SECTION 230900 - BUILDING AUTOMATION SYSTEM (BAS) GENERAL

Note to the Design AE: The AE and project manager should discuss the project with Applicable UNC Facilities personnel. There is a 'Preface' document describing how to employ this and other UNC controls-related Guide Specifications. The AE is instructed to consult the Preface document for guidance on the nature of this specification, methods for deleting non-applicable text, and the use and deletion of Editor's Note's before proceeding to customize this specification.

PART I. GENERAL

I.1 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

I.2 RELATED DOCUMENTS

A. Section ***{Insert Applicable Specification Section}*** -Basic Mechanical Requirements.

B. Section 230901 - Building Automation System (BAS) Basic Materials, Interface Devices, and Sensors

C. Section 230903 - BAS Field Panels

D. Section 230904 - BAS Communication Devices

E. Section 230905 - BAS Software and Programming

F. Section ***{Insert Applicable Specification Section(s)}*** – Sequences of Operation

G. Section 230993 – Sequence of Operation

H. Section 230801 - BAS Commissioning

I.3 DESCRIPTION OF WORK

A. The HVAC distributed digital control (DDC) and building automation system (BAS) defined in these specifications shall furnish and install a complete LONMARK®

Building Automation System (BAS) for all mechanical systems and other facility systems as included in the project documents.

B. The distributed digital control (DDC) and building automation system (BAS) defined in these specifications shall interface with UNC's EBMS - Enterprise Building Management System. The EMBS is utilized by the Facilities Maintenance Department to coordinate all facility management activities including but not limited to: graphic page management, alarm management, trend management, scheduling management, setpoint changes, etc.

C. 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 or pneumatic actuation of dampers and valves to perform control sequences and functions specified. The BAS for this project will generally consist of monitoring and control of systems listed below. Reference also controls drawings, sequences of operation, and point lists.

D. 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.

I.4 ENTERPRISE BUILDING MANAGEMENT SYSTEM INTEGRATION

A. The Contractor is required to connect to and provide all control variables and network variables for control as described in detail in this and other specifications to the EBMS but generally include:

1. All Input and Output (I/O) points
2. Calibration variables for all I/O points
3. All setpoint variables. The controllers/systems to which these variables are applicable shall be bound and the name of the receiving variable shall be the same for these controllers/systems.
4. Zone Occupancy and setpoint adjustment variables. The controllers/systems to which these variables are applicable shall be bound and the name of the receiving variable shall be the same for these controllers/systems.
5. All system/building mode variables (Occupied, Unoccupied, Warm-up, Cool-down, Optimal Start/stop, etc.). The building controls contractor shall inform the EBMS Integrator of all occupancy commands required. The controllers/systems to which the occupancy commands are applicable shall be bound and the name of the receiving variable shall be the same for these controllers/systems.

I.5 APPLICATION OF OPEN PROTOCOLS

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 complying with the latest version of the ANSI/EIA standard 709.1 and the LonMark International Interoperability Standards.

I.6 PROCUREMENT

A. The BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system of the following manufacturer. No other vendor's products will be considered as substitutions.

B. Acceptable Manufacturers

1. Invensys Building Systems (IBS), I/A Series®
2. Johnson Controls Incorporated (JCI), Metasys® (Lon only, no BACnet or N2 product line)
3. Tour Andover Corporation (TAC), Vista®
4. Substitutions: None

I.7 QUALITY ASSURANCE

Use "A" to define any specific qualifications needed; otherwise leave "Reserved"

A. Reserved

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

B. **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 [***1***] year since date of final completion in at least [***10***] installations of comparative [***size***] [***and complexity***]. Submittals shall document this requirement with references.

The following requirement relates to the actual installing contractor.

C. **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 character as this project. If installer is a Value Added Reseller (VAR) of a manufacturer's product, installer must demonstrate at least three years prior experience with that manufacturer's products. Sub-Contractors for installation of wiring, tubing, and conduit must also meet these requirements. Experience starts with awarded Final Completion of previous projects. Submittals must document this experience with references. The firm shall have an office which is staffed with LONWORKS® trained engineers and technicians fully capable of providing instruction and routine emergency maintenance service on all system components within the requirements listed for warranty service.

The following requirement relates to the actual installing contractor's experience with the proposed product line. Edit to suit approach.

D. **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 [***one***] year from date of final completion on at least [***3***] 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.

E. **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.
3. **LonMark Training**: The LonMark BAS shall be furnished, engineered and installed by individuals who have completed the LonMark Network Design, Installation and Maintenance Training Program. Certifications shall be provided.

F. **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.

G. Installer's Response Time and Proximity

1. Installer must maintain a fully capable service facility within a 60 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.

I.8 CODES AND STANDARDS

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

B. Echelon Corporation

1. Junction Box and Wiring Guidelines for Twisted Pair LonWorks Networks (2003)

C. Electronics Industries Alliance

1. EIA-709.1-A-99: Control Network Protocol Specification
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-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.

D. Underwriters Laboratories

1. UL 916: Energy Management Systems.

The following rating is required only for devices used for smoke control purposes. If these are not intended, delete. The designer will list each device that has to be UUKL IN SECTION 230903.

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 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

H. Telecommunication Industry Association

1. ANSI/TIA/EIA 568: Commercial Building Telecommunication Cabling Standard (2001)

I.9 DEFINITIONS

A. **Acknowledged**: The data is transmitted repeatedly until an acknowledgement is received. This type of service should be used for critical data using one to one bindings only. This type of service shall not be used for one to many bindings.

B. **Adjustable (Adj):** A characteristic of a control logic parameter such that it can be varied by the operator without downloading the program. See also initial value.

C. **Analog Calibration Offsets**: For all analog input measured variables with the exception of velocity pressure, there is a requirement to adjust the value measured by the hardware based analog input point to match the value reported by a certified test instrument. An analog calibration offset is a parameter that can be added or subtracted from the raw value measured by the sensor to produce a calibrated value that will be use by the control logic and reported to the operator workstations. The initial value of this parameter is set at zero and it is adjusted when the calibration process is executed. This adjustment is referred to as a single point calibration. These parameters are

mandatory for all analog inputs except velocity pressure sensors (requirements for velocity pressure sensors are presented elsewhere). These offset values are configuration parameters and as such shall be written to EEPROM

D. **Application Programming Tool**: A vendor unique software tool used to create applications for programmable controllers

E. **Application Specific Controller**: (ASC). An application specific controller is one which has a fixed program installed during manufacturing which cannot be changed. These controllers can typically be configured to fit specific circumstances, but only within a narrow range. For example, a VAV controller would be configured to select the type of reheat (none/hot water/staged electric), pressure independent/dependent box, fan powered/no fan, and other similar options, but could not be set up to control an AHU or chiller. Generally not considered Primary Control Units. See Programmable Controller.

F. **Academic Technology and Networking (ATN)**: Refers to an organizational name of a division within UNC-CH

G. **Bandwidth Utilization**: The average utilization of the network capacity. The TP/FT-10 (ANSI/EIA 709.3) LonTalk network operates at 78Kb per second. Network loading is controlled by the use of event driven transmission based data propagation and the use of appropriate binding services.

H. **Building Automation System Panel (BASP):** A panel containing one or more digital controllers and ancillary equipment (relays, E/Ps, HOA switches, termination strips, control transformers, etc.)

I. **Binding**: The concept of associating an output network variable from one device to the input network variable of a second device. There are three types of bindings:

a) One to One: A single output network variable is bound to a single input network variable

b) One to Many: A single output network variable is bound to input network variables on multiple devices.

c) Many to One: Output network variables from multiple devices are bound to a single input network variable on a different device. This is not well supported in Lon.

J. **Broadcasting**: The propagation of data from a device to the control network. Broadcast messages are sent to every device on the control network (or subnetwork). This is typically used for network control, not normal communication of application information. See Unicast.

K. **Building Automation System (BAS)**: The entire building energy management and control system

L. **Building Point of Connection (BPOC):** This gateway device defines the connection point between the BAS and the EBMS and performs the translation between the Lon-based building and the Web Services based EBMS. Depending on building size and/or complexity, multiple BPOCs may be required for a single project.

M. **Bus Topology**: A term used to describe the sequential connection of devices on a LON segment. The communication cable runs from device to device with no tees or stubs from the main communication cable to a device.

N. **Change of Value (COV)**: An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135-1995).

O. **Channel**: A LON network consisting of two or more segments connected by a physical layer repeater(s) or router(s) configured as a repeater(s). Each segment can support a theoretical limit of 64 connections.

P. **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.

Q. Configuration Parameter (CP):

1. A value used in control logic that is generally fixed at installation and is not changed by control logic. For example, a minimum flow setting for a VAV box.
2. In Lon networks, a Network Configuration Input (nci) that is written to the EEPROM. nci's are used for device configuration according to definition 1).

In either definition, configuration parameters can be changed periodically from the LCS but are not changed routinely as a function of control logic. See SCPT.

R. **Connection**: A connection is made when a device is physically connected to the TP/FTT-10 communication cable. Devices that count against the number of connections limit include LON Talk Adapters (PCLTA, PCC 10 etc.), any sensor, actuator or controller with a NodeID, and a router or repeater. Terminators are not considered to be a connection.

S. 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)

T. **Controller or Control Unit (CU)**: A microprocessor-based piece of hardware that connects to the control network and has either 1) at least one hardware I/O point and/or 2) is capable of executing application control logic. Controller is a generic reference, they may be further differentiated into Primary Control Units and Secondary Controllers. Controllers may also be categorized as ASCs or PCs. See ASC, PCU, PC, SCU.

U. **EMCS VLAN:** Reference to University of North Carolina Chapel Hill Information Technology virtual network, used for communication with the Enterprise Building Management System and the local building control systems on campus. Building control systems should be connected to this VLAN only through translating gateways which provide Web Services characterized by XML making use of published schema and SOAP as characterized by the W3Consortium.

V. **Enterprise Building Management System (EBMS)**: Used by UNC to coordinate all facility management activities including but not limited to: graphic page management, alarm management, trend management, scheduling management, etc…

W. **Equipment Distribution Room (EDR)**: Storage for telecommunications equipment for the EMCS network at the building level.

X. **Device**: Any control hardware. Includes sensors, controllers, actuators, routers, gateways, etc.. Often used interchangeably with "controller".

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

Z. **Enumerated SNVT**: An enumerated SNVT defines the format of a single piece of data using a state description concept. The data will consist of a series of integers and each integer shall convey a defined condition or state. The list of available enumerated SNVT types is defined in the LonMark Standard Enumeration Master List, dated May 2002. This document is available on the Echelon.com web site or from LonMark International.

AA. **Error Rate**: A measurement of communication quality that assesses the number of defective data packets as a percentage of the total number of data packets. Defective data packets are generally the result of poor installation practices or improper cable selection, but may be due to excessive network traffic.

BB. **Event Driven Communication**: A term used to describe the propagation of data from a device to the network where the device with the data transmits the device based on internal conditions rather than being polled from the data recipient. The send on delta parameter is used to define the event and the data propagation is further controlled by the minimum and maximum send time parameters.

CC. **Floating Control.** A common method of controlling an electric actuator. Instead of using an Analog Output, the controller uses two Binary Outputs. One output is connected to the "Open" terminal of the actuator, the other output to the "Close" terminal of the actuator. By providing pulses of the proper duration, the actuator can be opened or closed to any arbitrary position. A typical actuator might require 50 seconds to fully stroke; if the actuator starts at 20% open, a 15 second "Open" command would result in the actuator being 50% open. This method is subject to drift over time, and in the absence of actuator position feedback, requires a periodic re-zero where the actuator is driven either fully Open or fully Closed.

DD. **Free Topology**: A data wiring topology supported by LonWorks that allows for loops, tees, y-connections etc. When this topology is used only one terminator of a specific design is required and allowable cable lengths are significantly reduced. Guidelines on the application of this concept are available from www.Echelon.com.

EE. Functional Profile: See LonMark Profile.

FF. **Gateway (GTWY)**: A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-1995).

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

HH. **Host-Based Controller**: A term applicable only to Lon-based controllers where a processor other than a Neuron chip to is used to execute application control and I/O processes.

II. **Human-Machine Interface (HMI)**: A human-machine interfacing that allows the operator to manage, command, monitor, and program the system

JJ. **LNS:** Lon Network Services. A standard network database format for Lon systems developed and owned by Echelon Corporation. LNS is used and supported by most, but not all Lon vendors.

KK. **Local Control Station (LCS)**: A computer/server located within a building or group of building on the UNC EMCS VLAN that provides a platform for the vendor's device and network programming and configuration tools. The LCS will connect to the building ANSI 709.1 control network and serve as the primary platform for use of the engineering tools needed to troubleshoot and significantly alter system performance.

LL. **LON:** A group of protocols and technologies originally developed by the Echelon Corporation. In general usage, LonTalk or the "Lon network" is synonymous with the ANSI 709 network protocol. LonWorks generally refers to the technology as a whole: the ANSI 709 network and vendor products/solutions/systems based on it.

MM. **LonMark International**: (LM) or (LMI). An industry association of Lon vendors (formerly the Lon Mark Association) dedicated to the development of standards for and promotion of open Lon-based systems. LonMark Certification, functional profiles, SNVTs, and SCPTs are all products developed by LonMark International. http://www.lonmark.org

NN. **LonMark Profile**: To enhance interchangeability of control components at the sensor, actuator, terminal unit controller and package equipment controller level, LonMark International has created profiles that define the network image for these devices. These profiles define mandatory input and output variables and configuration parameters and a required format for each. Conformance to a LonMark profile provides to the facility owner the opportunity to replace a control component manufactured by one vendor with a similar component manufactured by a different vendor provided the embedded application of the replacement controller meets the sequence of control requirements.

OO. **Managed Communication**: The transmission of data from a controller to a data manager, which in turn re-transmits the data to a second controller. In some systems the data manager is referred to a Network Controller. Often, controllers cannot imitate communication on the network, they must be periodically queried by the Network Controller. See peer-to-peer.

PP. **Manual Control**: A concept where the operator from the operator workstation takes control of an end device and forces a specific position or state. From a software perspective, the value produced by the control logic is not allowed to affect the position or state of the end device. The manual mode and the desired manual position or states are parameters that are set by the operator.

QQ. **Many to One**: Output network variables from multiple devices are bound to a single input network variable on a different device. Not well supported by Lon networks.

RR. **Maximum Send Time**: An adjustable parameter that defines the maximum time period between transmissions of a software object's data to the network. Should the

value of a software object remain constant over an extended period of time, the value will be retransmitted once every maximum time period.

SS. **Minimum Send Time**: An adjustable parameter that defines a mandatory time period during which no transmission of data will occur. This parameter will prevent data from being transmitted more often than once per minimum send time. Once this time period has been exceeded without a transmission, the send on delta parameter or the maximum send time parameter shall determine when a transmission is initiated.

TT. **Multiple Controller Integrated Control (MCIC)**: A concept where multiple controllers with I/O are used to control a single mechanical system such as an air handling unit. Under this concept the mechanical system is sub-divided into a collection of processes to be controlled such as the fan start stop circuit, the fan variable speed drive, the mixed air section, the cooling coil section etc. With this concept all primary measured variables and the end device associated with a single process along with the primary control logic for the process shall be contained within a single controller. Secondary data from one process that affects the control of another process may be sent from one controller to the primary controller controlling the process. If the data being received over the network only affects the general thermodynamic or psychometric performance of the process but does not have a significant affect on safety or equipment protection then unacknowledged repeated binding services shall be used. If the data being received over the network does have a safety or equipment protection impact, then acknowledged repeated binding services shall be used. In both cases peer to peer communication is mandatory. All of the controllers must be on the same channel. Managed communication shall not be used to move data between the multiple controllers.

UU. **nci:** Network Configuration Input. An input to a controller intended to be used for a Configuration Parameter. The nci is further categorized by the parameter type, often a SCPT.

VV. **Node ID (Neuron ID)**: A unique 48-bit number assigned at manufacturing time to every Lon device. While the technical term is Node ID, Neuron ID is the commonly used substitute (since most Lon devices use a Neuron chip to implement the Lon network protocol). This is the MAC address for the Lon network.

WW. **nvi:** Network Variable Input: An input to a Lon device intended to be used to input application control data from the network. In Lon networks, controller A sends data to controller B by binding a nvo from controller A to a nvi at controller B. nvis are further categorized by the SNVT type. See nvo

XX. **nvo:** Network Variable Output: An output from a Lon device intended to be used to output application control data to the network. In Lon networks, controller A sends data to controller B by binding a nvo from controller A to a nvi at controller B. nvos are further categorized by the SNVT type. See nvi

YY. **One to Many**: A single output network variable is bound to input network variables on multiple devices.

ZZ. **One to One**: A single output network variable is bound to a single input network variable

AAA. **Operator Interface (OI)**: A device used by the operator to manage the BAS including LCSs, and POTs,.

BBB. Peer-to-Peer. A communications protocol where any network device can initiate transmission on the network and send data directly to any other network device. Peer-to-peer networks are often described as being "logically flat" since there is no hierarchy where some controllers have better communication capabilities than others. (As a technical aside, peer-to-peer networks may have routers and repeaters.) See Managed Communication.

CCC. Polling Communication: The concept of a control device requesting a network variable from a second control device at a specified interval. Polling communication is typically used to populate dynamic data on an active graphic page and for temporary or short term trending of data where the trend data is not stored at the controller level. See Event Driven Communication.

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

EEE. **Primary Control Unit (PCU)**: A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems. Has "above average" capabilities in terms of I/O count, program complexity, ability to execute supervisory control functions, or general robustness. See Secondary Controller.

FFF. **Programmable Controller (PC)**: A controller that does not contain a fixed application program. A generic device that can be programmed to run any sequence, subject to complexity and I/O restrictions of the controller. See Application Specific Controller.

GGG. Plugin: In Lon networks, a plugin is a software application that runs under an LNS compatible network management tool and provides a user-friendly interface for device configuration. Plugins are almost always associated with ASCs, not programmable controllers.

HHH. Repeater: A physical device used to connect two segments. A repeater does not filter any message traffic. A repeater does isolate physical problems such as short circuits to a single segment and is typically required to allow the use of additional devices or additional cable length.

III. **Router**: Is an active LonWorks compatible device that physically connects two or more LonWorks channels. Routers perform filtering of network traffic by receiving a message on one channel, and making a decision whether the message needs to be transmitted on the other channel.

JJJ. SCPT: Standard Configuration Property Type. These are ncis as defined by LonMark International for device configuration. Similar to SNVTs, SCPTs are used to define device configuration information in an open standard. See UCPT.

KKK. Secondary Controller: A controller with more limited capabilities than a Primary Control Unit. Usually an ASC. See PCU.

LLL. **Segment**: A single section of a LON network that contains no routers or repeaters.

MMM. Send on Delta: An adjustable parameter that defines a requirement to transmit when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data this parameters defaults to a change of state. The transmission of data is initiated when this criteria and the minimum send time requirement have been met. See Event Driven Communications.

NNN. **Simple SNVT**: A simple SNVT defines the format of a single piece of data. The definition of a simple SNVT in the master list of SNVTs will include the type of variable being measured (temperature, electric current, power etc.), the data type (signed integer, unsigned integer, floating point etc.), the data range, the resolution of the data and the engineering units.

OOO. **Smart Device/Smart Sensor/Smart Actuator**: A control I/O device such as a sensor or actuator that can directly communicate with the controller network to which it is connected. Many of these devices incorporate control capability, generally a PID loop. These devices are classed as Secondary Controllers. VFDs are often equipped with a Lon interface, making them a type of smart actuator. Most VFD smart actuators incorporate a PID loop with a configurable setpoint and a hardware AI point, allowing them to perform stand alone closed-loop control on their own output.

PPP. SNVT: An acronym for STANDARD NETWORK VARIABLE TYPE. A SNVT is a data format statement for implicit (open) communication on a LonTalk network. The current master list of SNVTs is available from LonMark International in a document defined as SNVT Master List. (While technically a SNVT is a variable *type*, for example "temperature", the term is often used to mean the variable itself, for example "The SNVT 'Supply-Air-Temp' has SNVT type 'temperature'". Where these specifications say "SNVT type", they refer to the type, "SNVT name" refers to the network variable itself) See UNVT.

QQQ. **Stand-Alone Controller**: A stand alone controller has provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air handling unit, chiller or boiler. The controller shall also have embedded in it all of the control logic that associated the physical inputs to the physical outputs. A stand-alone controller may rely on other networked devices for time schedule inputs and trend data storage.

RRR. **Structured SNVT**: A structured SNVT defines the format of a network variable that contains several different data elements. A simple SNVT or an enumerated SNVT may define each data element within a structured SNVT.

SSS. **Supervisory Logic**: The concept of gathering performance data from multiple terminal units to determine if a specific condition exists within the family of terminal devices. Examples: Are any of the VAV terminals supported by a particular AHU operating the reheat processes? Is there an indication from any of the control zones that an occupant has requested the temporary operation of the air delivery system?

TTT. **Terminator**: An electronic component that consists of a resistive and/or capacitive circuit specifically designed to enhance the quality of communications on a segment. On a bus topology, a terminator is connected to each end of a segment. For a channel

consisting of two bus topology segments, a total of 4 terminators are required, one at each end of each segment.

UUU. **Test Mode**: A concept where the operator from the operator work-station can interrupt the flow of data from a sensor to the control logic and insert a mandatory test value or test state to be used by the control logic. The test mode and the desired test value or states are parameters that are set by the operator.

VVV. **UCPT**: User defined Configuration Property Type. A vendor-defined configuration property type. This is essentially proprietary to a vendor; however its use does not close the system since the use of configuration properties is not part of executing normal control applications. See SCPT.

WWW. **Unacknowledged Repeated**: The data being transmitted is sent three times and an acknowledgement of receipt is not required. This type of service shall be used for most process control related data requiring timely receipt of the data.

XXX. **Unacknowledged Send**: The data being transmitted is sent one time and an acknowledgement of receipt is not required. This type of service shall be used for non-critical data where there is no significant impact should the receiving device have to wait for the next transmission.

YYY. **Unicast**: A message sent on the control network to a specific destination device. The vast majority of data transmissions for control purposes are unicast, where one controller sends data to a second controller. See Broadcast.

ZZZ. **UNVT**: User defined Network Variable Type. A vendor defined network variable type. This is essentially proprietary to a vendor and its use creates closes the system by creating a proprietary exchange of data necessary for executing control applications. See SNVT.

AAAA. **XIF File**: A file indicating the interface specifications for LonMark devices.

I.10 FUNCTIONAL INTENT

A. Throughout Sections 230900 through 230905, the Sequences of Operation, and Section 230801 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, at the sole discretion of UNC.

B. The intent of these specifications is to provide an open system which can be maintained and modified by various competing service providers of UNC's selection, at no cost disadvantage to local dealers, resellers or manufacturers' service branches. Any restriction or limitation imposed on the aftermarket (including but not limited to restrictions on provision of technical or product information, restrictions or price discrimination in providing software and software licensing, and restrictions or price discrimination in selling parts) which has the intent or effect of creating such limitation on aftermarket competition shall be disclosed to UNC, in writing, no later than

submission of submittals. If the Contractor is in doubt as to whether a practice or policy of the manufacturer would constitute such a restriction on aftermarket competition, the Contractor is advised to notify UNC of the practice or procedure. If UNC determines that a product line is sold subject to material impediments to aftermarket competition, UNC may reject such product line and require the Contractor to install a different, compliant, product line at no additional cost to UNC. This requirement can alternatively be met by granting UNC the status of a dealer, with all rights of dealers and a purchasing multiplier the same as local dealer(s), if under that manufacturer's policy dealers are given rights to install and support systems of any size and complexity without limitation.

I.11 SUBMITTALS

A. Submit under provisions of Section ***{Insert Appropriate Section Number}***. Refer to Section 230801 for additional Commissioning Submittal requirements.

B. **Electronic Submittals**: While all requirements for hard copy submittal apply, control submittals and O&M information shall also be provided in electronic format as follows.

1. **Drawings and Diagrams**: Shop drawings shall be provided on electronic media as an AutoCAD 2003 or later version of AutoCAD, or in Visio format. During the initial submittal approval process the drawings can be submitted in PDF format. All 'x reference' and font files must be provided with AutoCAD files.
2. **Other Submittals**: All other submittals shall be provided in Adobe Portable Document Format

C. **Qualifications**: Manufacturer, Installer, and Key personnel qualifications as indicated for the appropriate item above.

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. **Shop Drawings**: Submit shop drawings electronically on AutoCAD 2003 software 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:

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, address, Node ID, drawing reference number, and controller type for each control unit. Indicate media, and type of each LAN. All optical isolators, routers, repeaters, end-of-line terminators, junctions, ground locations etc. shall be located on the diagram.
   b) Provide floor plans locating all control units, workstations, servers, gateways, etc. Include all and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, address, Node ID, drawing reference number, and controller type for each control unit. Indicate media, and type of each LAN. All optical isolators, routers, repeaters, end-of-line terminators, junctions, ground

locations etc. shall be located on the floor plans. 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.

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, SNVT name, SNVT type, and alarm limits as appropriate, See Section 230905 - 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. With each schematic, provide valve and actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.
9. 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 is existing, factory-installed and portions to be field-installed.
10. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
11. Sheets shall be consecutively numbered.
12. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
13. Table of Contents listing sheet titles and sheet numbers
14. Legend and list of abbreviations
15. Memory allocation projections
16. Submit along with shop drawings but under separate cover calculated and guaranteed system response times of the most heavily loaded LonTalk LAN in the system.

F. Lon Works Device and Protocol Information

1. Binding table indicating all SNVTs, used in the project, SNVT names, SNVT Types, Node ID and domain, subnet and channel address, and associated bound

variables. Clearly indicate which parameters of a functional profile are bound and which can be overridden.

2. A point binding diagram shall be provided with each control schematic depicting all bound network variables along with the associated functional profiles. Binding diagram shall list SNVTs for control functionality, SNVTs bound to the BPOC, and SNVTs for scheduling. For SNVTs bound to the BPOC, indicate if the point is a monitoring point, an override point, or an alarm point. Each point shall clearly indicate the SNVT name (i.e. the name used to bind the variable in the ANSI 709 network) and SNVT type.
3. For Application Specific Controllers: LNS plugins (or documentation of configuration properties and a request to use an ASC without a plugin) and LonMark functional profile certifications (or evidence of self-certification and a request to use a non-certified controller)
4. For Programmable Controllers: Application program source code, application programming tool (x licenses ***designer to obtain required number of licenses from UNC***) and associated files required for all controllers.
5. Backup of systems configuration information, application programs, and LNS database on CD. This shall be provided at substantial completion and at the end of the warranty period.
6. XIF files for all LonMark components.

G. BPOC Information

1. LonWorks NodeID, domain, subnet, node address.
2. Web Services description Language
3. Binding table indicating all SNVTs bound to the BPOC listing SNVT name, type, whether it is a nvi or nvo, and description
4. Documentation of use of WebServices to access all SNVTs bound to BPOC, schedules, and any other control functionality in the BPOC.
5. Documentation of system modes in the BPOC and scheduled controllers sufficient to allow modification of schedules via Web Services
6. If the BPOC includes control functionality, contractor shall provide additional submittals as if BPOC were a device of that type (for example, Lon Works Device and Protocol Information, application software source code, etc.).

H. **Compressed Air Systems**: ***{Designer include this section only when applicable}***

1. Product data including rated capacities of selected models, weights (shipping, installed, and operating), furnished specialties, and accessories; indicating dimensions, required clearances, and methods of assembly of components, and piping and wiring connections.
2. Wiring diagrams from manufacturers detailing electrical power supply wiring to equipment. Include ladder-type wiring diagrams for interlock and control wiring required for final installation. Differentiate between portions of wiring that are factory-installed and portions that are field-installed.
3. Pneumatic piping plan and riser layouts including all main air and branch air piping sizes, and calculated pressure losses for all pneumatic lines to all components, devices, and panels.

4. Certificates of shop inspection and data report as required by provisions of the ASME Boiler and Pressure Vessel Code.

I. **Framed Control Drawings**: Laminated control drawings including system control schematics, sequences of operation and panel termination drawings, shall be provided in panels and mounted in a suitable frame with a .125" Lexan polycarbonate cover for major pieces of equipment. Drawings should be of sufficient size to be easily read. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

J. Control Logic Documentation

1. Submit control logic program listings (for graphical programming, if the requirements below are met) and logic flow charts illustrating (for line type programs or ASCs) to document the control software of all control units.
2. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Graphic programs that provide simple blocks connected by multiple lines that are not specific in detail and easily understandable are not acceptable. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation with all requirements of the sequence provided in detail. Provide in detail all virtual and real points, variables, PID loops, reset blocks, switches, timers, high/low selectors, alarms, proofing modules, staging blocks, etc. to fully describe the sequence of operation.
3. Include written description of each control sequence.
4. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters and limits.
5. Sheets shall be consecutively numbered.
6. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.
7. Include Table of Contents listing sheet titles and sheet numbers
8. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set will count toward the required number of Operation and Maintenance materials specified below and in Section ***{Insert Appropriate Section Number}***.

K. Operation and Maintenance Materials:

1. Submit documents under provisions of Section ***{Insert Appropriate Section Number}***. (*X*) copies of the materials shall be delivered directly to the Owner's facilities operation staff along with an electronic (PDF format) version, in addition to the copies required by other Sections.
2. Submit maintenance instructions and spare parts lists for each type of control device, control unit, and accessory.
3. Submit BAS User's Guides (Operating Manuals) for each controller type and LCS software.
4. Submit BAS advanced Programming Manuals for each controller type and for all LCS software.

5. 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.

L. Controls contractor shall provide UNC 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. This service will be provided for 5 years as part of the contract price, and will be offered to UNC thereafter for the same price as to a dealer or branch.

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

L. **Product Warranty Certificates**: submit manufacturers product warranty certificates covering the hardware provided.

M. **Software Licenses**: Provide required copies of all licenses for software, to include both software loaded on LCS's and software loaded or embedded in controllers or other network devices.

I.12 PROJECT RECORD DOCUMENTS

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

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 paper and on CD's. 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 CDs.

E. Provide as-built network architecture drawings showing all LonTalk nodes, including Node ID and domain, sub-network and channel addresses.

F. 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. Indicate drawing reference number.

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

H. Maintain project record documents throughout the warranty period and submit final documents at the end of the warranty period

I.13 SYSTEM ARCHITECTURE

A. Application of Open Protocols

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 the latest version of the ANSI/EIA standards 709.1, 709.3 and the LonMark International Interoperability Standards.

B. 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.

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

D. The system architecture shall consist of a Local Area Network (LAN) that support controllers and Local Control Stations (LCS) as applicable. The following indicates a functional description of the BAS/EBMS structure.

1. **EMCS VLAN**: 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 VLAN. ***Designer to coordinate Ethernet port requirements below with Division 16 design requirements***.

   An EMCS VLAN Network Port will be installed inside each major fan system control panel to provide access to the EBMS. This work is not part of this Contract and is to be installed by UNC.

2. **BPOC:** The contractor shall provide, install and configure the BPOC as described elsewhere in these specifications. Contractor shall connect BPOC to EMCS VLAN using network ports provided by UNC.

3. **LCS:** UNC shall provide a computer for hosting the LCS and connect it to the EMCS VLAN. The contractor shall install the vendor's engineering tools (device and network programming, configuration, etc.) tools on this computer and shall connect this computer to the building control network. UNC will require written notification 3 weeks prior to the need for the computer.

4. **ANSI 709.1 h**igh-speed, peer-to-peer communicating LAN used to connect BPOC(s), LCS computer, and controllers. The LonTalk standalone BAS shall be comprised of a network of PCUs and other Lon controllers and devices performing stand-alone control, supporting LonTalk protocol (ANSI 709.1) and shall utilize ANSI 709.3 twisted pair, TP/FT-10 bus topology communicating at 78 kbps. All network data exchange required for applications shall be via SNVTs; no other form of inter-device network communication is allowed. Each segment shall meet performance and standalone requirements, and to meet the requirements for response time, trending and bandwidth utilization as specified elsewhere in the specifications. A terminator shall be installed at both ends of each segment. It is the responsibility of the installing contractor to employ Lon routers and network segmentation as needed and to design an overall LAN topology that ensure that bandwidth utilization limits are met. *Exception: With the prior approval of UNC,*

vendors may utilize TP/XF-1250 media instead of TP/FT-10 for portions of the control network. The only hardware that may be connected to such a TP/XF-1250 network is the LCS computer, the BPOC(s), and Lon routers. No DDC controllers may be connected directly to the TP/XF-1250 media,

E. **Dynamic Data Access**: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers, BPOCs, and LCS.

F. **Remote Data Access**: Remote access to the System will be through the EBMS.

G. The communication speed between the controllers and the LCS and/or BPOC shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with shop drawings including calculations to support the guarantee. 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.

1. 7 seconds between an operator command via the BPOC to change a setpoint and the subsequent change in the controller.
2. 3 seconds between an operator command via the BPOC to start/stop a device and the subsequent command to be received at the controller.
3. 5 seconds between a change of value or state of a network variable and it being updated at the BPOC. (subject to limitations imposed by the minimum send time parameter).

H. The PCUs, shall monitor, control, and provide the field interface for all points specified. Each PCU shall be capable of performing all specified energy management functions, and all DDC functions, independent of other PCUs and operator interface devices as more fully specified in Section 230903 - BAS Field Panels.

I. **Systems Configuration Database**: The system architecture shall support maintaining the systems configuration database on the LCS computer. User tools provided to the Owner shall allow configuring, updating, maintaining, etc. current configurations and settings whether they are initiated at the server or the end device.

1. Database Schema shall be published and provided to the Owner to facilitate easy access to the data.
2. The network database shall be LonWorks Network Services (LNS) (latest version). The Network Management Application shall be fully compatible with LNS, capable of reading and writing LNS databases, and is to be used for commissioning and management of the LonTalk control architecture. The network management service tool shall remain on the project as the property of the University. A copy of the :LNS network database shall be archived on the service tool, documenting system bindings and node addressing. In addition all system variables shall have a plain English language description for each variable. This service tool shall be used for all system maintenance and expansion, so that the network database backup remains current.

J. Interruptions or fault at any point on the Lon network shall not interrupt communications between other nodes on the network.

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

L. Anytime any controller's database or program is changed in the field, the controller shall be capable of automatically uploading the new data to the LCS

I.14 WARRANTY MAINTENANCE

A. Contractor shall warrant all products and labor for a period of ***{Insert warranty period}*** after Final Acceptance.

B. The Owner reserves the right to make changes (set point changes, deadbands and tuning adjustments) 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 Owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

AE shall consult with UNC personnel prior to specifying the response times. Quicker response times may be dictated by the type of systems and facility. Edit to suit the project

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

1. Maintenance services shall be provided for all devices and hardware specified in sections 230901 through ***{Insert Additional Specification Sections as applicable}***. Service all equipment per the manufacturer's recommendations. All devices except owner excluded equipment and terminal level equipment 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 telephonic notification by the Owner to the Contractor.

AE shall consult with UNC personnel prior to specifying the 24/7/365 response time.

a) Emergency service shall be provided 24 hours per day, 7 days per week, and 365 days per year with no exceptions and at no cost to the Owner.

b) Response by telephone to any request for service shall be provided within two (2) hours of the Owner's initial telephone request for service.

c) 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 Owner's site within four (4) hours of the Owner'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 Owner to the Contractor.

a) Response by telephone to any request for service shall be provided within eight (8) working hours (contractor specified 40 hr per week normal working period) of the Owner'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 Owner's site within three (3) working days of the Owner's initial telephone request for such services, as specified.

4. At any time during the warranty period the Contractor is on site for maintenance, emergency, or normal service the Contractor shall notify the Owner via UNC Building Services and the local building operating personnel. The Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition no work affecting system operation shall commence until express permission is granted. After the work is completed a work order ticket describing in detail all work performed (i.e. hardware replaced or serviced, software or firmware modifications made, etc.), hours worked, follow-up work required, etc., must be signed by an authorized building operators or UNC Building Services personnel.
5. Owners Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for Owner 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. Alternatively, pagers can be used for technicians trained in system to be serviced. One of the three paged technicians shall respond to every call within 15 minutes.
6. Technical Support: Contractor shall provide technical support by telephone throughout the warranty period at no cost UNC.
7. Preventive maintenance shall be provided throughout the warranty period in accordance with the hardware component manufacturer's requirements.
8. In the last month of the warranty period, all System software and controller firmware, software, drivers, etc. will be upgraded and validated to the latest release (version) in effect at the end of the Warranty Period.

I.15 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 weather.

I.16 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 or where the system will be specified to provide the firemen's override panel in the Fire Command Center which is typical for a high rise building. 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. PRODUCTS

II.1 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.

II.2 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. EXECUTION

III.1 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.

III.2 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.

Digital control stations should specifically be shown on the drawings. You should select appropriate wall/floor locations that minimize wire and tubing runs, and coordinate these locations with other disciplines. If the project is a control renovation, locate spare breakers in a power panel where the control contractor can obtain 120V power and show it on the floor plans

III.3 DIGITAL CONTROL STATIONS, CONTROLLER QUANTITY AND LOCATION

AE shall designate locations for control stations and specifically reserve wall/floor space and indicate it on the drawings and coordinate it with other trades. Preferably you will have the electrical contract provide power (normal, emergency or uninterruptible as applicable) and then delete the requirement for this contractor to provide the power.

A. Individual Building Automation System Panels (BASP) are referenced to indicate allocation of points to each BASP and BASP location. Digital control stations shall consist of one or multiple controllers to meet requirements of this specification.

B. Where a BASP is referenced, Contractor shall provide at least one (1) controller, and additional controllers as required, in sufficient quantity to meet the requirements of this Specification. Restrictions in applying controllers are specified in Section 230903: BAS Field Panels. This Contractor shall extend power to the BASP 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. Contractor shall locate BASPs as referenced. 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.

AE shall consult with UNC personnel prior to specifying the BASP and Controller requirements. Controller requirements are be dictated by the type of systems and facility. Edit to suit the project

D. Contractor shall provide a minimum of the following:

1. One BASP (including at least one controller) in each chilled water/hot water plant mechanical room
2. One BASP (including at least one controller) for each air handler located in applicable mechanical room
3. One BASP (including at least one controller) for each critical fan system
4. One BASP (including at least one controller) for each pumping system
5. One controller for each piece of terminal equipment located at the equipment.

III.4 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 controllers, operator interfaces, 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.

III.5 CONTROL POWER SOURCE AND SUPPLY

It is preferable to have the Division 16 contractor supply power to BASP locations and provide the appropriate level of power of all control system components as located by the AE. For instance, it is usually good to at least have emergency power (and sometimes uninterruptible power when available) at critical controllers, control system servers, routers, workstations etc. However, this section if mainly for retrofits where no Div 16 contractor applies.

A. Section 230900 Contractor shall extend all power source wiring required for operation of all equipment and devices provided under Sections 230900 through 230905 and Sequences of Operation.

The following item will have to be customized for each system and project. The consideration is where to power controllers from. For distributed controllers that are associated with one unit, it is convenient to power them along with the system so the controller can take action based on the presence of power. However on large centralized panels, it may be best to put these on the most reliable source of power that serves the equipment being controlled and then provide for individual monitoring of the various systems' power sources by the controller. The object here is to make a robust system that does not interpret power failures as device failure and therefore in some instances have to take down the unit for manual acknowledged reset. This can compromise reliability.

B. General requirements for obtaining power include the following:

1. In the case where additional power is required, 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.

2. 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. ***Designer to provide list of which equipment requires more than normal power source.*** 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. Furthermore, the controller in that condition shall monitor each power type served to determine so logic can assess whether a failure is due to a power loss and respond appropriately. A three-phase monitor into a digital input shall suffice as power monitoring.
4. Provide an uninterruptible power supply (UPS) system providing battery backup for each controller or BASP except terminal equipment controllers. UPS shall protect against blackouts, brownouts, surges and noise. UPS shall include LAN port and modem line surge protection. UPS shall be sized for a 7-minute full load runtime, 23-minute ½ load runtime, with a typical runtime of up to 60 minutes. Transfer time shall be 2-4 milliseconds. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90% recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts. Provide all software, cables, peripherals etc. for a complete system.
5. Standalone Functionality: Refer to Section 230903.

The AE shall carefully coordinate the training requirements with the needs of UNC's facilities staff. Expansions of existing systems obviously require less training than brand new systems. The following generally outlines an on-site training session for which you always want some basic site-specific training on-site. The more advanced training may be better provided off site on a case-by-case basis. Edit to suit project.

III.6 BAS START UP, COMMISSIONING AND TRAINING

A. Refer to Section 230801

III.7 SEQUENCE OF OPERATION

A. Refer to Section ***{Insert applicable Specification Section}***- Sequences of Operation

END OF SECTION 230900