SECTION 15950
{23 0900}
BUILDING AUTOMATION SYSTEM (BAS) GENERAL
(THIE SECTION MUST BE REVIEWED PRIOR TO EACH PROJECT)

PART I. GENERAL

1.01 SECTION INCLUDES
A. General Requirements
B. Description of Work
C. Quality Assurance
D. System Architecture
E. Distributed Processing Units/Quantity and Location
F. Demolition and Reuse of Existing Materials and Equipment
G. Sequence of Work

1.02 RELATED DOCUMENTS
A. Section {15010} -Basic Mechanical Requirements.
B. Section 15951 – Building Automation System (BAS) Basic Materials, Interface Devices, and Sensors
C. Section 23 0913 – Building Automation System (BAS) Basic Materials, Interface Devices, and Sensors
D. Section 15952 - BAS Operator Interfaces
E. Section 23 0902 - BAS Operator Interfaces
F. Section 15953 - BAS Field Panels
G. Section 23 0903 - BAS Field Panels
H. Section 15954 - BAS Communication Devices
I. Section 23 0904 - BAS Communication Devices
J. Section 15955 - BAS Software and Programming
K. Section 23 0905 - BAS Software and Programming
L. Section 15958 - Sequences 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. Contractor shall furnish and install a direct digital control and building automation system (BAS). The new BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform control sequences and functions specified. Refer also to control drawings, sequences of operation, and point lists.
B. The distributed digital control (DDC) and building automation system (BAS) defined in this specification shall interface with the University private VLAN, and shall utilize open communications. Towards this end, contractor shall provide a router/gateway(s) as necessary to facilitate all specified objects and services and have them configured/mapped as applicable.

C. The systems to be controlled under work of this section basically comprise {describe the scope of the project.} The HVAC systems being controlled are {describe the configuration of and the type of mechanical systems included in the project}. This Section defines the manner and method by which these controls function.

D. All control work shall be installed by the BAS contractor, unless specified otherwise. Certain mechanical systems such as chillers, boilers, cooling towers, and energy recovery units are equipped with manufacturer furnished controls. All labor, materials, equipment, software, and services necessary for the installation of a complete integrated system shall be provided.

1.04 APPLICATION OF OPEN PROTOCOLS

The following requirement applies only at the direction of UCB and must be carefully edited to achieve the Interoperability Level applicable to this project.

A. Subject to the detailed requirements provided throughout the specifications, the BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system utilizing BACnet. System components shall communicate using native BACnet in accordance with ASHRAE Standard 135 and current addenda and annexes, including all workstations, all building controllers, and all application specific controllers.

1.05 QUALITY ASSURANCE

The following requirement is relative to the demonstrated history of the product line they are proposing. Edit to suit project.

A. Product Line Demonstrated History: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of [5] years since date of final completion in at least [20] installations of comparative size and complexity. Documentation of this requirement with references shall be available upon request.

B. Installer's Qualifications: Firms specializing and experienced in control system installations for not less than [5] years. Firms with experience in DDC installation projects with point counts equal to this project and systems of the same complexity as those of this project. Experience starts with awarded Final Completion of previous projects. Documentation of this requirement with references shall be available upon request.

C. Installer's Experience with Proposed Product Line: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than [three] years from date of final completion on at least [5] projects of similar size and complexity. Submittals shall document this experience with references.

The following requirements relate to the key individuals who will be working on the project.
D. **Installer's Field Coordinator and Sequence Programmer Qualifications:** Individual(s) shall specialize in and be experienced with control system installation for not less than [5] years. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than [2] projects of similar [size] [and complexity]. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. {Edit as applicable} The proposed individuals must show proof of the following training:

1. **Product Line Training:** Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training offered by the Manufacturer on that product line for installation and configuration.

2. **Programming Training:** Individuals involved with programming the site-specific sequences shall provide evidence of the most advanced programming training offered by the vendor of the programming application offered by the Manufacturer.

E. **Installer's Service Qualifications:** The installer must be experienced in control system operation, maintenance and service. Installer must document a minimum [5] year history of servicing installations of similar size and complexity. Installer must also document at least a one year history of servicing the proposed product line.

F. **Installer's Response Time and Proximity**

1. Installer must maintain a fully capable service facility within a [45 mile] radius of the project site. Service facility shall manage the emergency service dispatches and maintain the inventory of spare parts.

2. Emergency response times are listed below in this section. Installer must demonstrate the ability to meet the response times.

G. **Installer's Quality Assurance Plan**

1. Installer must provide a description of their quality assurance operations from contract award through final delivery. The description shall include organizational responsibilities for each department represented within the execution of this document from installer’s to engineers, service technicians and management.

### 1.06 CODES AND STANDARDS

A. The following codes and standard intended to apply as applicable as not all will apply to all installations

B. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)


C. Electronics Industries Alliance

2. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification
3. EIA-232: Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
4. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes
6. EIA-472: General and Sectional Specifications for Fiber Optic Cable
7. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications
8. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications
9. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications

D. Underwriters Laboratories

   *The following rating is required only for devices used for smoke control purposes. If these are not intended, delete.*
   2. UUKL 864: UL Supervised Smoke Control

E. NEMA Compliance
   1. NEMA 250: Enclosure for Electrical Equipment
   2. NEMA ICS 1: General Standards for Industrial Controls.

F. NFPA Compliance
   1. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
   2. NFPA 70 National Electrical Code (NEC)

G. Institute of Electrical and Electronics Engineers (IEEE)
   1. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems
   2. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN
   3. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN

   *Edit the definitions below to apply for a given project.*

1.07 DEFINITIONS

A. **Accuracy**: As stated in Section 15951 [23 0913], accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

B. **Advanced Application Controller (AAC)**: A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications.

C. **Application Protocol Data Unit (APDU)**: A unit of data specified in an application protocol and consisting of application protocol control information and possible application user data (ISO 9545).

D. **Application Specific Controller (ASC)**: A device with limited resources relative to the Advanced Application Controller (AAC). It may support a level of programming and may also be intended for application-specific applications.

E. **BACnet/BACnet Standard**: BACnet communication requirements as defined by ASHRAE/ANSI 135-2004.

F. **BACnet Interoperability Building Blocks (BIBB)**: A BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBS are combined to build the BACnet functional requirements for a device in a specification.

G. **Binding**: In the general sense, binding refers to the associations or mappings of the sources network variable and their intended output required destinations.
H. **Building Automation System (BAS):** The entire integrated management and control system.

I. **Building Controller (BC):** A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems, acting as a communications router between the LAN backbone and sub-LANs, and data storage for trend information, time schedules, and alarm data.

J. **Change of Value (COV):** An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135-2004).

K. **Client:** A device that is the requestor of services from a server. A client device makes requests of and receives responses from a server device.

L. **Continuous Monitoring:** A sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).

M. **Controller or Control Unit (CU):** Intelligent stand-alone control panel. Controller is a generic reference and shall include BCs, AACs, and ASCs as appropriate.

N. **Control Systems Server (CSS):** This shall be a computer (or computers) that maintains the systems configuration and programming database. This may double as an operator workstation.

O. **Direct Digital Control (DDC):** Microprocessor-based control including Analog/Digital conversion and program logic.

P. **Functional Profile:** A collection of variables required to define the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.

Q. **Facility Maintenance Information Technology (FMIT):** Reference to the facility’s Information Technology department, responsible for providing and maintaining all OI hardware.

R. **Gateway (GTWY):** A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-2004).

S. **Hand Held Device (HHD):** Manufacturer’s microprocessor based device for direct connection to a Controller.

T. **LAN Interface Device (LANID):** Device or function used to facilitate communication and sharing of data throughout the BAS.

U. **Local Area Network (LAN):** General term for a network segment within the architecture. Various types and functions of LANs are defined herein.

V. **Local Supervisory LAN:** Ethernet-based LAN connecting Primary Controller LANs with each other and OWSs and CSSs. See System Architecture below. This LAN can function as the Primary Controlling LAN.

W. **Master-Slave/Token Passing (MS/TP):** Data link protocol as defined by the BACnet standard. (ASHRAE/ANSI 135-2004).

X. **Open Database Connectivity (ODBC):** An open standard application-programming interface (API) for accessing a database developed. ODBC compliant systems make it possible to access any data from any application, regardless of which database management system (DBMS) is handling the data.

Y. **Operator Interface (OI):** A device used by the operator to manage the BAS including OWSs, POTs, and HHDs.
Z. **Operator Workstation (OWS):** The user’s interface with the BAS system. As the BAS network devices are stand-alone, the OWS is not required for communications to occur.

AA. **Point-to-Point (PTP):** Serial communication as defined in the BACnet standard.

BB. **Portable Operators Terminal (POT):** Laptop PC used both for direct connection to a controller and for remote dial up connection.

CC. **Protocol Implementation Conformance Statement (PICS):** A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device (ASHRAE/ANSI 135-2004).

DD. **Primary Controlling LAN:** High speed, peer-to-peer controller LAN connecting BCs and optionally AACs and ASCs. Refer to System Architecture below.

EE. **Router:** A device that connects two or more networks at the network layer.

FF. **Secondary Controlling LAN:** LAN connecting AACs and ASCs, generally lower speed and less reliable than the Primary Controlling LAN. Refer to System Architecture below.

GG. **Server:** A device that is a provider of services to a client. A client device makes requests of and receives responses from a server device.

HH. **SQL:** Standardized Query Language, a standardized means for requesting information from a database.

II. **Smart Device:** A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. This differs from an ASC in that it typically deals only with one variable.

JJ. **University of Colorado at Boulder (UCB):** Owner of the facility.

KK. **UCB Ethernet:** Reference to the facility’s Information Technology network, used for normal business-related e-mail and Internet communication. Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser.

LL. **XML (Extensible Markup Language):** A specification developed by the World Wide Web Consortium. XML is a pared-down version of SGML, designed especially for Web documents. It allows designers to create their own customized tags, enabling the definition, transmission, validation, and interpretation of data between applications and between organizations.

**1.08 FUNCTIONAL INTENT**

A. Throughout Sections 15950 {23 0900} through 15955 {23 0905}, the Sequences of Operation, and Section 15959 {23 0801} detailed requirements are specified, some of which indicate a means, method or configuration acceptable to meet that requirement. Contractor may submit products that utilize alternate means, methods, and configurations that meet the functional intent. However these will only be allowed with prior approval by the University.

**1.09 SUBMITTALS**

A. Submit under provisions of Section {Insert Appropriate Section Number}.

B. **Electronic Submittals:** Control submittals and O&M information shall be provided in Adobe PDF or Microsoft Word format. Preferably documents will be converted from their native electronic format directly to a preferred format. Any documents scanned as
images must be converted to a searchable text format using OCR (Optical Character Recognition) and reduced in size prior to submission.

C. **Qualifications**: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate item above. Include QA/QC plan for all phases (design, install, Cx, warranty) along with documentation of industry standard QA/QC practices followed.

D. **Product Data**: Submit manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.

E. **Shop Drawings**: Submit shop drawings for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Each shop drawing shall contain the following information:

*Designer shall provide general panel locations on bid set mechanical floor plan documents.*

1. **System Architecture and System Layout**:
   a) One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, drawing reference number, and controller type for each control unit. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the diagram.

   *{Edit the following for the level of detail required, particularly with regard to open protocol application. (i.e. Campus wide implementations of BACnet require higher levels of coordination)}* Indicate device instance and MAC address for each CU. Indicate media, protocol, baud rate, and type of each LAN.

   b) Provide floor plans on Adobe PDF software locating all control units, LAN interface devices, gateways, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.

   *{Edit the following for the level of detail required, particularly with regard to open protocol application. (i.e. Campus wide implementations of BACnet require higher levels of coordination)}* Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans.

2. **Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices.** Include verbal description of sequence of operation.

3. **All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table**.

4. **With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number).** See Section 15955 {23 0905} - Part III for additional requirements.

5. **Label each control device with setting or adjustable range of control.**
6. Label each input and output with the appropriate range.

7. Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.

8. Provide a Control Valve Schedule listing valve and actuator information including: size, C_v, design flow, design pressure drop, manufacturer, model number, close off rating, control signal, etc. Indicate normal positions of spring return valves.

9. Provide a Control Damper Schedule listing damper and actuator information including: size, material, blade arrangement, manufacturer, model number, control signal, etc. Indicate normal positions of spring return dampers.

10. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination drawings on separate drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring, which are existing, factory-installed and portions to be field-installed.

11. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations. Provide panel layout drawing including power supply, control unit(s) and wiring terminals.

12. Sheets shall be consecutively numbered.

13. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.

14. Table of Contents listing sheet titles and sheet numbers.

15. Provide a symbol legend and list of abbreviations.

*Include the following whenever third party open applications will be accessing the control system.*

F. **Open Protocol Information**

1. BACnet Systems:
   a) BACnet object description, object ID, and device ID, for each I/O point.
   b) Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.
   c) Submit PICS indicating the BACnet functionality and configuration of each controller.

G. **Control Logic Documentation**

1. Submit control logic program listings to document the control software of all control units.
2. Include written description of each control sequence.
3. Include test plan for each unique control program.
4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.

H. **Operation and Maintenance Materials:**

1. Submit documents under provisions of Section {Insert Appropriate Section Number}. Documents shall be provided electronically as described above (1.10/B).
2. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.

3. Include all submittals (product data, shop drawings, control logic documentation, hardware manuals, software manuals, installation guides or manuals, maintenance instructions and spare parts lists) in maintenance manual; in accordance with requirements of Division 1. Only include sections for equipment and software used on this project. Do not provide entire catalog of product data with extraneous information.

4. Submit BAS User’s Guides (Operating Manuals) for each controller type and for all workstation hardware and software and workstation peripherals.

5. Submit BAS advanced Programming Manuals for each controller type and for all workstation software.

   I. Controls contractor shall provide University with all product line technical manuals and technical bulletins, to include new and upgraded products, by the same distribution channel as to dealers or branches throughout the warranty period of the project.

   J. Manufacturers Certificates: For all listed and/or labeled products, provide certificate of conformance.

   K. Product Warranty Certificates: UCB shall approve all warranty start dates. Coordinate and submit manufacturers product warranty certificates covering the hardware provided once approved.

1.10 PROJECT RECORD DOCUMENTS

   A. Submit documents under provisions of Section [Insert Appropriate Section Number]. Documentation shall be provided electronically as defined in section 1.10/B above.

   B. Record copies of product data and control shop drawings updated to reflect the final installed condition.

   C. Record copies of approved control logic programming and database on CD/DVD. Accurately record actual setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing.

   D. Record copies of approved project specific graphic software on CD/DVD.

   E. Record copies shall include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring.

   F. Provide record riser diagram showing the location of all controllers.

1.11 SYSTEM ARCHITECTURE

   A. The system provided shall incorporate hardware resources sufficient to meet the functional requirements of these Specifications. The Contractor shall include all items not specifically itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.

   B. The system shall be configured as a distributed processing network(s) capable of expansion as specified below.

   C. The system architecture shall consist of a Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) or multi-leveled LANs that support BCs, AACs,
ASCs, Operator Workstations (OWS), Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable. The following indicates a functional description of the BAS structure.

1. **UC WAN**: Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser. This is an existing infrastructure and contractor is not required to configure any components of this WAN. Refer to Section 15954 for requirements:

2. **Local Supervisory LAN**: The Local Supervisory LAN shall be an Ethernet-based, 100 Mbps LAN connecting Primary Control LANs and OWSs. The LAN serves as the inter-BC gateway and OWS-to-BC gateway and communications path. Contractor shall provide this as a dedicated LAN for the control system. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 5 cable with switches and routers that support 100 Mbps throughput. Power-line carrier communication shall not be acceptable for communications.

The following specifies a typical BACnet system

The higher level layers of this network shall be BACnet as described below:

a) **BACnet Supervisory LAN**: BACnet/IP as defined in Addendum A (Annex J) of the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet. Point/Object naming conventions are specified in 15955 - Part III.

3. **Primary Controller LAN** (‘Primary LAN’): High-speed, peer-to-peer communicating LAN used to connect AACs, ASCs and Building Controllers (BCs) and communicate exclusively control information. Acceptable technologies include:

   a) Ethernet (IEEE802.3)

4. **Secondary Controller LAN** (‘Secondary LAN’): Network used to connect AACs, ASCs or SDs. These can be Master Slave/Token Passing or polling, in addition to those allowed for Primary Controller LANs. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending requirements.

D. **Dynamic Data Access**: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.

E. **Remote Data Access**: Coordinate remote access connectivity with FMIT (Facilities Management Information Technology) department. The system shall support the following methods of remote access to the building data.

UCB uses Ethernet for campus wide BAS access. Special cases requiring dial-up connectivity will be addressed as needed by UCB.

1. **Browser-based access**: A remote user using a standard browser shall be able access all control system facilities and graphics with proper password. UC shall provide the required internet connection. The following paradigms are acceptable for browser-based access:

   a) Native Internet-based user interfaces (HTML, Java, XML, etc.) that do not require a plug-in. The user interface must be compatible with the most current stable version of the supporting software (Java, etc.) without requiring the user to downgrade to a lesser version.

F. The communication speed between the controllers, LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading...
condition. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements. Generally requirements do not apply when a remote connection must be established via modem:

1. 5 seconds between a Level 1 (critical) alarm occurrence and enunciation at operator workstation.
2. 10 seconds between a Level 2 alarm occurrence and enunciation at operator workstation.
3. 20 seconds between and a Level 3-5 alarm occurrence and enunciation at operator workstation.
4. 10 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controller.
5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.
6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.
7. 10 seconds between an operator selection of a graphic and it completely painting the screen and updating at least 10 points.

G. Control Systems Server (CSS): This shall be a computer (or computers) that maintain the systems configuration and programming database. This server may operate virtually under the supervision of FMIT. It shall hold the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers. It shall also act as a control information server to non-control system based programs. It shall allow secure multiple-access to the control information. Refer to Section 15952 [23 0902] - BAS Operator Interfaces for its requirements.

H. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. Refer to Section 15952 [23 0902] – BAS Operator Interfaces.

I. The BCs, AACs, ASCs, and SDs shall monitor, control, and provide the field interface for all points specified. Each BC, AAC, or ASC shall be capable of performing all specified energy management functions, and all DDC functions, independent of other BCs, AACs, or ASCs and operator interface devices as more fully specified in Section 15953 [23 0903] - BAS Field Panels.

J. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.

K. All line drivers, signal boosters, and signal conditioners etc. shall be provided as necessary for proper data communication.

1.12 WARRANTY MAINTENANCE

A. Contractor shall warrant all products and labor for a period of two years after Final Acceptance by UCB. Provide unit pricing for additional warranty years at discretion of UCB

B. The University reserves the right to make changes to the BAS during the warranty period. Such changes do not constitute a waiver of warranty. The Contractor shall warrant parts and installation work regardless of any such changes made by the University, unless the
Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS. Any disagreement between the University and the Contractor on such matters shall be subject to resolution through the contract ‘Disputes’ clause.

C. At no cost to the University, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:

1. Maintenance services shall be provided for all devices and hardware specified in sections 15951 through 15954. Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period.

2. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following notification by the University to the Contractor.
   a) Response by telephone to any request for service shall be provided within one (1) hour of the University's initial telephone request for service.
   b) In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the University's site within two (2) hours of the University's initial telephone request for such services, as specified.

3. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the University to the Contractor.
   a) Response by telephone to any request for service shall be provided within two (2) working hours (contractor specified 40 hr per week normal working period) of the University's initial telephone request for service.
   b) In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the University's site within three (3) working days of the University's initial telephone request for such services, as specified.

4. Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for University to call in the event of a need for service. At least one of the lines shall be attended at any given time at all times. Once contacted a technician shall respond to every call within 15 minutes.

5. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period.

6. Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from construction work and weather.
1.14 LISTING AND LABELING

A. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.

*The following should only be included when it is applicable, namely when the system is part of an engineered smoke control system. Smoke control and fire alarm systems should be segregated from the BAS in any new installations. Modify the applicability of this listing as appropriate.*

B. The BAS shall be listed by Underwriters Laboratories (UUKL 864) for supervised smoke control.
PART II. PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT
A. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where drawings or specs specifically allow existing materials to remain in place.

2.02 UNIFORMITY
A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.
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, roughing-in drawings and details shown on drawings.

B. Refer to additional requirements in other sections of this specification.

3.03 CONTROL PANELS, CONTROLLER QUANTITY AND LOCATION

A. Control panels shall consist of one or multiple controllers to meet requirements of this specification. Control panels shall be wall mounted within mechanical equipment rooms. In no case shall panels, other than terminal unit controllers, be located above ceilings. Control panels for lighting control may be located in the electrical equipment room served by the control panel only with prior approval from UCB.

B. Restrictions in applying controllers are specified in Section 15953 {23 0903}: BAS Field Panels. This Contractor shall extend power to the control panel from an acceptable power panel. If the control contractor wishes to further distribute panels to other locations, control contractor is responsible for extending power to that location also. Furthermore, contractor is responsible for ensuring adequate locations for the panels that do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.

C. It is the Contractor's responsibility to provide enough controllers to ensure a completely functioning system, according to the point list and sequence of operations.

D. For rooftop AHUs and ERUs, controllers rated for use outside the building envelope shall be mounted inside the unit casings. If adequate space is not available for installation of the controllers per the manufacturer's recommendations, they shall be installed in NEMA4X enclosures adjacent to the unit served. For all other controllers serving rooftop equipment coordinate with UCB for control panel location, typically within the building envelope directly below equipment served in an accessible location.

E. Controllers for terminal equipment:

1. For equipment located in the conditioned space, controllers shall be mounted inside the unit enclosure. Where sufficient mounting space is not available inside the unit enclosure, a control panel shall be installed above the drop ceiling, inside the room, as close to the room space sensor as possible. Coordinate with UCB to clarify acceptable mounting locations.

2. For equipment located above the drop ceiling, controllers shall be unit mounted. (Notify UCB if 36” clearance in front of control panel has not or cannot be provided.) Provide adhesive backed ceiling labels, affixed to ceiling grid below all ceiling concealed controllers, affix to ceiling panel access door for solid ceilings.
F. Laminated control drawings, including system control schematics, sequences of operation and panel termination drawings, shall be provided in panels for major pieces of equipment. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

3.04 SURGE PROTECTION

A. The Contractor shall furnish and install any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BCs, AAC/ASCS operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10% above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

3.05 DEMOLITION AND REUSE OF EXISTING MATERIALS AND EQUIPMENT {Include and edit if applicable}

A. Contractor shall assume that existing equipment that specifically is indicated to be reused is in good condition and is operable. Coordinate with UCB for clarification of reusable equipment. Contractor, during the course of work, shall inspect these devices and determine if any devices are in need of replacement or repair. Contractor shall prepare an itemized list of suggested repairs/replacement. This repair/replacement will be at the discretion of the University.

B. Existing wire, conduit, and control panel cabinets may be reused at the University Project Engineer’s discretion, but only if such materials or equipment comply with the applicable specification for new materials and equipment. Such materials shall not be reused if visibly damaged or otherwise unsuitable for the intended service.

C. Where such materials are reused, the contractor’s shop drawings shall reflect the existing wiring designation. If existing labeling is illegible or otherwise does not comply with the applicable specification for labeling, wiring runs shall be relabeled in accordance with the requirements specified elsewhere.

D. Existing pneumatic tubing and tubing conduit located between the existing BAS panels and the pneumatic operators may be reused as long as such materials comply with the applicable specification for new materials. Materials shall not be reused if visibly damaged or otherwise unsuitable for the intended service. All pneumatic tubing to be reused shall be pressure tested and all leaks shall be repaired. All reused pneumatic tubing shall be purged with dry air or nitrogen.

E. The existing pneumatic main air supply system shall be modified as required and reused to serve existing pneumatic controls that are to remain, and shall be extended as necessary to serve new pneumatic controls. Where existing pneumatic controls are removed, main air piping shall be removed back to the point of connection to the main air supply which remains in use, and shall be capped or plugged.

F. Existing valves and dampers and their operators may be reused only when preapproved by University. Contractor shall lubricate all damper linkages of dampers being controlled under this project.

G. Other materials and equipment not specifically mentioned herein may be reused only if specifically allowed by indications on the drawings and approved by UCB.

H. For HVAC systems which are indicated to receive a new BAS, all existing materials and equipment associated with the existing pneumatic controls and EMCS shall be
removed unless otherwise specified or indicated to remain, or unless reused in accordance with the above requirements, except for the following:

1. Conduit and electrical boxes (but not wiring within conduit) may remain in place if not reused (leave a pull line);
2. Inaccessible pneumatic tubing may remain in place if not reused. Tubing must be sealed and permanently labeled as “Abandoned in Place”.

Existing materials and equipment to be removed shall be removed subject to the requirements in paragraph “Sequence of Work”. For HVAC systems, which are not to receive a new DDC BAS, the existing pneumatic control system shall remain fully functional.

Include and edit the following only when applicable.

3.06 SEQUENCE OF WORK FOR EXISTING SYSTEMS CONVERSION

A. General: All work involving changeover of control functions from existing pneumatic control system to the new DDC BAS shall be performed in accordance with the following sequence in order to minimize the duration of equipment outages. The following descriptions are intended to indicate the sequence in which the work shall be performed, not to define fully the scope of the work.

B. Install operator’s terminal, peripherals, graphic software, and LAN prior to placing any equipment under the control of the new BAS.

C. Work which requires shutting down a pump motor, fan motor, or chiller shall be considered a utility shutdown and shall be subject to the restrictions specified in UCB’s power outage protocol “UCB Outage Notification Protocol”.

D. The following sequence applies to an individually controlled HVAC subsystem, such as an air handling unit. Only one such system shall be placed under manual control (as described below) at any given time.

1. Install controllers adjacent to (or within) existing control panel. Programming shall be complete (except for loading and debugging) prior to installation. Install all field devices, which do not require interruption of the existing control system.
2. Install all conduit, wiring, and pneumatic tubing which does not require interruption of the existing control system.
3. Remove existing controls including wiring, conduit, and tubing (except materials to be reused in accordance with provisions specified elsewhere) which must be removed to facilitate installation of new BAS materials and equipment.
4. Remove existing digital control system points (if applicable). Install and calibrate remainder of new BAS materials and equipment for this subsystem. Load controller software. Connect controller(s) to LAN.
5. Perform all field testing and calibration that does not require connection of permanent pneumatic outputs.
6. Remove remaining existing pneumatic and digital control system materials and equipment (except materials to be reused in accordance with provisions specified elsewhere). All existing digital controls equipment for those subsystems that have not yet been converted shall remain intact, on-line, and fully functional.
7. Schedule work in University occupied spaces 10 working days in advance with the University’s representative. Scheduling shall not be required for work in equipment rooms, electrical closets, and similar service areas.
3.07 CONTROL POWER SOURCE AND SUPPLY
   A. Section 15950 \[23 0900\] Contractor shall extend all power source wiring required for operation of all equipment and devices provided under Sections 15950 \[23 0900\] through 15955 \[23 0905\] and Sequences of Operation.
   B. General requirements for obtaining power include the following:
      1. All control panels shall be served by dedicated power circuits. BC control panels shall additionally be provided with external UPS power supplies to meet the requirements for BC power failure operation in Section 15954 \[23 0904\]. Control panel shall be labeled with electrical panel & circuit source.
      2. Where a controller controls multiple systems on varying levels of power reliability (normal, emergency, and/or interruptible), the controller shall be powered by the highest level of reliability served.
      3. Standalone Functionality: Refer to Section 15953 \[23 0903\].
   *The following applies to repair/renovation work where dedicated power circuits are not available.*
      4. Obtain power from a source that feeds the equipment being controlled such that both the control component and the equipment are powered from the same panel. Where equipment is powered from a 460V source, obtain power from the electrically most proximate 120v source fed from a common origin.
      5. Where control equipment is located inside a new equipment enclosure, coordinate with the equipment manufacturer and feed the control with the same source as the equipment. If the equipment’s control transformer is large enough and of the correct voltage to supply the controls it may be used. If the equipment’s control transformer is not large enough or of the correct voltage to supply the controls provide separate transformer

3.08 BAS START UP, COMMISSIONING AND TRAINING
   A. Refer to Section 15959 \[23 0801\] – BAS Commissioning

3.09 SEQUENCE OF OPERATION
   A. Refer to Section 15958 \[23 0993\] - Sequences of Operation

END OF SECTION 15950 \[23 0900\]