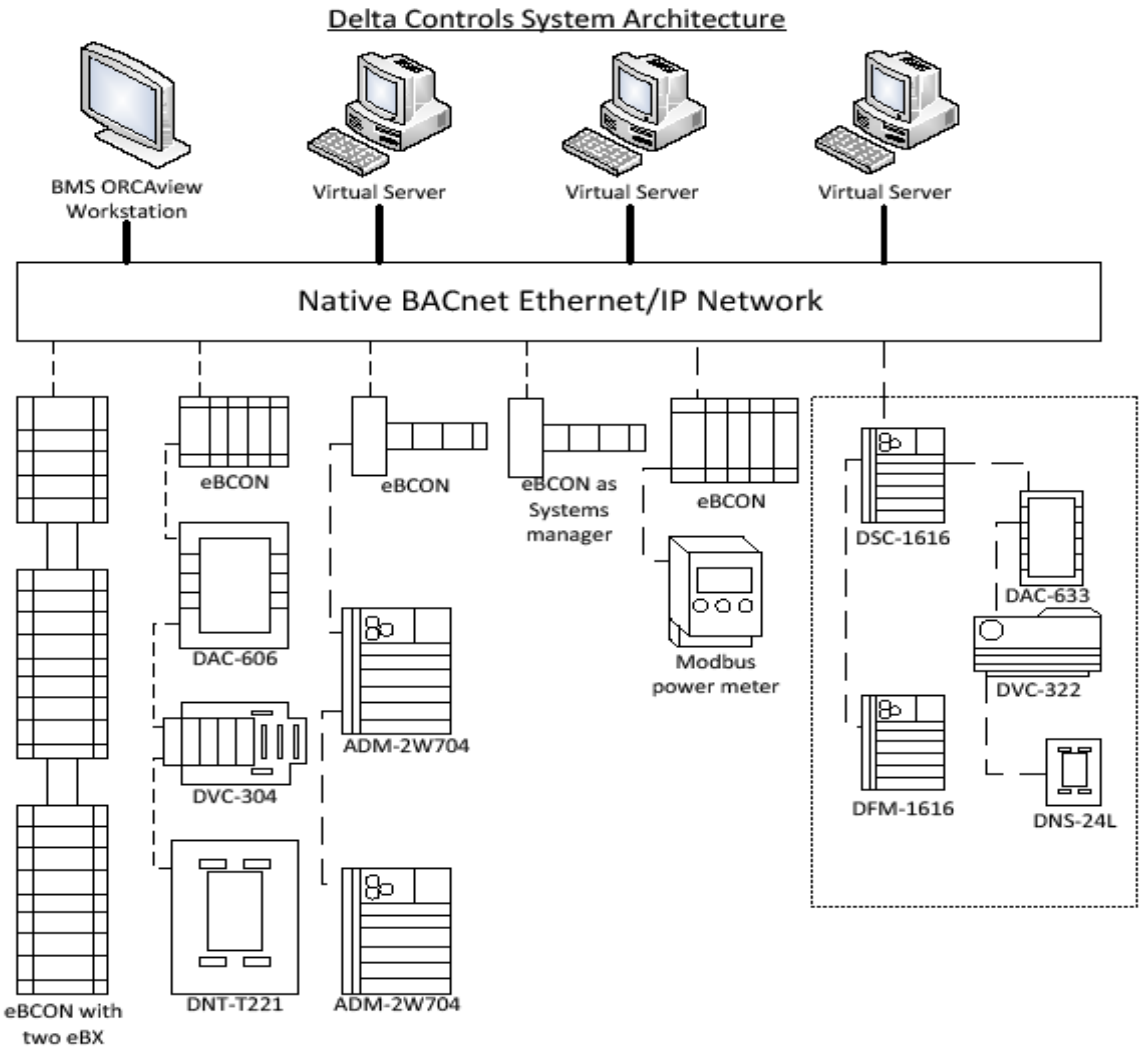
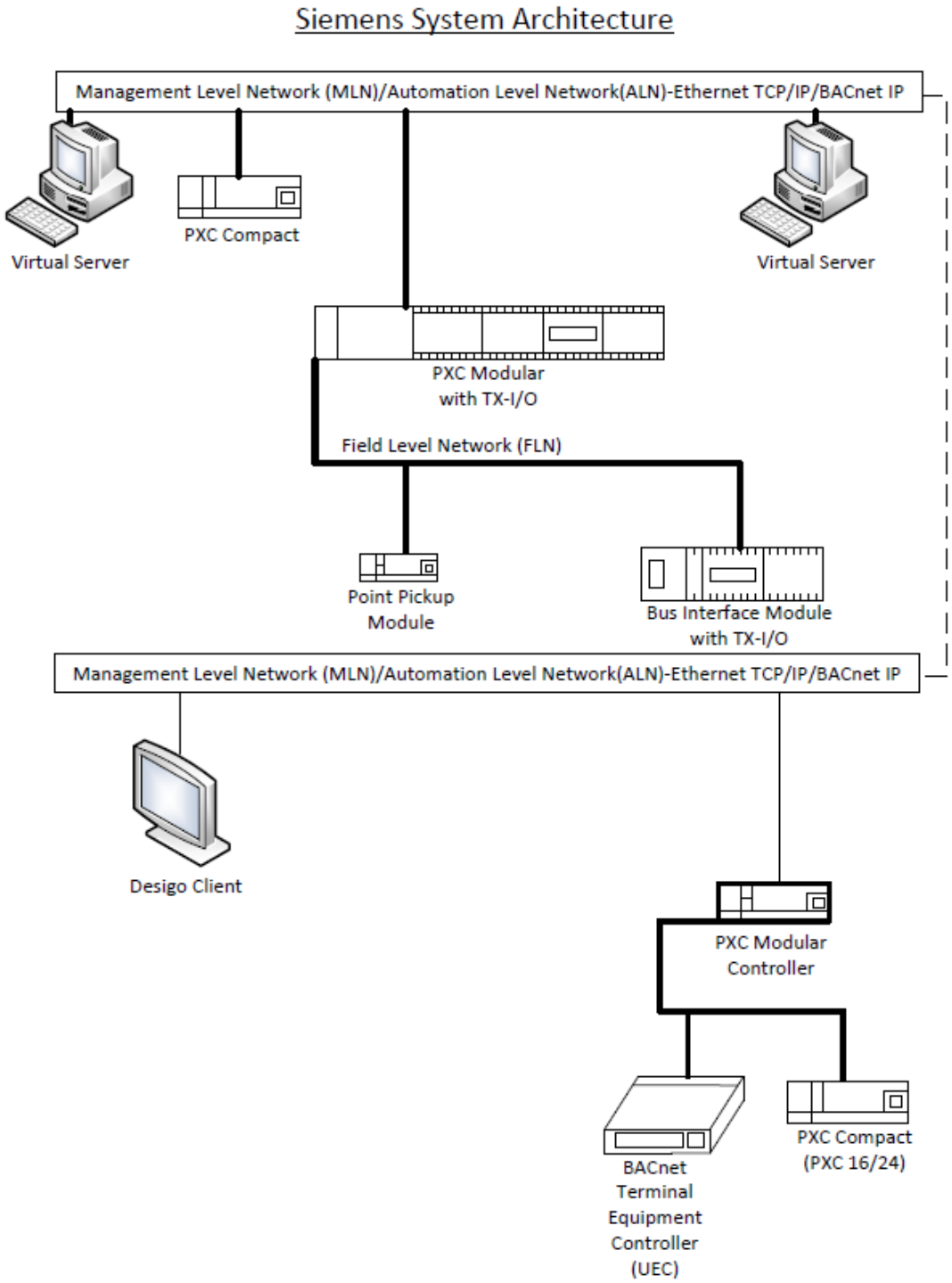


Figure 3: Building Automation System with Siemens product (Apogee hardware and Desigo Software only) product:



END OF PSU BAS GUIDE SPECIFICATION
SECTION 25 55 00