

**SECTION 15953 {23 0903} - BAS FIELD PANELS****PART I. PART 1 - GENERAL****1.01 SECTION INCLUDES:**

- A. Building Controller (BC)
- B. Advance Application Specific Controller (AAC)
- C. Application Specific Controller (ASC)

**1.02 RELATED DOCUMENTS:**

- A. Section *{Insert Applicable Specification Section}* - Basic Mechanical Requirements
- B. Section 15950 - Building Automation System (BAS) General – Refer to this section for definitions of terminology
- C. *Section 23 0900 - Building Automation System (BAS) General*
- D. Section 15951 - BAS Basic Materials, Interface Devices, and Sensors
- E. *Section 23 0913 – BAS Basic Materials, Interface Devices, and Sensors*
- F. Section 15952 - BAS Operator Interfaces
- G. *Section 23 0902 - BAS Operator Interfaces*
- H. Section 15954 - BAS Communications Devices
- I. *Section 23 0904 - BAS Communication Devices*
- J. Section 15955 - BAS Software
- K. *Section 23 0905 - BAS Software and Programming*
- L. Section 15958 - Sequence of Operation
- M. *Section 23 0993 - Sequences of Operation*
- N. Section 15959 - BAS Commissioning
- O. *Section 23 0801 - BAS Commissioning*

**1.03 DESCRIPTION OF WORK:**

- A. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.
- B. Refer to Section 15950 *{23 0900}* for general requirements.

**PART II. PART 2 - PRODUCTS****2.01 STAND-ALONE FUNCTIONALITY**

- A. **General:** These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in Part 3. This item refers to acceptable paradigms for associating the points with the processor.
- B. **Functional Boundary:** Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single

control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.

- C. The following configurations are considered acceptable with reference to a controller's standalone functionality:
1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
  2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
  3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.
  4. I/O point expansion devices connected to the main controller board via wiring and as such may be remote from the controller and that communicate via a sub LAN protocol. These arrangements to be considered standalone shall have a sub LAN that is dedicated to that controller and include no other controller devices (AACs or ASCs). All wiring to interconnect the I/O expander board shall be:
    - a) Contained in the control panel enclosure;
    - b) Or run in conduit. Wiring shall only be accessible at the terminations.
- D. The following configurations are considered unacceptable with reference to a controller's standalone functionality:
1. Multiple controllers enclosed in the same control panel to accomplish the point requirement.

## **2.02 BUILDING CONTROLLER (BC)**

### **A. General Requirements:**

1. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.
2. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. BCs shall be programmable from an operator workstation, portable operators terminal, or hand

held operating device. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.

3. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN.
4. All BCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:
  - a) Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. *Self-diagnostic routine shall report an alarm for a low battery condition.*
  - b) EEPROM, EPROM, or NOVROM non-volatile memory
5. In addition BCs may provide intelligent, standalone control of HVAC functions. Each BC may be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices. Refer to standalone functionality specified above.
6. The BC may provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
7. All BC point data, algorithms and application software shall be modifiable from the Operator Workstation.
8. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.
9. BC shall provide buffer for holding alarms, messages, trends etc.
10. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
11. Each BC shall contain software to perform full DDC/PID control loops.
12. For systems requiring end-of-line resistors those resistors shall be located in the BC.
13. Input-Output Processing
  - a) Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and [a manual hand off or auto switch to allow for override]. [If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.] Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
  - b) Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input

- shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
- c) Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board.
  - d) Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
  - e) Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO [*and transducer*] is acceptable only with University approval (Generally these will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.). Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.
  - f) Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.
- 14. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.
  - 15. Each BC shall be equipped with loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator Workstation software is acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
  - 16. All analog output points shall have a selectable failure setpoint. The BC shall be capable of maintaining this failure setpoint in the event of a system malfunction, which causes loss of BC control, or loss of output signal, as long as power is available at the BC. The failure setpoint shall be selectable on a per point basis.
  - 17. Slope intercepts and gain adjustments shall be available on a per-point basis.
  - 18. BC Power Loss:
    - a) Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.
    - b) Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. *An alarm diagnostic message shall indicate that the BC is under battery power.*

- c) Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
  - d) Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the University shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.
19. BC Failure:
- a) Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
  - b) BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.
20. Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
21. BCs may include LAN communications interface functions for controlling secondary controlling LANs Refer to Section 15954 {23 0904} - BAS System Communications Devices for requirements if this function is packaged with the BC.
22. BCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 enclosure, as specified elsewhere.

*The following only applies to strict BACnet projects; coordinate with UCB*

**B. BACnet Building Controller Requirements:**

- 1. The BC(s) shall support all BIBBs defined in the BACnet Building Controller (B-BC) device profile as defined in the BACnet standard.
- 2. BCs shall communicate over the BACnet Building Controller LAN.
- 3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

**2.03 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)**

**A. General Requirements:**

- 1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and

will continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN. Refer to standalone requirements by application specified in Part 3 of this section. In addition, it shall be able to share information with every other BC and AAC /ASC on the entire network.

2. Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.
3. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
4. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty- (50) hrs with a battery life of five years.
5. All point data; algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation.
6. AAC and ASC Input-Output Processing
  - a) Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and [a manual hand off or auto switch to allow for override]. [If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure.] Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
  - b) Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 8-10 bits depending on application.
  - c) Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors may only be done in non-critical applications and only with prior approval of Architect/Engineer
  - d) Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
  - e) Electronic Analog Outputs (AO) as required by application: voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. D/A converters shall have a minimum resolution of 8 bits.

- f) [Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer or 0-10vdc to pneumatic transducer are acceptable. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.]

*The following only applies to strict BACnet projects; coordinate with UCB*

**B. BACnet AAC(s) and ASC(s) Requirements:**

1. The AAC(s) and ASC(s) shall support all BIBBs defined in the BACnet Building Controller (B-AAC and B-ASC) device profile as defined in the BACnet standard.
2. AAC(s) and ASC(s) shall communicate over the BACnet Building Controller LAN or the ASC LAN or sub-LAN.
3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

**C. Terminal Box Controllers:**

1. Terminal box controllers controlling damper positions to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total quantity of controllers in a building to perform this function at the same time. When possible the controllers shall perform this function when the supply or exhaust air system is not operating or is unoccupied.

**PART III. PART 3 - EXECUTION****3.01 INSPECTION:**

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

**3.02 INSTALLATION OF CONTROL SYSTEMS:**

- A. General: Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details shown on drawings. Contractor shall install all controllers in accordance with manufacturer's installation procedures and practices.

**3.03 HARDWARE APPLICATION REQUIREMENTS**

- A. **General:** The functional intent of this specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions. A Building Controller as specified above is generally fully featured and customizable whereas the AAC/ASC refers to a more cost-effective unit designed for lower-end applications. Specific requirements indicated below are required for the respective application. Manufacturer may apply the most cost-effective unit that meets the requirement of that application.
- B. **Standalone Capability:** Each Control Unit shall be capable of performing the required sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Refer to Item 2.01 above for physical limitations of standalone functionality. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs or SDs via LAN.
- C. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.
- D. **Application Category 0** (Distributed monitoring)
  - 1. Applications in this category include the following:
    - a) Monitoring of variables that are not used in a control loop, sequence logic, or safety.
  - 2. Points on BCs, AACs, and ASCs may be used in these applications as well as SDs and/or general-purpose I/O modules.
  - 3. Where these points are trended, contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
- E. **Application Category 1** (Application Specific Controller):
  - 1. Applications in this category include the following:
    - a) Fan Coil Units
    - b) Airflow Control Boxes (VAV and Constant Volume Terminal Units)

- c) Misc. Heaters
  - d) Unitary equipment <15 tons (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps)
  - e) Induction Units
  - f) Variable Speed Drive (VSD) controllers not requiring safety shutdowns of the controlled device.
2. ASCs may be used in these applications.
  3. **Standalone Capability:** Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

<u>Physical/Virtual Point</u>	<u>Default Value</u>
Scheduling Period	Normal
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter

4. **Mounting:**
  - a) ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure (36" clearance required) and shall be rated for plenum use.
  - b) ASCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
  - c) ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical space.
  - d) Section 15953 **{23 0913}** contractor may furnish ASCs to the terminal unit manufacturer for factory mounting.
5. **Programmability:** Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Application-specific block control algorithms may be used to meet the sequence of operations. The ability to customize the control algorithm is not required unless specifically indicated otherwise.
6. **Network Restrictions:** Limit the number of nodes on the network to the maximum recommended by the manufacturer.

**F. Application Category 2 (General Purpose Terminal Controller)**

1. Applications in this category include the following:
  - a) Unitary Equipment  $\geq$  15 tons (Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units, and the like)

- b) Small, Constant Volume Single Zone Air Handling Units
  - c) Constant Volume Pump Start/Stop
  - d) Misc. Equipment (Exhaust Fan) Start/Stop
  - e) Misc. Monitoring (not directly associated with a control sequence and where trending is not critical)
  - f) Steam Converter Control
- 2. BCs may be used in these applications.
  - 3. ASC's may be used in these applications provided the ASC meets all requirements specified below. This category requires a general-purpose ASC to which application-specific control algorithms can be attached.
  - 4. **Standalone Capability:** Only the following data (as applicable) may be acquired from other ASCs via LANs. In the event of a loss of communications with any other ASCs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC/ASC shall use the last value obtained before the fault occurred.
  - 5. **Mounting:**
    - a) ASCs that control equipment located above accessible (36" clearance required) ceilings shall be mounted on the equipment and shall be rated for plenum use.
    - b) ASCs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the contractor) or in a near by mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.
  - 6. **Programmability:** Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Operator shall be able to address and configure spare inputs for monitoring. [\[Operator shall be able to address and configure spare outputs for simple single loop control actions or event initiated actions.\]](#) Application-specific block control algorithms may be used to meet the sequence of operations.
  - 7. **Network Restrictions:** Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 32.

**G. Application Category 3 (Advanced Application Controller)**

- 1. Applications in this category include the following:
  - a) Large Constant Volume Air Handlers
  - b) VAV Air Handlers {generally >5,000 and <10,000cfm}
  - c) Dual Duct Air Handlers {generally >5000 and < 10,000 cfm}
  - d) Multizone Air Handlers
  - e) Self Contained VAV Units
- 2. BCs may be used in these applications.
- 3. AAC's may be used in these applications provided:
  - a) The AAC's meets all requirements specified below.

- b) All control functions and physical I/O associated with a given unit resides in one AAC.
  - c) Input A/D is 10-bit. *Exception:* 8-bit input A/D can be used when matched with high accuracy sensors, the range of which meets the resolution requirements specified for the applicable sensor in Section 15951 {23 0900}.
  - d) Pulsed inputs required for the application can be monitored and accumulated effectively.
4. **Standalone Capability:** Only the following data (as applicable) may be acquired from other AACs via LANs. In the event of a loss of communications with any other AACs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC shall use the last value obtained before the fault occurred.
5. **Mounting:**
- a) AACs that control equipment located above accessible (36" clearance required) ceilings shall be mounted on the equipment and shall be rated for plenum use.
  - b) AACs that control equipment located in occupied spaces or outside shall either be mounted within the equipment enclosure (responsibility for physical fit remains with the contractor) or in a near by mechanical/utility room in which case it shall be enclosed in a NEMA 1, locking enclosure.
6. **Programmability:** Operator shall be able to modify all setpoints (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, interstage timing parameters, and mode settings. Operator shall be able to address and configure spare inputs for monitoring. Operator shall be able to program custom DDC control algorithms and specify trending parameters, which will be retained in memory in the event of a loss of communications. Application-specific block control algorithms may be used provided they meet the sequence of operations. The control algorithms shall be completely customizable.
7. **Network Restrictions:** Each LAN which participates in the transfer of data between the CU and the local operator workstation shall be subject to the following criteria:
- a) Limit the number of nodes servicing any one of these applications on the AAC/ASC LAN to 16.
  - b) The building controller LAN shall be subject only to manufacturer's published LAN limitations.

#### H. Application Category 4

- 1. Applications in this category include the following:
  - a) Central Cooling Plant
  - b) Central Heating Plant
  - c) Cooling Towers
  - d) Sequenced or Variable Speed Pump Control
  - e) Local Chiller Control (unit specific)
  - f) Local Free Cooling Heat Exchanger Control
  - g) Air Handlers over 10,000 cfm or serving critical areas

2. BCs shall be used in these applications.

*The following does not apply to all projects; coordinate with UCB*

### **3.04 NETWORK BANDWIDTH MANAGEMENT**

- A. This section is designed to address the MS/TP networks within the DDC systems. Information passed within the MS/TP network will greatly affect the overall performance of the building systems. Scan times from the first controller to the last controller within the building network that exceed 2 seconds are not acceptable. If scan times of 2 seconds or less cannot be achieved, contact UCB.
- B. Once the network is properly configured the contractor shall provide a network bandwidth analysis of the controller network. The analysis shall document network bandwidth utilization does not exceed the requirements stated above for a continuous one hour period.

### **3.05 CONTROL UNIT REQUIREMENTS**

- A. Refer to Section 15950 *{23 0900}* for requirements pertaining to control unit quantity and location.

### **3.06 CONTROL MODULE INSTALLATION**

- A. **Building Controller (BC):**
  1. The Controls contractor shall follow the specifications shown in the Hardware Installation Guide unless stated otherwise herein.
  2. Ensure proper shield grounding is applied on the RS485 connections.
  3. Install Minimum 650VA UPS in Separate Panel to power Controller.
- B. **Field Bus Controllers (AAC/ASC):**
  1. The Controls contractor shall follow the specifications shown in the Hardware Installation Guide unless stated otherwise herein.
  2. Controller Power shall have a separate disconnect (or fuse) for each controller.
  3. All digital outputs must be equipped with a relay rated to manage the connected load.
  4. Only two pair (incoming & outgoing) communication wires shall be connected to the communication terminal on the controller. (No “star” network configurations)
- C. **Expansion Modules:**
  1. The Controls contractor shall follow the specifications shown in the Hardware Installation Guide unless stated otherwise herein.
  2. The use of DCC expansion Modules, including quantity, shall be pre-approved by the University HVAC Shop.

***END OF SECTION 15953 {23 0903}***