SECTION XX XX XX
Submetering Specification

PART 1 - GENERAL

1.1 GENERAL SYSTEM INTENT
A. The work under this section includes meters as specified herein and shown on the Drawings.

1.2 CONTRACTOR QUALIFICATIONS
A. Prime contractor shall be currently designing and or installing the metering system they will propose. Contractor shall provide. Contractor shall have a minimum of 5 years of experience installing metering systems for gas, water and electrical systems.
1. Prime contractor shall assume full responsibility for accepting bids from contractors meeting this qualification.

1.3 GUARANTEE
A. The Contractor shall warrantee in writing all work performed under this contract for a period of one year from the date of completion acceptance. All controls and metering hardware provided will have a minimum one-year warrantee starting from the date of notice of completion.
B. When notified of a system, hardware, or software failure relating to the work performed under this contract, the contractor will be responsible for all investigation, diagnoses, repair, revision or replacement necessary to correct the condition.

1.4 GENERAL PRODUCT DESCRIPTION
A. The proposed metering system shall include the following metering types:
1. Gas Meters
   1. Onicon 5500 Series Thermal Mass Flow Meter
   2. Existing Meters with Pulse Output
      1) Existing pulse metering systems shall be refurbished and re-used.
      2) In the event existing pulse metering system components are found to be deficient, the Prime Contractor shall notify the owner
   3. Existing Meters missing Pulse Output
      1) Provide new pulse meter output system to existing meter.
      2) In the event this isn’t feasible for the existing meter, the Prime Contractor shall notify the owner
2. Water Meters
   1. Onicon F-4600 (Ultrasonic)
   2. Onicon F-3500 (Electromagnetic)
3. **Electrical Meters**
   
   1. Dent PowerScout 3037

**B. Metering system integration to campus Johnson Controls Metasys BAS shall include:**

1. NEMA 1 or NEMA 3R UL listed panel housing a Metasys FEC, Gateway, and ancillary components as laid out in the drawings or as needed to complete a fully functional metering to Metasys integration.

2. Metering system architecture includes local installation of all necessary metering components plus the integration into the campus Johnson Controls Metasys master Energy Management System.

3. The prime contractor for all metering systems must also provide the integration, graphical interface, logging, trending, and programming of the new metering system for all metering types (gas, water, & electrical).

4. Metering controls integration field controllers shall be Johnson Controls Metasys to match existing. No exceptions.

### 1.5 NETWORKING COMMUNICATIONS

**A.** The design of the Metering Energy Management System shall network all metering types as shown on the architectural system configuration drawing. Inherent in the system's design shall be the ability to integrate into the Johnson Controls Metasys BAS via BACnet RS485 (MSTP) or BACnet IP.

**B. Local Area Network**

1. All building-level metering systems shall include a Johnson Controls FEC controller and be connected to the sites LAN through a BACnet to IP Gateway. Controls contractor shall coordinate this task with the University IT department. The controls contractor is responsible for pulling the Cat5/6 cable or BACnet certified wiring (if MSTP) and terminating at both ends.

2. **Dynamic Data Access:** All operator devices, either network resident or connected via any method, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment. Access to system data shall not be restricted by the hardware configuration of the Building Management System. The hardware configuration of the BAS network shall be totally transparent to the user when accessing data or developing control programs.

3. The automation network shall be configured as a Client/Server network with a web server operating on the Clients LAN/WAN. The web browser interface is extended over the LAN/WAN. Monitoring and control of the BAS is available using the web browser interface.

4. The BAS shall network multiple user interface clients, system controllers and systems supervisors(s) as required for systems operation.
5. The automation network option shall be capable of operating at a communication speed of 100 Mbps. The automation network option will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices. Control networks shall provide either “Peer-to-Peer,” Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 38,400 to 76,800 baud.

6. Supervisory Controllers (NAE/NCE) shall provide supervisory control over the metering and control network and shall support all three (3) of the following communication protocols:
   1. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9
   2. BACnet IP
   3. ModBus TCP/IP

   1) Note: All enterprise software and supervisory controllers are existing. Contractor is required to provide all components shown in the drawings to provide a fully functioning metering system for gas, water, and electrical usage that is tied into and monitored by the campus master Johnson Controls Metasys BAS.

C. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each meter and controller device (master or slave) that will communicate on the BACnet MS/TP or BACnet IP Bus.
   1. The PICS shall be included within the Controls Contractor bid. It is the Prime Contractor’s responsibility to include this information at time of bid.

D. General Network Design: Network design shall include the following provisions:
   1. High-speed data transfer rates for alarm reporting, quick report generation from multiple controllers, and upload/download efficiency between network devices.
   2. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.
   3. Detection and accommodation of single or multiple failures of either DDC panels, system controllers or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

PART 2 - SYSTEM HARDWARE FEATURES

2.1 DIGITAL ELECTRIC METERS
   A. Electronic meter with digital display shall accept input from standard current transformers rated 5 amperes. Sub-meters may use 0-2V Current Sensors or 0-0.333V Current Transducers in lieu of Current Transformers. Meter shall be
suitable for connection to a three-phase, four-wire wye system, a three-phase, three-wire delta system, or a 120/240V single-phase system.

B. Meter shall monitor voltage, current, power, energy, and many other electrical parameters on an electrical system, including but not limited to:
   1. System and Phase measurements for: Amps, Volts, Frequency, kW, kWh, KVAR, kVARh, kVA, kVAh, dPF or aPF.
   2. Net System true energy (kWh)
   3. System True Power +/- (kW)
      1. Meter shall be capable of measuring both positive and negative power to ascertain between power demand or power generation for demand response, smart grid and on-site generation applications.
   4. System True Energy +/- (kWh)
      1. Meter shall be capable of measuring both positive and negative energy to ascertain between energy consumption or energy generation for demand response, smart grid and on-site generation applications.
   5. Peak Demand (adjustable window) and Min/Max System Power.

C. Measured data updates shall occur every 1 second.

D. Meter shall have a regulated 5VDC output, 140 mA Max.

E. Meter shall be configurable for operation on Single Phase (AN or AB), Split Phase (ABN), Delta (ABC), and Wye (ABCN) systems.

F. Meter shall be available with either or both Serial RS-485 or Ethernet interface.

G. Serial RS-485 communication shall support the BACnet MS/TP protocol. Meter shall be a BACnet Testing Labs (BTL) certified smart sensor (B-SS).

H. Ethernet communicating model shall support the BACnet IP protocol in addition to the meter’s serial interface supporting BACnet MS/TP protocol.

I. Meter shall have optional multi-line backlit LCD displaying measured parameters.

J. Meter shall be Line-Powered from L1 Phase to L2 Phase. 80-600 VAC, CAT III, 50/60Hz, 70mA max. No external power supplies shall be required to power the meter.

K. Meter shall measure up to three voltage channels, 80 to 346 VAC Line to Neutral, 600 VAC Line to Line, CAT III.

L. Meter shall accept 0 to 0.333VAC input from up to three current transducer types, 0 to 4000A.
   1. Rogowski Coils
   2. Split Core Current Transducers
   3. Solid Core Current Transducers

M. Meter shall provide bi-color visual LED verification of correct CT phase wiring to meter.

N. Current transducers shall be available from <1A to 4000A. Sensors shall be available in split-core configuration 5A to 1000A or Rogowski Coil for 5–4000A and interchangeable on the meter.
   1. Hinged split core current transformers with current ratings of 20 to 200A
2. Split-core current transformers with current ratings of 5 to 1000A
3. Rogowski Coils for current measurement range to 5-4000A

O. Meter shall be equipped with a USB port for meter powering and configuring the device.

P. Meter shall include pulse output capability for sending kWh or other pulses to an external device. Open Collector. 5mA max current. 30V max voltage.

Q. Meter accuracy shall be ANSI C12.20-2010 Class 0.2 or better.

R. Meter shall comply with the following safety specifications:
   1. UL/CUL listed
   2. Conforms to UL Std 61010-1.
   3. Certified to CSA Std C22.2 No. 61010-1
   4. CE Low Voltage and EMC Directives

S. Meter shall be capable of operating in ambient conditions ranging from –4ºF to +140ºF (-20ºC to +60ºC).

T. Meter shall have dimensions not exceeding 9.5” x 3.3” x 1.6”. It shall be capable of being mounted inside an electrical panel containing the circuits to be measured. Meter shall include DIN rail channel compatible with TS35/7 rail and angled mounting tabs for optional panel mount in an external enclosure.

U. Meter enclosure shall consist of ABS Plastic with a 94-VO flammability rating.

2.2 DIGITAL GAS METERS

A. ONICON F-5500 Series Thermal Mass Flow Meter
   1. Provide complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand-insertable up to 60 psid.
   2. Provide a flow conditioner if required to meet the manufacturer’s minimum upstream straight pipe run requirement.
   3. For pipe sizes smaller than 1½ inch, provide an Onicon F-5500 Series Inline Thermal Mass Flow Meter.
   4. For pipes larger than 3” provide the a Onicon F-1200 dual turbine insertion series meter.
   5. Materials of construction for wetted metal components shall be 316 SS.
   6. The flow meter shall provide flow readings from a pair of encapsulated platinum sensors and shall not require additional temperature or pressure compensation. In addition, the meter shall allow for field validation testing of the current calibration and provide for a printed validation test report.
   7. Each flow meter shall be individually wet-calibrated against a standard that is directly traceable to NIST.
   8. A certificate of calibration shall be provided with each flow meter. Accuracy shall be within ± 1% of rate from 500-7000 SFPM and ± 2% of rate from 100-500 SFPM. Overall turndown shall exceed 1000:1. Output signals shall consist of the following: (1) analog 4-20mA output and (1) additional output that is factory configured as either a totalizing pulse or
an RS485 interface for connection to a BACnet MS/TP serial network. The meter shall be equipped with an integrally mounted display with a user interface that allows for field programming of the meter. Each flow meter shall be covered by the manufacturer’s two-year warranty.

1. Meters shall communicate using BACnet protocol to comply with campus standard unless pulse is approved by university.

B. Existing Meters with Pulse Output
1. Existing gas pulse metering systems shall be refurbished, shall have rain/water protection installed, and re-used.
2. If existing pulse metering system components are found to be deficient and/or not in good working order, the Prime Contractor shall notify the owner.

C. Existing Meters missing Pulse Output
1. New pulse metering components shall be provided by the Prime Contractor.
2. Pulse metering components shall be specifically manufactured for compatibility with the existing meter. All pulse output rates and translation information shall be provided to the Controls Contractor and Owner for proper integration into the campus master Johnson Controls Metasys BAS.
3. In the event this isn’t feasible for the existing meter, the Prime Contractor shall notify the owner.

2.3 DIGITAL WATER METERS
A. All digital water meters shall be built and calibrated by a single manufacturer, ONICON Incorporated. A certificate of NIST traceable calibration shall be provided with each system. All equipment shall be covered by the manufacturer’s two-year warranty.
1. BTU Metering: If a BTU style meter is required, all components including the meter, temperature sensors, mechanical installation hardware and thermowells shall be provided by the same manufacturer.

B. Remote Display Components: Should remote mount displays be required by the plans contractor shall supply components specifically designed to work with the specified water meter. Display components shall be made by the same manufacturer as the metering hardware.

C. Flow Meter: Provide an ONICON
1. Onicon F-3600 Series Electromagnetic Insertion Flow Meter (provided complete with integral or remote electronics module).
1. The electronics module shall include a backlit graphic display and keypad. Connections to the piping shall be ANSI class 150 flanges (ANSI class 300 available where required).
2. Serial RS-485 communication shall support the BACnet MS/TP protocol
3. The installing contractor is responsible for providing suitable mating flanges. The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene or ebonite for low temperature service, PFTE for hot water service.

4. Each flow meter shall be individually wet-calibrated and accurate to within ±0.2% of reading from 1.6 to 33 feet per second velocity.

5. A certificate of calibration shall be provided with each flow meter. Output signals shall be 4-20 mA and programmable pulse.

6. The flow meter shall be capable of measuring bi-directional flow. For installations in non-metallic pipe, install grounding rings between flanges.

7. Each flow meter shall be factory programmed for its specific application and shall be re-programmable using the integral keypad on the converter (no special interface device or computer required).

8. Each flow meter shall be covered by the manufacturer’s two-year warranty.

2. Onicon F-4600 Series Ultrasonic Inline Flow Meter (provided complete with integral or remote electronics module).

1. The electronics module shall include a backlit graphic display and keypad. Connections to the piping shall be ANSI class 150 flanges (ANSI class 300 available where required).

2. Serial RS-485 communication shall support the BACnet MS/TP protocol

3. The installing contractor is responsible for providing suitable mating flanges. The flow tube shall be epoxy coated steel; the sensing electrodes shall be 316SS; the liner shall be polypropylene or ebonite for low temperature service, PFTE for hot water service.

4. Each flow meter shall be individually wet-calibrated and accurate to within ±0.2% of reading from 1.6 to 33 feet per second velocity.

5. A certificate of calibration shall be provided with each flow meter. Output signals shall be 4-20 mA and programmable pulse.

6. The flow meter shall be capable of measuring bi-directional flow.

7. For installations in non-metallic pipe, install grounding rings between flanges.

8. Each flow meter shall be factory programmed for its specific application and shall be re-programmable using the integral keypad on the converter (no special interface device or computer required).

9. Each flow meter shall be covered by the manufacturer’s two-year warranty.

2.4 JOHNSON CONTROLS METASYS COMPONENTS

A. Field Equipment Controller (FEC X611)
1. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol or optionally via N2Open.

2. The FEC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
   1. The FEC shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
   2. The FEC shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
   3. A BACnet Protocol Implementation Conformance Statement shall be provided for the FEC.
   4. The Conformance Statement shall be submitted 10 days prior to bidding.

3. The FEC shall include troubleshooting LED indicators to identify the following conditions:
   1. Power On
   2. Power Off
   3. Download or Startup in progress, not ready for normal operation
   4. No Faults
   5. Device Fault
   6. Field Controller Bus - Normal Data Transmission
   7. Field Controller Bus - No Data Transmission
   8. Field Controller Bus - No Communication
   9. Sensor-Actuator Bus - Normal Data Transmission
  10. Sensor-Actuator Bus - No Data Transmission
  11. Sensor-Actuator Bus - No Communication

4. The FEC shall accommodate the direct wiring of analog and binary I/O field points.

5. The FEC shall support the following types of inputs and outputs:
   1. Universal Inputs - shall be configured to monitor any of the following:
      1) Analog Input, Voltage Mode
      2) Analog Input, Current Mode
      3) Analog Input, Resistive Mode
      4) Binary Input, Dry Contact Maintained Mode
      5) Binary Input, Pulse Counter Mode
   2. Binary Inputs - shall be configured to monitor either of the following:
      1) Dry Contact Maintained Mode
      2) Pulse Counter Mode
   3. Analog Outputs - shall be configured to output either of the following:
      1) Analog Output, Voltage Mode
      2) Analog Output, Current Mode
4. Binary Outputs - shall output the following:
   1) 24 VAC Triac

5. Configurable Outputs - shall be capable of the following:
   1) Analog Output, Voltage Mode
   2) Binary Output Mode

6. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
   1. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus
   2. The FC Bus shall support communications between the FECs and
      the NAE.
   3. The FC Bus shall also support Input/Output Module (IOM)
      communications with the FEC and with the NAE.
   4. The FC Bus shall support a minimum of 100 IOMs and FECs in any
      combination.
   5. The FC Bus shall operate at a maximum distance of 15,000 Ft.
      between the FEC and the furthest connected device.

7. The FEC shall have the ability to monitor and control a network of sensors
    and actuators over a Sensor-Actuator Bus (SA Bus).
   1. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus
   2. The SA Bus shall support a minimum of 10 devices per trunk.
   3. The SA Bus shall operate at a maximum distance of 1,200 Ft.
      between the FEC and the furthest connected device.

8. The FEC shall have the capability to execute complex control sequences
    involving direct wired I/O points as well as input and output devices
    communicating over the FC Bus or the SA Bus.

9. The FEC shall support, but not be limited to, the following applications:
   1. Heating central plant applications
   2. Built-up air handling units for special applications
   3. Terminal & package units
   4. Special programs as required for systems control

10. The FEC shall support a Local Controller Display (DIS-1710) either as an
    integral part of the FEC or as a remote device communicating over the SA
    Bus.
    1. The Display shall use a BACnet Standard SSPC-135, clause 9
       Master-Slave/Token-Passing protocol.
    2. The Display shall allow the user to view monitored points without
       logging into the system.
    3. The Display shall allow the user to view and change setpoints,
       modes of operation, and parameters.
    4. The Display shall provide password protection with user adjustable
       password timeout.
    5. The Display shall be menu driven with separate paths for:
       1) Input/Output
2) Parameter/Setpoint
3) Overrides
11. The Display shall use easy-to-read English text messages.
12. The Display shall allow the user to select the points to be shown and in what order.
13. The Display shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.
14. The display shall be a minimum of 4 lines and a minimum of 20 characters per line.
15. The Display shall have a keypad with no more than 6 keys.
16. The Display shall be panel mountable.

PART 3 - SYSTEM SOFTWARE FEATURES

3.1 USER INTERFACE

A. Johnson Controls Metasys Browser-Based Interface
1. All meters and metering systems shall be fully integrated into the campus master Johnson Controls Metasys server. Trending, alarming, graphics, histories and metering data shall be shared and integrated into the JCI Metasys system.
2. The system shall be capable of supporting an unlimited number of clients using standard Web browser such as Firefox, Google Chrome, etc. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers such as JAVA shall not be acceptable. HTML5 is acceptable. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the Building Automation System (BAS), shall not be acceptable.
3. The Web browser client shall support at a minimum, the following functions:
   1. User log-on identification and password shall be required. If an unauthorized user attempts access, notice of access failure shall be displayed. Security using authentication and encryption techniques to prevent unauthorized access shall be implemented.
   2. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
   3. Storage of the graphical screens shall be in the Supervisory Controller and central BAS server, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
4. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

5. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
   1) Modify common application objects, such as schedules and setpoints in a graphical manner.
   2) Commands binary objects to start and stop.
   3) View logs and charts.
   4) View alarms.

6. User rights shall be created by Contractor to match the Owners standard.
   1) Owner shall be assigned as the highest-level user with full access to the system.
   2) Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

B. Alarms
   1. Alarm feature shall allow user configuration of criteria to create, route, and manage alarms and events. It shall be possible for specific alarms from specific points to be routed to specific alarm recipients. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
      1. Allow configuration to generate alarms on any numeric, binary, or data point in the system.
      2. Generate alarm records that contain a minimum of a timestamp, original state, acknowledged state, alarm class and priority.
      3. Allow the establishment of alarm classes that provide the routing of alarms with similar characteristics to common recipients.
      4. Allow a user, with the appropriate security level, to manage alarms - including sorting, acknowledging, and tagging alarms.
      5. Reports and Summaries generation shall be created and directed to the user interface displays, with subsequent assignment to printers, or disk accessible to the Owner. As a minimum, the system shall provide the following reports:
         1) Pre-approved points found in the approved points list
         2) All points in a user-defined group of points
         3) All points currently in alarm
         4) Alternately, if a specific system Points List is already provided and Owner approved, only those points are necessary to be provided.
   6. Reports shall be exportable to .pdf, .txt, or .csv formats
7. The system shall allow for the creation of custom reports and queries.

8. Alarm Messages: In addition to the point’s descriptor and the time and date, the user shall be able to email, display or store a 65-character alarm messages to more fully describe the alarm condition or direct operator response.

C. Historical Data Collection

1. All numeric, binary or data points in the system database shall allow their values to be logged over time (trend log). Each historical record shall include the point’s name, a time stamp including time zone, and the point’s value.

2. The NCE/NAE shall have the ability to store its historical data records locally and periodically to a remote server on the network (archiving).

3. The configuration of the historical data collection shall allow for recording data based on change of value or on a user-defined time interval.

4. The configuration of the historical data collection shall allow for the collection process to stop or rollover when capacity has been reached.

5. A historical data viewing utility shall be provided with access to all history records. This utility shall allow historical data to be viewed in a table or chart format.

1. The history data table view shall allow the user to hide/show columns and to filter data based on time and date. The history data table shall allow exporting to .txt, .csv, or .pdf file formats.

2. The historical data chart view shall allow different point histories to be displayed simultaneously, and also provide panning and zooming capabilities.

3. Address history intervals for BIs and COV trends with Owner before programming.

D. Audit Log

1. Logs and Summaries: Reports shall be generated automatically or manually, and directed to either CRT displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types or reports:

1. A general listing of all points in the network
2. List all points currently in alarm
3. A general listing of all points in the network
4. List all points currently in alarm
5. List of all off-line points
6. List all points currently in override status
7. List of all disabled points
8. List all points currently locked out
9. List of all items defined in a “Follow-Up” file
10. List all Weekly Schedules
11. List all Holiday Programming
E. Database Backup and Storage
   1. The user shall have the ability to back up the metering databases.

3.2 COLOR GRAPHIC DISPLAY
   A. Color graphic floor plan displays shall be provided.
      1. Site Plan:
         1. A graphic showing all buildings of a site shall be provided.
      2. Building Level:
         1. Each building within a site shall show individual meter and FEC panel locations
      3. Note: All points called out on the pre-approved points list shall be represented graphically and made writeable when available.

PART 4 - COMMISSIONING AND TRENDING

4.1 BUILDING AUTOMATION SYSTEM TRENDING
   A. Data Accessibility: The BAS shall provide data access to the University’s analytics platform by fully integrating into the campus master Johnson Controls Metasys server.
      1. BAS trend histories shall be readily accessible to the analytics platform in one or more of the following ways:
         1. Direct, read-only query of the BAS trend histories in a trend history SQL database
         2. Scheduled export of all selected BAS trends in .csv, .xls, or .xml format to local network folder location
         3. Direct query of the trend histories via Open RestAPI
         4. Direct BACNet IP query (accessible network path required)
   B. Trending Required: The BAS server shall trend all points and store the data for a minimum of twelve months.
      1. Trend intervals:
         1. Analog points for valve positions, equipment speeds, damper positions shall be recorded on a maximum of 1-minute intervals
         2. Electric, water, and gas submeters shall be recorded on a maximum of 15-minute intervals
         3. Remaining Analog points shall be recorded on a maximum of 5-minute intervals
         4. Boolean trends shall be recorded on change of value

4.2 COMMISSIONING THE SYSTEM
   A. The building Commissioning (Cx) process is essential to the delivery of high-quality facilities for the campus and must include the participation of an Owner approved CxA (Commissioning Authority).
   B. The Prime Contractor and or Controls Contractor shall participate in the Cx
process with the CxA throughout the project including the design phase, construction phase and close-out phase.

C. The commissioning period starts when the following conditions are met:
1. The DDC system and all Metering Equipment have been installed, connected to the DDC system and ready to operate.
2. A commissioning meeting has been conducted with representative of contractors involved building occupants, Prime Contractor, Mechanical Contractor, CxA, Owner and the approved Controls Contractor.
3. Consensus is reached, by the representatives at the above referenced meeting, that it is appropriate for the commissioning process to start. The operational program is loaded into the DDC system by the approved Controls Contractor.

D. During the commissioning period, the approved Prime or Controls Contractor will maintain a commissioning file of the printed reports from the building. The owner will provide the necessary commissioning sheets.

E. The commissioning process will be completed, and the warranty period shall start when the following conditions are met.
1. All training to be provided as part of the project has been completed.
2. No "alarm" or "condition reports" are being generated by the DDC system for seven (7) calendar days (168 hours) due to incomplete or inaccurate installation, program, or programming.
3. All adjustments and "fine tuning" of the system have been completed.
4. The system has been accepted by the Prime Contractor and Building Owners and approved by the Mechanical Engineer.
5. All commissioning shall be approved by the Engineer and CxA with the final commissioning approval being reserved for the Owner.

F. To conclude the commissioning process As-Builts must be supplied. There will be no job close-out until all above conditions have been met to the satisfaction of the Owner and Engineer and (1) hard copy and (1) electronic copy of the As-Builts have been supplied.

G. No retention will be released until these parameters have been met.

H. Controls contractor will participate in the commissioning pre-site and site functional testing.

I. Refer to supplemental CxA specification section provided with the bid documents.

PART 5 - EXECUTION

5.1 PREPARATIONS
A. Prior to Installation: Inspect the installed work executed under other Sections which affect the installation of the controls. Report unacceptable conditions to Project Manager or Owners Representative. Do not begin work until unacceptable conditions have been corrected. Installation of the controls
shall constitute acceptance of existing conditions.

B. Coordination: Coordinate work with work specified under other Sections to ensure proper and adequate interface of work. Equipment and systems drawings are generally diagrammatic unless dimensions are indicated. Drawings and details shall be checked for interferences with structural and other conditions prior to performing work.

C. The Contractor shall be responsible for safety and good condition of his materials and equipment until final acceptance by the Owner. He shall erect and maintain suitable barriers, protective devices, lights and warning signs where required.

5.2 INSTALLATION

A. General:
   1. When applicable installation procedures are shown or specified in other sections, those procedures shall be followed.
   2. Provide all supports and hangers, etc., as required to install the equipment as specified or shown on the drawings. All equipment shall be supported, braced and cross-braced to comply with current CBC and CMC.
   3. Sealing: Wherever any part of the control system has to pierce the roofing, openings through the roof shall be flashed absolutely watertight.
   4. Arrange and support piping and equipment so that vibration is at a minimum and is not transmitted to or through building structure.
   5. All metering equipment and cabinets shall be installed in a fashion designed to protect the equipment from the elements or tampering.
      1. Panels shall be UL listed and lockable
      2. Exterior mounted gas and water meters shall have flashing, housing or rain/water shielding to protect the integrity of metering components.
      3. Rain and water shields shall be provided for all gas meter pulse output components.
      4. Underground metering installations shall be inspected for water infiltration. Sump pumps or water drainage provisions shall be made as needed by the contractor.

5.3 WIRING AND CONDUIT

A. Control and/or meter wiring and conduit shall be the responsibility of this section and be installed as follows:
   1. In equipment rooms/attics – Conductors shall be run in conduit. Final connection to equipment shall be flexible conduit.
   2. Concealed in building construction (wall/inaccessible ceilings) - Conduits shall be run in conduit.
   3. Roof mounted/exterior equipment yards - Conductors shall be in
conduit. All flexible conduit shall be seal-tite with weatherproof connections. Equipment on grade and detached from the building a distance greater than 36” shall have underground control conduit routed to equipment.

4. Above accessible ceiling spaces - Control cable shall be installed in conduit. Deviation for this requirement may be permittable and must be approved by the owner upon each exception.

5. Cabling shall be installed in conduit, no exceptions. No j-hooks, no free wiring, etc.

6. Cable is bundled/organized in management devices routed square with building lines (no diagonals) and kept clear of electrical devices (i.e., ballasts, transformers, etc.) that could cause interference.

7. Conduit sleeves are provided between accessible ceiling spaces (i.e., across soffits, gypsumboard ceilings, etc.) as required to maintain future access to cable.

8. Cable routed in accessible ceiling spaces shall comply with EIA/TIA standards for communications cabling. All wire shall be shielded, and plenum rated.

9. Wire for BAS shall be Belden or pre-approved equal to match campus standards.
   1. Reference campus master BAS specification for jacket color requirements.

5.4 IDENTIFICATION

A. Contractor shall submit on their labelling strategy for Owner approval.

B. Prime or Controls Contractor shall provide complete labeling of all terminals at all panels or equipment terminal strips and wiring. Equal to Brady marking on wires and number on terminals in sequence corresponding to control diagram.

C. The label wording shall match that used on the drawings and provide clearly readable printed labels for each control component inside a panel. When applicable, additional identification needed shall be documented on the Shop Drawings.

D. Engraved nameplates shall be provided on the face of each panel and beneath each actuator and control device not in a panel, describing its use.

E. All electrical devices within the panel shall be wired to a terminal strip within the panel. An "electric terminal" numbering system shall be applied to all terminals with aforementioned numbers matching terminals shown on Shop Drawings.

F. Gas, water or electrical meters shall be specifically identified and labelled in a fashion designed to withstand local installation conditions.
   1. Gas, water or electrical meters with remotely mounted pulse output converters, display modules or other components shall also have those components locations marked and labelled.
5.5 **PROGRAMMING COMPLETION AND ACCEPTANCE**

A. The Metering system shall be integrated into the campus Metasys BAS. Operational program and metering hardware integration will be provided by approved installing controls contractor. Programming shall be verified for proper operation by CxA (Commissioning Authority) or Owner with Controls Contractor assistance.

B. The Prime Contractor and or Controls Contractor shall furnish a complete and operating system. The Controls Contractor shall also verify, in the presence of the Owner or designee, the system accuracy and proper function of each controlled device and sensor. The following items shall be successfully demonstrated prior to acceptance by the Owner or designee:
   1. All system outputs including controllers, relays, and other control devices shall be addressed and start/stop functions demonstrated.
   2. All inputs shall be displayed and all event-initiated functions shall be demonstrated.
   3. Demonstrate program integrity and power restore sequence during and after a power failure and restoration.
   4. Deliver all Record Drawings, wiring diagrams, equipment specifications, calibration certificates, installation and Operation Manuals and other documentation as required to describe the system.
   5. Complete operator training in the use, programming, and operation of the system.
   6. All system programming to be provided by the Prime or Controls Contractor.

C. **Start-up of the System:**
   1. The start-up period starts when the following conditions are met:
      1. The Metering system and all involved BAS equipment have been installed, connected to the central Metasys server and are ready to operate.
      2. A start-up meeting has been conducted with representative of the Prime Contractor, Architect/Engineer, maintenance staff, CxA (if needed) and the Controls Contractor.
      3. Consensus is reached, by the representatives at the above referenced meeting that it is appropriate for the start-up process to start.
   2. The start-up process shall be completed and the warranty period shall start when the following conditions are met.
      1. All training to be provided as part of the project has been completed.
      2. No "alarm" or "condition reports" are being generated by the BAS system for seven (7) calendar days (168 hours) due to incomplete or inaccurate installation or programming. All adjustments and "fine tuning" of the system have been completed.
D. Verification: A written testing and start-up report must be submitted for approval before acceptance. In addition to the Controls Contractor's testing and start-up report, the Owner may independently verify the test results. The report on test results shall include setpoints and operating ranges of all components.

E. Project retention shall not be released until the above parameters have been met.

5.6 POINT NAMING CONVENTION

A. Contractors will adhere to the pre-approved University-provided official Points List. This document will be provided with the bid package.

1. The intent of the point naming convention is to provide a consistent programming approach for metering projects on all current and future buildings.

2. All contractors performing programming will be held accountable in regard to abiding by the pre-approved University official Points List.

3. Confirmation of proper programming point naming convention must be attained before final payment is released.

4. The naming convention for point and trend names shall conform to the following:
   1. [3-digit Building Number] [Meter Number and Meter Type] [Point Name]
   2. In the cases where the point short names are used, the contractor must include all appropriate unique identifiers.

5.7 SYSTEM INSTRUCTION AND TRAINING

A. Prior to final acceptance and release of retention, the Prime Contractor shall provide operational training to the Owner's personnel. The training sessions shall include a complete demonstration of the system. Dates and times of the training sessions shall be coordinated through the Owner not less than one week prior to session. The Controls Contractor shall maintain a log of training sessions including dates, times and names/titles of those attending.

1. As-Builts showing the specific locations of all metering types on a building by building basis shall be provided.

2. O&M manuals for each metering type shall be provided to the owner at the time of training.

3. Manufacturers technical support line shall be provided on a laminated 8 ½” x 11” sheet and left in each metering cabinet.

5.8 RECORD DRAWINGS

A. Instruction period shall be started after instruction books, service manuals and record drawings have been submitted to and approved by the University staff and shall be at hours (regular and non-regular) arranged by the University.

B. Service manuals shall include oiling, cleaning and servicing data, compiled in clearly and easily understood form and in a durable binder. Data shall show all
serial numbers of every piece of equipment and complete list of replacement parts.

C. Retention and final payment will not be released until University has received and approved of the final As-Built controls drawings.

1. As-Built Drawings must include the following:
   1. All Supervisory Panel and/or Field Controller Panel locations
   2. All Metering locations
   3. Communication bus routing
   4. All non-HVAC controllers including but not limited to Lighting, Water, Gas, etc. that are connected to the sites BAS shall have their location noted
   5. Laminated controls drawings shall be present in all Field and Metering controller panels

5.9 WARRANTY PERIOD

A. After the project has been officially closed out and approved by the Owner and Engineer the warranty period may begin.

1. Warranty period shall include (1) year parts (minimum) and (1) year labor

END OF SECTION
1.1 DESCRIPTION:
A. The intent of this document is to describe a system that is complete in every respect without further cost to the Owner. Anything not shown on the drawings or indicated in the specifications, and required for complete operating systems, shall be included as part of this work. This will also include all connections to new services.
   1. Controls that fall under this specifications section include but are not limited to HVAC, Lighting, Metering, and Analytics.
B. All parts of the plans and specifications fully apply when applicable to work of this Division. No attempt has been made to divide the work between the various trades or subcontractors.
C. In this document Humboldt State University is referred to as the “Owner” and any reference to either Humboldt State University or the “Owner” are interchangeable.
   1. The goal of this specification is to provide the Owner with a controls system that complies with their building standard.

1.2 CONTROL CONTRACTOR QUALIFICATIONS:
A. Controls contractor shall be currently authorized by the manufacturer of the controls system they will propose. Certifications shall be submitted with bid. Contractor shall provide certificate from the manufacturer stating authorization of installing such systems in this geographic area. No Exceptions.
B. General contractor shall assume full responsibility for accepting bids from contractors meeting this qualification. All bid qualifications will be reviewed by the Owner.

1.3 CONDUIT AND WIRING
A. Controls Contractor shall provide and install all low voltage conduit and wiring for DDC system as required for a complete and operating system. Conduit and wiring shall conform to Division 26 requirements.
B. Conduit: All conduits shall be rigid galvanized steel or EMT. All fittings shall be steel- not malleable or aluminum. Conduit for communication cable shall be minimum ¾” inch diameter. For underground conduit, provide 100% spare capacity by installing a second conduit (empty) along all conduit routes.
C. All conduit and wiring practices are subject to approval by the electrical engineer and Owner.

1.4 CODES, STANDARDS, ORDINANCES AND REGULATIONS:
A. All work and materials shall be in full accordance with the latest rules and regulations of applicable codes as amended and adopted by any governmental agency which has jurisdiction over this work. Nothing in these Plans or Specifications is to be construed to permit work not conforming to these codes. Should the Plans or Specifications call for material, methods, or construction of a higher quality or standard than required by the above rules, the higher quality or more restrictive shall apply.
B. When not contradicting the above, the manufacturers’ recommendations along with applicable parts of the following documents shall be the basis for quality and standards of installation.
1. Title 24, California Administrative Code, all parts.
2. Applicable publications of the National Fire Protection Association (NFPA), and the National Electrical Code (NEC).

1.5 SITE CONDITIONS AND LOCATIONS:
A. The general location and arrangement of system hardware is shown on the drawings. Information on the drawings relative to existing services is approximate only. Minor adjustments required to conform to actual locations shall be made without additional cost to Owner. The Contractor shall, as work progresses, verify the dimensions of the spaces available for the installation of the work and he shall assume full responsibility for the proper locations of each portion thereof.
B. The construction documents are generally diagrammatic and the locations indicated may be approximate only. They do not show every offset, bend, or elbow required for installation in the space provided. The Contractor, therefore, shall install all equipment, conduit runs and the like as follows:
   1. Adhere to the location indicated as near as possible.
   2. Maintain ample head room and access in all passageways, clearance around all equipment and under conduit runs for unrestricted passage and for easy servicing of all apparatus, equipment, devices and the like.
   3. Provide access for maintenance of all equipment.
   4. Ensure all code required clearances for adjacent equipment is maintained e.g. Panel boards, operating panels, HVAC access.

1.6 SUBMITTALS:
A. Control Submittal: All Submittals shall comply with Division 1 Specifications and with the following additional provisions; Within 21 calendar days after award of the contract, and before any materials of this Section are ordered and/or delivered to the job site, submit:
   1. Complete materials and equipment list with manufacturers' literature on all items proposed to be furnished and installed under this Section.
   2. Product data submittals must be complete and in a single bound document for all items supplied in this Division. Each document shall be bound with an index and marked with the equipment identification as specified in the Plans and Specifications.
   3. Provide complete control shop drawing including equipment, control devices, point to point connections with terminal numbers, and any details necessary for a complete control drawing.
   4. List of name plates to be engraved, showing each name plate wording and location.
   5. Two hard and one electronic copy of the previously listed documents must be supplied.
B. Record Documents:
   1. During progress of the work, maintain an accurate record of all changes made in the systems from those shown on the drawings, specifications and submittals.
   2. Revise Shop Drawings and provide on reproducible media and in DWG format compatible with Windows 8 & 10 and Autocad R-2016 or newer.
C. Owner's Manual: Upon completion of the work, a complete bound book containing the following information shall be submitted to the Owner:
1. Complete catalog and performance data on all control devices, including all documents included in submittals.
2. Complete manufacturers’ operating and maintenance instructions on all control devices.
3. Complete wiring and control diagrams for all equipment and systems, including list of materials, description of operation and system flow diagrams.
4. Manufacturers’ warranty certificates on all equipment.
5. Contractor’s warrantee letter.
6. USB Flash Drive with items 1-5 saved on it.

1.7 OPERATION:
   A. The Owner may require operation of parts or all the installation for beneficial occupancy prior to final acceptance.
   B. Existing system interruptions must be outlined and approved by the Owner before work may commence.

1.8 GUARANTEE:
The Contractor shall warrantee in writing all work performed under this contract for a period of one year from the date of notice of completion. All controls hardware provided will have a one-year warrantee starting from the date of notice of completion.
   A. When notified of a system failure relating to the work performed under this contract, the contractor will be responsible for all investigation, diagnoses, repair, revision or replacement necessary to correct the condition.

PART 2 – PRODUCTS

2.1 GENERAL PRODUCT DESCRIPTION
   A. The Building Automation System (BAS) shall be capable of integrating multiple building functions, including equipment supervision and control, alarm management, energy management, and trend data collection. Johnson Controls Metasys shall serve as the basis of design. Approved equals are accepted and shall demonstrate all functionality and features found in the basis of design. System shall be web based system with support from two or more contractors. All hardware, software, and training must be directly purchasable by the University through a source other than a contractor. BACnet, MODBUS, and Lon drivers shall reside in the Supervisory controller and Open licensing shall be included in each Supervisory controller. Programming of the Supervisory controller devices and creating all required dynamic graphics, points tagging, alarms, trending, and history shall be included in this section. All programming shall be provided by the installing Controls Contractor, no subcontractor or distributor shall provide programming.
   1. The Building Automation System installer shall be a BAS manufacturer-owned branch office, or an independent controls contractor who is factory trained and authorized by the BAS manufacturer to sell, service and support the Building Automation System specified herein.
   2. Independent controls contractors who are authorized by the BAS manufacturer must provide a letter written and signed by a company officer of the specific BAS manufacturer. This document must be dated within the 30 days prior to bid submittal and must state that they are currently a “direct authorized representative” in good standing for the BAS manufacturer for the building automation system products described and listed in this specification, that they have “direct purchasing access” to
all of the BAS manufacturer’s controllers, servers, software and components and technical support, and that they will continue to be an Authorized representative with this access for the duration of the installation and warranty phases of project.

B. The BAS shall consist of the following:
   1. Local Display Devices.
   2. Portable Operator Terminals - Portable PC’s – Portable Touchscreens
   3. Distributed User Interfaces
   4. Network processing, data storage and communications equipment
   5. DDC Controllers (HVAC etc)
   6. Electrical, Water, Gas or Sewage Metering systems
      a. Meters and meter software must be approved as compatible with overall BAS. Approval by Owner, no exceptions.
      b. Hardware related to the above must be approved by Owner.
   7. Interior and exterior lighting controls systems shall be integrate-able into the BAS via BACnet MSTP or IP. Either option shall be approved by the Owner.
   8. Other components required for a complete and working BAS.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, ASCs, and operator devices.

D. System architectural design shall eliminate dependence upon any single device for alarm generation and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

E. Control Components:
   1. Wall Switches: Plates for all wall switches and timers shall match those specified in Division 26.
   2. Labels: All labels, signs, etc. shall be engraved, laminated plastic, white on black background, 1/8" high lettering, minimum.
   3. Temperature Sensors:
      a. Sensor Type: All temperature sensors shall be made of a highly stable, precision thermistor material accurate to within ±0.36 Degrees F. Identify each temperature sensor with a "Lamicoid" label keyed to the control system as-built drawings.
      b. Room Sensor: Room temperature sensor shall have an Executive Decorator housing with programmable visible temperature indication. Housing shall include an occupancy override, temperature setpoint adjustment and a service tool jack.
      c. Vandal Resistant Room Sensor: Where noted, shall be a blank stainless-steel wall plate with the sensing element bonded to the back side. The plate back shall be insulated to reduce wall temperature influence.
      d. Duct Sensor: Duct temperature sensor shall be a probe type element with 8-inch insertion length. Element shall be installed where air mixture provides a true temperature indication. Where adequate mixing is not practical, the duct temperature sensor shall have an averaging type thermistor element.
      e. Outdoor Air Sensor: Outdoor air temperature sensor shall be a probe type element mounted in a ventilated, treated white PVC sun shield to minimize radiant energy effects. The sensor and sun shield shall be mounted on a weatherproof outlet box for outdoor installation.
      f. Low Differential Air Pressure Applications (0" to 5" W.C.): The differential pressure transmitter shall be of industrial quality and transmit a linear, 4
to 20 mA output in response to variation of differential pressure or air pressure sensing points. Non-interactive zero and span adjustments, adjustable from the outside cover. (0.00 - 1.00" to 5.00") W.C. input differential pressure ranges. 4-20 mA output. Maintain accuracy up to 20 to 1 ratio turndown. Reference Accuracy: +0.2% of full span.

g. CO2 Sensor: The sensor shall have a five-year recommended calibration interval. In addition, the sensor shall be provided with a five-year calibration guarantee, providing for free factory replacement if the sensor is found to be out of calibration within five years of the purchase date. The sensor shall have accuracy of ±50 ppm and repeatability of ±20 ppm. All adjustments to the sensor including output scaling, elevation adjustment, relay set point, relay dead-band, linear or exponential output, and single point calibration shall be made via on-board push buttons and LCD display. The LCD display must be covered by a solid door and only viewable when the door is opened for adjustments.

1. CO2 sensor shall provide a PPM range of 0-2000 ppm.

   a. If applicable, smoke detector shall be interlocked to fan and provide shutdown.

5. Status Sensor: Split-Core current sensing status sensor (with sensitivity adjustment for belt loss detection).

6. Electric Actuators:
   b. Valve Actuators: Provide with factory mounting brackets and linkage to the control valve. Capable of shutting off against a 50-psi differential.
   c. Damper Actuators: Positive position feedback and spring return. OSA dampers shall be spring return closed. Actuators shall be direct mounted onto the damper control shaft without linkage. Damper actuators shall be sized to provide a minimum of 5 in-lbs. torque per square foot of damper face area.

2.2 BAS ARCHITECTURE:
A. Automation Network Overview
   1. The automation network shall be configured as a Client/Server network with a web server operating on the Clients LAN/WAN. The web browser interface is extended over the LAN/WAN. Monitoring and control of the BAS is available using the web browser interface.
   2. The automation network shall include the option of a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard “off the shelf” products available through normal PC vendor channels.
   3. The BAS shall network multiple user interface clients, system controllers and systems supervisors(s) as required for systems operation.
   4. The automation network option shall be capable of operating at a communication speed of 100 Mbps. The automation network option will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.
5. Network Automation Engines (NAE) shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:
   a. BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9
      1. The NAE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
      2. The NAE shall be tested and certified as a BACnet Building Controller (B-BC).
   b. LonWorks enabled devices using the Free Topology Transceiver (FTT-10a).
   c. The Johnson Controls N2 Field Bus.

6. Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135

7. A BACnet Protocol Implementation Conformance Statement (PICS) shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.
   a. The PICS shall be submitted 10 days prior to bidding.

B. Control Network
1. Control networks shall provide either “Peer-to-Peer,” Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 38,400 to 76,800 baud.
2. Digital Controllers shall reside on the control network.

C. Integration
1. Hardwired
   a. Analog and digital signal values shall be passed from one system to another via hardwired connections.
   b. All hardwiring between controllers shall be completed based upon the manufacturer’s best practices recommendations. No star or free topology allowed for BACnet.
2. Direct Protocol (Integrator Panel)
   a. The BAS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BAS system and 3rd party manufacturers’ control panels. The BAS shall receive, react to, and return information from multiple building systems, including but not limited to the chillers, boilers, variable frequency drives, power monitoring system, etc.
   b. All data required by the application shall be mapped into the BAS system, and shall be viewable to the operator.
   c. Point inputs and outputs from the controllers shall have real-time interoperability with BAS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Local Area Network Communications.

2.3 USER INTERFACE
A. Browser Based Interface
1. The system shall be capable of supporting an unlimited number of clients using standard Web browser such as Firefox, Google Chrome, etc. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers such as JAVA shall not be acceptable.
2. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the Building Automation System (BAS), shall not be acceptable.

3. The Web browser client shall support at a minimum, the following functions:
   a. User log-on identification and password shall be required. If an unauthorized user attempts access, notice of access failure shall be displayed. Security using authentication and encryption techniques to prevent unauthorized access shall be implemented.
   b. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
   c. Storage of the graphical screens shall be in the Supervisory Controller and central BAS server, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
   d. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
   e. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
      1. Modify common application objects, such as schedules and setpoints in a graphical manner.
      2. Commands binary objects to start and stop.
      3. View logs and charts.
      4. View alarms.
   f. User rights shall be created by Contractor to match the Owners standard.
      1. Owner shall be assigned as the highest-level user with full access to the system.
   g. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

4. Alarms
   a. Alarm feature shall allow user configuration of criteria to create, route, and manage alarms and events. It shall be possible for specific alarms from specific points to be routed to specific alarm recipients. The alarm management portion of the user interface shall, at the minimum, provide the following functions:
      1. Allow configuration to generate alarms on any numeric, binary, or data point in the system.
      2. Generate alarm records that contain a minimum of a timestamp, original state, acknowledged state, alarm class and priority.
      3. Allow the establishment of alarm classes that provide the routing of alarms with similar characteristics to common recipients.
   a. Allow a user, with the appropriate security level, to manage alarms - including sorting, acknowledging, and tagging alarms.
   b. Reports and Summaries generation shall be created and directed to the user interface displays, with subsequent assignment to printers, or disk accessible
to the Owner. As a minimum, the system shall provide the following reports:

1. All points in the BAS
2. All points in each BAS application
3. All points in a specific controller
4. All points in a user-defined group of points
5. All points currently in alarm
6. All BAS schedules
7. All user defined and adjustable variables, schedules, interlocks and the like.

c. Reports shall be exportable to .pdf, .txt, or .csv formats.
d. The system shall allow for the creation of custom reports and queries.

5. Schedules
   a. A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:
      1. Regular schedules
      2. Repeating schedules
      3. Exception schedules
   b. Weekly schedules shall be provided for each group of equipment with a specific time use schedule.
   c. It shall be possible to define one or more exception schedules for each schedule including references to calendars.
   d. Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days. Holidays and special days shall be user-selected with the pointing device or keyboard.
   e. Necessary schedules shall be confirmed between the Owner and controls contractor. Controls contractor shall provide all requested schedules in this scope of work.

6. Password
   a. Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, Based on an assigned password.
   b. Each user shall have the following: a user name, a password, and access levels.
   c. The system shall require passwords with a minimum length of 8 characters and require a combination of upper/lower case characters and numerical or special characters.
   d. When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.
   e. The system shall provide unlimited flexibility with access rights. A minimum of four levels of access shall be provided along with the ability to customize the system to provide additional levels.
   f. Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.
   g. The system shall automatically generate a report of log-on/log-off and system activity for each user.
   h. All log data shall be available in .pdf, .txt, and .csv formats.
i. All user names, passwords and access levels must be approved by the Owner before programming can begin, no exceptions.

7. Dynamic Color Graphics
   a. The graphics application program shall be supplied as an integral part of the User Interface.
   b. All graphical floorplans shall be 3D thermographic in design.
   c. The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.
   d. The graphics shall be able to display real-time data that is acquired, derived, or entered.
   e. Graphics runtime functions – Each graphic application shall be capable of the following functions:
      1. All graphics shall be fully scalable.
      2. The graphics shall support a maintained aspect ratio.
      3. Multiple fonts shall be supported.
      4. Unique background shall be assignable on a per graphic basis.
      5. Mobile graphics with auto-scaling to match device are required. HTML5.
   f. Operation from graphics – It shall be possible to change values (setpoints) and states in systems controlled equipment within the Web browser interface.
   g. Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all runtime binding.

8. Historical Data Collection
   a. All numeric, binary or data points in the system database shall allow their values to be logged over time (trend log). Each historical record shall include the point’s name, a time stamp including time zone, and the point’s value.
   b. The Network Area Controller (NAC) shall have the ability to store its historical data records locally and periodically to a remote server on the network (archiving).
   c. The configuration of the historical data collection shall allow for recording data based on change of value or on a user-defined time interval.
   d. The configuration of the historical data collection shall allow for the collection process to stop or rollover when capacity has been reached.
   e. A historical data viewing utility shall be provided with access to all history records. This utility shall allow historical data to be viewed in a table or chart format.
   f. The history data table view shall allow the user to hide/show columns and to filter data based on time and date. The history data table shall allow exporting to .txt, .csv, or .pdf file formats.
   g. The historical data chart view shall allow different point histories to be displayed simultaneously, and also provide panning and zooming capabilities.
   h. Address history intervals for BIs and COV trends with Owner before programming.

9. Audit Log
   a. For each log entry, provide the following data:
1. **Time and date.**
2. **User ID**
3. **Change or activity:** i.e., change setpoint, add or delete objects, commands, etc.

10. **Database Backup and Storage**
   a. The user shall have the ability to back up the System Controller databases.

11. **Graphical User Interface Portable Device (If Required)**
   a. On Site GUI - All sites shall also include the capability to use a touch panel PC. GUI shall include the following features.
   1. **Kiosk mode** – Powers up directly to the approved Building Automation System
   2. **Open licensing** shall be required
   3. **Touchscreen** shall be a minimum of 15”, flat panel. Panel shall be UL listed as a complete package.
   4. **GUI** shall be incorporated in the NAC (SCP) Enclosure or stand alone as dictated by the Owner and approved by the Engineer.
   5. If necessary, user shall supply the Wi-Fi equipment.

2.4 **AUTOMATION NETWORK**

A. **Network Server Is Required**
   1. All Network Area Controllers (NAC), Supervisory Controllers and BAS devices shall be connected to a new central server network. Server software provided by the Controls Contractor, server hardware provided by the Owner.
   2. Server software provided by the Controls Contractor will be licensed to accommodate all new site Network Area Controllers (NAC), Supervisory Controllers and BAS devices with room for an additional 10% capacity beyond that. If server software licensing requires yearly Software Maintenance Agreements for updates, the Controls Contractor shall include a minimum of 5 years.
   3. **Server Hardware Requirements:** The server software provided by the Controls Contractor shall be installed on a university-provided resource, typically a virtual machine in the main data center.
      a. The Controls Contractor shall provide server hardware and network requirements for the software package to the university at time of bid.
      b. For approved exceptions where the Controls Contractor provides the server, the server hardware platform shall have the following requirements:
         1. The computer shall be an Intel i7, quad core Pentium based computer (minimum processing speed of 3.0 GHz with 16 GB RAM and a 256-gigabyte SSD hard drive). It shall include a 32X CD-ROM drive with write and rewrite capability (R, RW), 1-parallel port, 2-asynchronous serial ports and 4-USB ports. A minimum 27”, 4k UHD color flat screen monitor with a minimum 80 Hz refresh rate shall also be included. Keyboard and mouse to be provided by Controls Contractor as well.
         2. The server operating system shall be Microsoft Windows 10 Server, with current Service Pack. Provide all licenses required for operation. Controls Contractor shall confirm compatibility and coordinate all server operating systems installation.
3. Connection to the FMCS network shall be 1GB Up/Down via an Ethernet network Cat5E/Cat6 interface card.
   c. A pre-installation meeting will be coordinated by the Controls Contractor with the university IT department. All aspects of the server installation will be pre-approved by the universities IT department.

4. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1 or dial-up connection.

5. It shall be possible to provide access to all Network Area Controllers via a single connection to the server. In this configuration, each Network Area Controller can be accessed from the Graphical User Interface (GUI) or from a standard Web browser (WBI) by connecting to the server.
   a. All graphics for all systems included in this scope of work will be accessible via a single login through the server. Coordinate network security and establishment with Owner.

6. The server shall provide the following functions, at a minimum:
   a. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
   b. Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.
   c. The server shall include a master clock service for its subsystems and provide time synchronization for all Network Area Controllers (NAC).
   d. The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
   e. The server shall provide scheduling for all Network Area Controllers and their underlying field control devices.
   f. The server shall be enabled to provide demand limiting that operates across all Network Area Controllers upon user request. Automated Demand Response load shed upon receipt of signal from local power company shall be enabled as well. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
   g. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Network Area Controllers. Systems not employing this prioritization shall not be accepted.
   h. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
   i. The server shall provide central alarm management for all Network Area Controllers supported by the server. Alarm management shall include:
      1. Routing of alarms to display, printer, email and email compatible pagers
      2. View and acknowledge of alarms
      3. Query alarm logs based on user-defined parameters
   j. The server shall provide central management of log data for all Network Area
Controllers supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs.

k. The server (ADX or other pre-approved manufacturer’s server software) shall encompass all New and Existing Supervisory controllers on the HSU campus. All necessary graphical points as described in the points list shall be built in the server software.

B. Network Area Controller (NAC) / Supervisory Controller
1. The NAC must provide the following hardware features as a minimum:
   a. Communications
      1. One 10/100 Mb Ethernet Port – RJ-45 connection
      2. One RS-232 port and two RS-485 ports (up to 96,000 baud) shall be standard.
      3. All required protocol drivers are included. BACnet shall be resident as standard without additional costs, additional hardware External gateways shall not be acceptable.
      4. System shall be capable of connecting to a ZigBee self-healing wireless mesh network. If necessary as determined by the Engineer and Owner, antenna and driver shall reside in NAC controller as standard.
      5. Upgraded memory licensing options shall be included in all devices and provided to incorporate all field devices, supervisory devices and servers included in this scope of work.
   b. Battery Backup
      1. Battery backup provided for all on board functions including I/O
      2. Battery is monitored and trickle charged
      3. Battery maintains processor operation through power failures for a pre-determined interval, and then writes all data to flash memory, shuts the processor down, and maintains the clock for five years.
   c. Environment
      1. Must be capable of operation over a temperature range of 0ºC to 55ºC.
      2. Must be capable of withstanding storage temperatures of between 0ºC and 70ºC.
      3. Must be capable of operation over a humidity range of 5% to 95% RH, non-condensing.
   d. Performance
      1. NAC or Supervisory Controller provided must be capable of being “upgraded” to accept additional field controllers.
      2. The Network Area Controller (NAC) shall be a fully user-programmable device
      3. Automation network – The Network Area Controller (NAC) shall reside on the automation network. Each NAC shall support one or more sub-networks of controllers.
      4. User Interface – Each Network Area Controller (NAC) shall have the ability to deliver a web based user interface as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.
      5. Power Failure – In the event of the loss of normal power, The Network Area Controller (NAC) shall continue to operate for a define period after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software. Flash memory shall be incorporated for all critical
controller configuration data.
   a. During a loss of normal power, the control sequences shall go to the
      normal system shutdown conditions.
   b. Upon restoration of normal power and after a minimum off-time delay, the
      controller shall automatically resume full operation without manual
      intervention through a normal soft-start sequence.
   c. Certification – All controllers shall be listed by Underwriters
      Laboratories (UL).

C. Application Specific Controllers (ACS's)
   1. The ASC devices must provide the following hardware features as a minimum:
      a. Communications:
         1. All field controllers must support BACnet MSTP (via RS485).
      b. Inputs/Outputs
         1. All form C SPDT relay outputs rated for 24 VAC/DC @ 2Amps resistive
            each with individual LED indicators.
         2. All Universal Inputs must support 1K, 4-20 mA, or 0-10 V, Dry contact.
         3. All field controllers shall be provided with an additional 10% unused Input
            and Outputs.
      c. Environment
         1. Must be capable of operation over a temperature range of
            0ºC to 55ºC.
         2. Must be capable of withstanding storage temperatures of between
            0ºC and 70ºC.
         3. Must be capable of operation over a humidity range of 5% to 95% RH,
            non-condensing.

D. Field Equipment Controller (FEC, FEC X611)

E. The Field Equipment Controller (FEC) shall be a fully user-programmable, digital
controller that communicates via BACnet MS/TP protocol or optionally via N2Open.
   1. The FEC shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135,
      Clause 9 on the controller network.
      a. The FEC shall be BACnet Testing Labs (BTL) certified and carry the BTL
         Label.
      b. The FEC shall be tested and certified as a BACnet Application Specific
         Controller (B-ASC).
      c. A BACnet Protocol Implementation Conformance Statement shall be
         provided for the FEC.
      d. The Conformance Statement shall be submitted 10 days prior to bidding.

F. The FEC shall employ a finite state control engine to eliminate unnecessary conflicts
between control functions at crossover points in their operational
sequences. Suppliers using non-state based DDC shall provide separate control
strategy diagrams for all controlled functions in their submittals.

G. Controllers shall be factory programmed with a continuous adaptive tuning algorithm
that senses changes in the physical environment and continually adjusts loop tuning
parameters appropriately. Controllers that require manual tuning of loops or perform
automatic tuning on command only shall not be acceptable. The FEC shall be
assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

H. The FEC shall include an integral real-time clock and support time-based tasks which
enable these field controllers to monitor and control:
   1. Schedules
2. Calendars  
3. Alarms  
4. Trends  

I. The FEC can continue time-based monitoring when offline for extended periods of time from a control system network.

J. The FEC can operate as a stand-alone controller in applications that do not require a networked supervisory device or for network applications where it is preferred to have the scheduling, alarming, and/or trending performed locally in the field controllers.

K. The FEC shall include troubleshooting LED indicators to identify the following conditions:
   1. Power On
   2. Power Off
   3. Download or Startup in progress, not ready for normal operation
   4. No Faults
   5. Device Fault
   6. Field Controller Bus - Normal Data Transmission
   7. Field Controller Bus - No Data Transmission
   8. Field Controller Bus - No Communication
   9. Sensor-Actuator Bus - Normal Data Transmission
  10. Sensor-Actuator Bus - No Data Transmission
  11. Sensor-Actuator Bus - No Communication

L. The FEC shall accommodate the direct wiring of analog and binary I/O field points.

M. The FEC shall support the following types of inputs and outputs:
   1. Universal Inputs - shall be configured to monitor any of the following:
      a. Analog Input, Voltage Mode
      b. Analog Input, Current Mode
      c. Analog Input, Resistive Mode
      d. Binary Input, Dry Contact Maintained Mode
      e. Binary Input, Pulse Counter Mode
   2. Binary Inputs - shall be configured to monitor either of the following:
      a. Dry Contact Maintained Mode
      b. Pulse Counter Mode
   3. Analog Outputs - shall be configured to output either of the following:
      a. Analog Output, Voltage Mode
      b. Analog Output, current Mode
   4. Binary Outputs - shall output the following:
      a. 24 VAC Triac
   5. Configurable Outputs - shall be capable of the following:
      a. Analog Output, Voltage Mode
      b. Binary Output Mode

N. The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).
   1. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
   2. The FC Bus shall support communications between the FECs and the NAE.
   3. The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.
   4. The FC Bus shall support a minimum of 100 IOMs and FECs in any combination.
   5. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.
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O. The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).

2. The SA Bus shall support a minimum of 10 devices per trunk.
3. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.

P. The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.

Q. The FEC shall support, but not be limited to, the following applications:

1. Heating central plant applications
2. Built-up air handling units for special applications
3. Terminal & package units
4. Special programs as required for systems control

R. The FEC shall support a Local Controller Display (DIS-1710) either as an integral part of the FEC or as a remote device communicating over the SA Bus.

1. The Display shall use a BACnet Standard SSPC-135, clause 9 Master-Slave/Token-Passing protocol.
2. The Display shall allow the user to view monitored points without logging into the system.
3. The Display shall allow the user to view and change setpoints, modes of operation, and parameters.
4. The Display shall provide password protection with user adjustable password timeout.
5. The Display shall be menu driven with separate paths for:
   a. Input/Output
   b. Parameter/Setpoint
   c. Overrides
6. The Display shall use easy-to-read English text messages.
7. The Display shall allow the user to select the points to be shown and in what order.
8. The Display shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.
9. The display shall be a minimum of 4 lines and a minimum of 20 characters per line
10. The Display shall have a keypad with no more than 6 keys.
11. The Display shall be panel mountable.

2.5 SOFTWARE PROGRAMMING/TOOLS

A. Network Area and Field Controller Toolset shall be one and the same, or, if two are required they must be provided to the owner at no additional cost:

1. Device embedded toolset shall provide the following capabilities in a graphical environment using a standard Web browser:
   a. Device and point management
   b. Scheduling, alarming and trending setup
   c. Creation and binding of graphics
   d. Time management
e. User management

2. Toolset provides additional engineering capabilities including:
   a. Editable table based point listings.
   b. Automatically generated graphics for standard applications.

B. Device Program Editor
   1. Definition of application and logic and display operation shall be available in a completely graphic environment.
   2. All temperature and equipment control strategies, energy management routines, scheduled operations and local device status indicators shall be definable by the operator. User password access and language options shall be definable by the operator.
   3. Event definition, prioritization, logging and reporting options are definable by the operator.
   4. Application logic shall provide for stand-alone applications as well as distributed applications that are automatically downloaded from master controllers to a network of controllers.
   5. The programming environment shall provide help menus and instructions for each operation and/or application performed, for all programming library functions, and for the programming language itself.
   6. Libraries of standard application modules shall be provided, such as temperature, humidity, and flow control. These modules may be used as “building blocks” in defining or creating new control sequences. In addition, the user shall have the capability to easily create and archive new modules and control sequences.

C. All supervisory level software and controller level software must be supplied to the Owner, no exceptions along with all user names and passwords for both the platform and station.

2.6 VARIABLE FREQUENCY MOTOR SPEED CONTROL DRIVES
   A. All necessary site VFD's shall be manufactured by ABB. All drives supplied shall include conduit kits and BACnet communication. Units over 5HP shall be complete with Bypass Switches and Line Reactors.
   1. Provide VFD with following features:
      a. Full Protection - Ground Fault, Phase to Phase, Over Voltage, Under Voltage, Over Temperature and Motor Over Current.
      b. 32-character backlit display. Give simultaneous indication of status, speed, load, direction, and speed reference type.
      c. Built in speed/frequency, load amp, kilowatt hour, and elapsed time indicator. Speed indicator can be set to read Hertz, RPM, % of speed, /S,/M,/H,#/S,#/M, or #/H.
      d. RS232 serial communications.
      e. BACnet bus compatible RS485 communications and shall match existing protocol.
      g. All VFDs shall have hardwired control points and BACnet communication for enhanced device monitoring, trending, and control.

2.7 LOCAL CONTROL PANELS
   A. All control panels shall be provided by the installing contractor. All control components
shall be UL inspected and listed. Control panels shall be fully enclosed, with sub-panel, hinged door, and slotted flush latch. Control panels shall exist on all equipment specified and shall be UL listed as a complete fabricated system. UL listing number shall be shown on final drawings.

B. In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.

1. Relays shall be provided for all DO’s, shall have LED indicators, and shall have manual override switches.

C. All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.

D. Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

E. All wiring shall be neatly installed in plastic trays and labeled with heat shrink labels on both ends (field device and panel/controller side).

F. A convenience 120 VAC duplex receptacle shall be provided in each enclosure, with fused on/off power switch, and required transformers.

G. All control panels shall be UL listed and manufactured by either the installing contractor or controls hardware manufacturer.

H. All control panels shall have a NEMA rating appropriate for the conditions at the proposed installation location. Proposed panel NEMA designation to be submitted to Owner for approval with the controls submittal.

2.8 INTERIOR AND EXTERIOR LIGHTING CONTROL

A. Existing Lighting (Controls Retrofit): Existing exterior and interior lighting panels/contactors controlled by existing control system shall be integrated into the new BAS via BACnet or hardwired connections when called out.

1. Controls Contractor shall provide any needed hardware and integration required to replicate existing lighting control functionality.

B. New Lighting Controls Integration with BAS

1. Controls must meet the most recent edition of Title 24 available at time of bid.

2. Lighting control system must communicate with the BAS and allow for complete integration. All control systems must be licensed under the Owner.

a. Approved systems include:

   1. Wattstopper
   2. nLight Acuity
   3. Pre-Approved Equal

b. Lighting occupancy sensing data shall have the capability to be integrated with BAS in support of zone unoccupied setback controls

   1. Acceptable protocols are BACnet MSTP, BACnet IP(TCP) and Johnson N2.

2. All proposed interior and exterior lighting systems must be included in the submittal documentation. The Owner and Engineer must provide acceptance of any of the approved systems before installation can begin.

2.9 BUILDING AUTOMATION SYSTEM SHALL BE FDD/ANALYTICS READY

A. Purpose: The purpose of the Fault Detection and Diagnostic (FDD) analytic software application is to analyze energy and equipment data to identify faults, opportunities for
improved performance, and reduced energy use in the operational of building systems. The analytics platform will also be used by the university to enhance the commissioning of the BAS system and support the ongoing optimization of the building systems.

B. Data Accessibility: The BAS shall provide data access to the university’s analytics platform.

1. BAS trend histories shall be readily accessible to the analytics platform in one or more of the following ways:
   a. Direct, read-only query of the BAS trend histories in a trend history SQL database
   b. Scheduled export of all selected BAS trends in .csv, .xls, or .xml format to local network folder location
   c. Direct query of the trend histories via Open RestAPI
   d. Direct nHaystack query (accessible network path required)

2. BAS current value data shall be readily accessible to the analytics platform in one or more of the following ways:
   a. Direct BACNet IP query (accessible network path required)
   b. Direct nHaystack query (accessible network path required)

C. Trending Required: The BAS server shall have the capacity to trend all points and store the data for a minimum of two weeks for transfer to the analytics platform.

1. Trend intervals:
   a. Analog points for valve positions, equipment speeds, supply temperatures, and damper positions shall be recorded on a maximum of 1-minute intervals
   b. Electric submeters shall be recorded on 15-minute intervals
   c. Remaining Analog points shall be recorded on a maximum of 5-minute intervals
   d. Boolean trends shall be recorded on change of value

PART 3 – EXECUTION

3.1 PREPARATIONS:

A. Prior to Installation: Inspect the installed work executed under other Sections which affect the installation of the controls. Report unacceptable conditions to Engineer. Do not begin work until unacceptable conditions have been corrected. Installation of the controls shall constitute acceptance of existing conditions.

B. Coordination: Coordinate work with work specified under other Sections to ensure proper and adequate interface of work. Equipment and systems drawings are generally diagrammatic unless dimensions are indicated. Drawings and details shall be checked for interferences with structural and other conditions prior to performing work.

C. The Contractor shall be responsible for safety and good condition of his materials and equipment until final acceptance by the Owner. He shall erect and maintain suitable barriers, protective devices, lights and warning signs where required.

3.2 INSTALLATION:

A. General:
   1. When applicable installation procedures are shown or specified in other sections, those procedures shall be followed.
   2. Provide all supports and hangers, etc., as required to install the equipment as
specified or shown on the drawings. All equipment shall be supported, braced and cross-braced to comply with current CBC and CMC.

3. Sealing: Wherever any part of the control system has to pierce the roofing, openings through the roof shall be flashed absolutely watertight.

4. Arrange and support piping and equipment so that vibration is at a minimum and is not transmitted to or through building structure.

3.3 WIRING AND CONDUIT:

A. Control wiring and conduit shall be the responsibility of this section and be installed as follows:

1. In equipment rooms/attics – Conductors shall be run in conduit. Final connection to equipment shall be flexible conduit.

2. Concealed in building construction (wall/inaccessible ceilings) - Conductors shall be run in conduit.

3. Roof mounted/exterior equipment yards - Conductors shall be in conduit. All flexible conduit shall be seal-tite with weatherproof connections. Equipment on grade and detached from the building a distance greater than 36” shall have underground control conduit routed to equipment.

4. Above accessible ceiling spaces - Control cable shall be installed in conduit. Deviation for this requirement may be permittable and must be approved by the owner upon each exception.

a. Cable is an approved type for the application.

b. Cable is bundled/organized in management devices routed square with building lines (no diagonals) and kept clear of electrical devices (i.e., ballasts, transformers, etc.) that could cause interference.

c. Conduit sleeves are provided between accessible ceiling spaces (i.e., across soffits, gypboard ceilings, etc.) as required to maintain future access to cable.

5. Cable routed in accessible ceiling spaces shall comply with EIA/TIA standards for communications cabling. All wire shall be shielded and plenum rated. Wire for BAS shall be Belden or pre-approved equal to match below:

a. BACnet bus – Blue

b. Output Devices – Pink

c. Input Sensors – Purple

d. Low Voltage Wiring – Orange

3.4 IDENTIFICATION:

A. Contractor shall submit on their labelling strategy for Owner approval.

B. DDC/EMS Contractor shall provide complete labeling of all terminals at all panels or equipment terminal strips and wiring. Equal to Brady marking on wires and number on terminals in sequence corresponding to control diagram.

C. The label wording shall match that used on the drawings and provide clearly readable printed labels for each control component inside a panel. When applicable, additional identification needed shall be documented on the Shop Drawings.

D. Engraved nameplates shall be provided on the face of each panel and beneath each actuator and control device not in a panel describing its use.

E. All electrical devices within the panel shall be wired to a terminal strip within the panel. An "electric terminal" numbering system shall be applied to all terminals with
3.5 **CLOSING-IN OF UNINSPECTED WORK:**

A. **General:** Do not allow or cause any of the Work of this Section to be covered up or enclosed until it has been inspected, tested, and approved by the Mechanical Engineer and by all other authorities having jurisdiction.

B. **Uncovering:** Should any of the Work of this Section be covered up or enclosed before it has been completely inspected, tested, or approved, do all things necessary to uncover all such work. After the Work has been completely inspected, tested, and approved, provide all materials and labor necessary and make all repairs necessary to restore the Work to its original and proper condition at no additional cost to the Owner.

3.6 **PROGRAMMING:**

A. The Direct Digital Control (DDC) operational program will be provided by approved installing contractor. The factory certified installing contractor shall provide all necessary programs to fully test the operation of the various components. Programming shall be verified for proper operation by CxA with Controls Contractor assistance.

B. The DDC/EMS Contractor shall furnish a complete and operating system. The DDC/EMS Contractor shall also verify, in the presence of the Owner or designee, the system accuracy and proper function of each controlled device and sensor. The following items shall be successfully demonstrated prior to acceptance by the Owner or designee:
   1. All system outputs including controllers, relays, and other control devices shall be addressed and start/stop functions demonstrated.
   2. All inputs shall be displayed and all event-initiated functions shall be demonstrated.
   3. Demonstrate program integrity and power restore sequence during and after a power failure and restoration.
   4. Deliver all Record Drawings, wiring diagrams, equipment specifications, installation and Operation Manuals and other documentation as required to describe the system.
   5. Complete operator training in the use, programming, and operation of the system.

C. **Start-up of the System:**
   1. The start-up period starts when the following conditions are met:
      a. The DDC/EMS system and all involved HVAC equipment have been installed, connected to the DDC/EMS system, and are ready to operate.
      b. A start-up meeting has been conducted with representative of the General Contractor, Architect/Engineer, maintenance staff, and the DDC/EMS Contractor.
      c. Consensus is reached, by the representatives at the above referenced meeting that it is appropriate for the start-up process to start.
   2. The alarm notifications sent by the control system during the start-up period shall be sent to the Mechanical Contractor and/or DDC/EMS Contractor as appropriate. The Mechanical Contractor and DDC/EMS Contractor shall respond to all notifications from the control system and work cooperatively to insure that the building environmental standards are maintained.

D. **Verification:** A written testing and start-up report must be submitted for approval before acceptance. In addition to the DDC/EMS Contractor’s testing and start-up report, the Owner may independently verify the test results in person or via FDD/analytics. The
report on test results shall include setpoints and operating ranges of all components.

3.7 POINT NAMING CONVENTION
   A. Contractors will adhere to the pre-approved HSU official Points List.
      1. The intent of the point naming convention is to provide a consistent programming approach for all current and future buildings, rooms, equipment and sub-points that current and future contractors shall follow.
      2. All contractors performing programming will be held accountable in regard to abiding by the pre-approved HSU official Points List.
      3. Confirmation of proper programming point naming convention must be attained before final payment is released.
   B. The naming convention for point and trend names shall conform to the following:
      1. [3-digit Building Number] [Unit or Equipment Name] [Point Name]
      2. Points associated with zones shall append the following to the point name: _RM*, where “**” represents the room number(s).
      3. In the cases where the point short names are used, the contractor must include all appropriate unique identifiers.
   C. Refer to separate Points List document.

3.8 SEQUENCE OF OPERATION:
   A. The below sequences of operation are to be used as a primary guideline for DDC/EMS control logic sequence development. Any/all variations from the below operation sequences must be approved by the University DDC/EMS operator prior to implementation. All fans providing ventilation to meet minimum outside air requirements shall run continuously during occupied hours. Airside equipment (air handlers, etc.) shall start by normally open relay and signal from DDC/EMS.
   B. Refer to separate Sequence of Operations document.

3.9 SYSTEM INSTRUCTION AND TRAINING
   A. Prior to final acceptance and release of retention, the DDC/EMS Contractor shall provide operational training to the Owner's personnel. The training sessions shall include a complete demonstration of the system. Dates and times of the training sessions shall be coordinated through the Owner not less than one week prior to session. The DDC/EMS Contractor shall maintain a log of training sessions including dates, times and names/titles of those attending. The DDC/EMS Contractor shall submit a copy of this log on request.
      1. Training shall be broken out into three different levels
         a. Level 1 – Basic system operation overview including instruction on how to log into the system, navigate and access remotely. This training will be provided in 2-hour sessions (minimum) on three separate occasions within the first year of system operation.
         b. Level 2 – Intermediate system operation instruction on how to navigate the Supervisory controller’s logic files, create trends and histories. This training will be provided in 4-hour sessions (minimum) on three separate occasions within the first year of system operation.
         c. Level 3 – Advanced system operation instruction focus on programming at the supervisory and field controller level. This includes training on controller logic blocks, wire sheets and manipulating graphics. This training will be provided in 8-hour sessions (minimum) on three separate occasions within the first year of system operation.
system operation.

2. Contractor shall provide 1-week factory certified training schedule and class at owners’ discretion.

3.10 RECORD DRAWINGS
A. Instruction period shall be started after instruction books, service manuals and record drawings have been submitted to and approved by the HSU and shall be at hours (regular and non-regular) arranged by the HSU.
B. Service manuals shall include oiling, cleaning and servicing data, compiled in clearly and easily understood form and in a durable binder. Data shall show all serial numbers of every piece of equipment and complete list of replacement parts.
C. Retention and final payment will not be released until HSU has received and approved of the final As-Built controls drawings.

3.11 COMMISSIONING:
A. The Building Commissioning (Cx) Process: Commissioning building systems and equipment (including controls) is essential to the delivery of high-quality facilities for the campus.
   1. The Controls Contractor shall participate as required in the commissioning process in support of the University’s Commissioning Agent (CxA). This may include, but is not limited to:
      a. Design Phase: Basis of control system design, controls design review responses.
   2. Refer to separate CSU Commissioning guideline.
B. Control System Device Checkout and Testing: Device checkout and testing is to be completed and documented as part of control system startup before the system demonstration to the commissioning agent.
   1. Calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under the project specifications. Factory calibration is generally acceptable for non-critical sensors, such as zone temperature sensors in offices. Critical sensors requiring field calibration shall be noted in control drawings and submittals.
   2. Verify that all control wiring is properly installed and connected.
   3. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers’ recommendations.
   4. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
   5. Verify that all analog output devices are functional with proper output signal range, and default value settings.
   6. Alarms and Interlocks:
      a. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
      b. Interlocks shall be exercised using field contacts to check logic, as well as to ensure that the fail-safe conditions are properly set.
      c. Interlock actions shall be tested by simulating alarm conditions to check for
C. Control System Demonstration and Acceptance/Functional Testing
   1. Demonstration/Functional Testing
      a. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, started up the system, and performed his/her own tests. The tests described in this section are to be performed in addition to the tests that the contractor performs as a necessary part of the installation, start-up, and debugging process and as specified in the “Control System Device Checkout and Testing” article in this specification.
      b. The CxA/engineer will be present to observe and review these tests. The CxA/engineer shall be notified at least 10 days in advance of the start of the testing procedures.
      c. The contractor shall provide at least two persons equipped with two-way communication and shall demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the calibration, response, and action of every point and system. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.
      d. The specific functional tests will be defined by the CxA/engineer in the commissioning plan and project-specific commissioning specification. This may include, but is not limited to:
         i. As each control input and output is checked, a log shall be completed showing the date, technician’s initials, and any corrective action taken or needed.
         ii. Demonstrate compliance with sequences of operation through all modes of operation.
         iii. Demonstrate complete operation of operator interface.
         iv. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop’s response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
      e. The University’s FDD/analytics platform may also be used by the CxA to verify proper system operation. The controls contractor shall support the integration of BAS data to the FDD/analytics platform in support of the commissioning effort.
      f. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the CxA/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in electronic format.
      g. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or
revisions to the hardware or software to successfully complete all tests.

2. Acceptance
   a. All tests described in this specification shall have been performed to the satisfaction of both the CxA/engineer and University prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.
   b. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved by the University.

3. The System Demonstration and Acceptance period starts when the following conditions are met:
   a. The DDC system and all involved HVAC equipment, Metering Equipment and Lighting Controls have been installed, connected to the DDC system, completed start-up, and are ready to operate.
   b. A commissioning meeting has been conducted with representative of contractors involved building occupants, General Contractor, Mechanical Contractor, Owner and the approved Controls Contractor.
   c. Consensus is reached by the representatives at the above referenced meeting that it is appropriate for the process to start. The operational program is loaded into the DDC system by the approved Controls Contractor.

4. During the commissioning period, the approved Controls Contractor will maintain a commissioning file of the printed reports from the building. The owner will provide the necessary commissioning sheets.

5. During the commissioning period, all mechanical equipment with filters shall have new filters installed. The static pressure across the fan shall be accurately measured and documented if installed.

6. The commissioning process will be completed and the warranty period shall start when the following conditions are met.
   a. All training to be provided as part of the project has been completed.
   b. No "alarm" or "condition reports" are being generated by the DDC system for seven (7) calendar days (168 hours) due to incomplete or inaccurate installation, program, or programming.
   c. All adjustments and "fine tuning" of the system have been completed.
   d. The system has been accepted by the General Contractor and Building Owners and approved by the Engineer.
   e. All commissioning shall be approved by the CxA/Engineer with the final commissioning approval being reserved for the Owner.

7. In order to conclude the commissioning process As-Builts must be supplied. There will be no job close-out until all above conditions have been met to the satisfaction of the Owner and Engineer and (1) hard copy and (1) electronic copy of the As-Builts have been supplied.

8. No retention will be released until these parameters have been met.
3.12 WARRANTY PERIOD.
   A. After the project has been officially closed out and approved by the Owner and Engineer the warranty period may begin.
      1. Warranty period shall include (1) year parts and (1) year labor

   END OF SECTION