SECTION 23 09 00 - HVAC DIRECT DIGITAL CONTROLS

1 PART 1 – GENERAL

1.1 - SECTION INCLUDES

A. Furnish all labor, materials, equipment, and services for the installation of a complete Direct Digital Control System (DDC) as indicated, in accordance with provisions of the Contract Documents and Northwest Missouri State University General Design Conditions. Northwest Missouri State University (NWMSU) shall contract independently for graphic programming and Front-End integration related to this project on the Tridium N4 Supervisor through approved Master Service Integrator (MSI).

B. Although such work is not specifically indicated, provide all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation.

1.2 - RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

1.3 - DESCRIPTION

A. General:

- Northwest Missouri State University is using the Niagara N4 software as the “Front-End” interface to all buildings. All BAS equipment installed shall be compatible with Niagara N4. Northwest Missouri State University will separately contract the integration services for the Niagara Front End integration.
- All control system equipment, including sensors, transmitters, control modules and communication link wiring between controllers required for the installation shall be provided by the Temperature Control Contractor.
- Communication wiring shall be tested to demonstrate functional operation.
- All wiring and control hardware to be installed by the Temperature Control Contractor.
- Temperature Control Contractor to provide all labor incidental to the Building Automation System including engineering assistance, start-up, check-out and programming.
- Control valves and dampers to be furnished by the temperature control contractor and installed by Mechanical or Sheet metal contractor.
- The control system shall consist of a high-speed, peer-to-peer network of DDC controllers, a control system server, and a web-based operator interface.
- All existing Tracer 100 and Pneumatic controls shall be removed and replaced with new DDC devices under this contract.
- NWMSU shall be given first right of refusal for all equipment and devices removed from the facilities under this contract.
- Existing pneumatic devices and systems shall be notified to NWMSU and their removal based upon the direction of NWMSU removed in their entirety.

B. System software shall be based on a server/thin client architecture, designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the owner's local area network, and (at the owner's discretion) over the Internet. The

intent of the thin-client architecture is to provide operators complete access to the control system via a Web browser. No special software other than a web browser shall be required to access point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.

C. System shall use the BACnet protocol for communication between control modules. I/O points, schedules, setpoints, trends and alarms specified in the Sequence of Operations for HVAC Controls shall be BACnet objects.

1.4 - QUALITY ASSURANCE

A. The following are the approved manufacturers of control equipment for this project, or their equivalent:
- ALC – Automated Logic (Update after RFP – XXXX-XX)
- JCI – Metasys (Update after RFP – XXXX-XX)
- Schneider – EcoStruxture (Update after RFP – XXXX-XX)
- TBD (Optional)
- TBD (Optional)

B. MSI manufacture is Niagara Framework Web Supervisor N4.x and Niagara Workbench as defined in Section 250000 – Enterprise Integrated Facility Management and Control System

C. Manufacturers of equivalent equipment may be submitted for approval by the Mechanical Engineer for consideration pending approval of substitution by NWMSU.as per the requirements below.

D. Other manufacturers' equipment may be proposed but must comply with the following specifications. To obtain bid approval, a detailed technical proposal shall be required of bidders and shall be furnished along with the bid. The information required shall list at least 3 similar digital transmission, computer oriented, integrated DDC installations which have been on-line for at least 5 years. The list shall include a synopsis of the type of control strategies being implemented, name of primary contact and phone number along with the local service capability. Technical cut sheets for all non-approved products being proposed shall also be provided. Cut sheets shall provide technical information and network requirements. Also provide cut sheets for any custom editing/programming software required for programming controllers.

E. The BAS shall be installed by competent mechanics and checked out by competent technicians regularly employed by the manufacturer of the equipment.

F. Single source responsibility of the Temperature Control Contractor shall include installations, calibration, and check out of systems.

G. The Temperature Control Contractor shall have an in-place, local support facility with technical staff, spare parts inventory, and all necessary test diagnostic equipment.

It is the intent of the University that each building will be on a single building automation system of the same manufacture, era, and programming. A building is defined by Northwest Missouri State University by either Name of building, structure of building(s), and/or by system infrastructure. Exclusions to this and any of the above conditions can only be made by written acceptance of exclusion by Northwest Missouri University.

1.5 - CODES AND STANDARDS

A. It is the responsibility of the Temperature Control Contractor to be familiar with all codes, rules, ordinances, and regulations of the Authority Having Jurisdiction and their interpretations which are in effect at the site of work.

B. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with the current editions in effect 30 days prior to the receipt of bids of the following codes:

- Federal Communications Commission (FCC)
- Electronics Industries Association (EIA)
- American Society of Mechanical Engineers (ASME)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriter's Laboratories (UL)
- Occupational Safety and Health Administration (OSHA)
- National Electric Code (NEC)
- International Building Code (IBC)
    - Section 719 Ducts and Air Transfer Openings
    - Section 907 Fire Alarm and Detection Systems
    - Chapter 28 Mechanical
- International Mechanical Code (IMC)
- American National Standards Institute (ANSI)
- American Society of Heating, Refrigeration and Air Conditioning Engineers
- ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Systems

C. The Temperature Control Contractor shall be solely responsible for compliance with all health and safety regulations, performing the work in a safe and competent manner, and use industry accepted installation procedures required for the work as outlined in this document.

D. All systems equipment, components, accessories, and installation hardware shall be new and free from defects and shall be UL listed where applicable. All components shall be in current production and shall be a standard product of the system or device manufacturer. Refurbished or reconditioned components are unacceptable. Each component shall bear the make, model number, device tag number (if any), and the UL label as applicable. All System components of a given type shall be the product of the same manufacturer.

1.6 - SUBMITTALS

A. Product Data and Shop Drawings: Meet requirements of Section 01 30 00 on Shop Drawings, Product Data, and Samples. In addition, the contractor shall provide an electronic copy of all shop drawings or other submittals on hardware, software, and equipment to be installed or provided. No work may begin on any segment of this project until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2013 (or newer) compatible files on magnetic or optical disk (file format:

B. .DWG, .DXF, or comparable) and three 11” x 17” prints of each drawing. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and

drawing shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Submittals shall be provided within 3 weeks of contract award. Submittals shall include:

C. DDC System Hardware
- A complete bill of materials to be used indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
- Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
    - Direct digital controllers (controller panels)
    - Transducers and transmitters
    - Sensors (including accuracy data)
    - Actuators
    - Valves
    - Relays and switches
    - Control panels
    - Power supplies
    - Batteries
    - Operator interface equipment
    - Wiring
- Wiring diagrams and layouts for each control panel. Show termination numbers.
- Schematic diagrams for all field sensors and controllers. Provide floor plans of all sensor locations and control hardware. Riser diagrams showing control network layout, communication protocol, and wire types.

D. Controlled Systems
- Riser diagrams showing control network layout, communication protocol, and wire types. System architecture drawing shall identify the exact order in which devices are to be wired for communication, including equipment with packaged controls.
- A schematic diagram of each controlled system. The schematics shall have all control points labeled with point names shown or listed. The schematics shall graphically show the location of all control elements in the system. Locations of controllers, pressure transmitters etc. shall be provided.
- A schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.
- An instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
- A mounting, wiring, and routing plan-view drawing. The design shall take into account HVAC, electrical, and other systems' design and elevation requirements. The drawing shall show the specific location of all concrete pads and bases and any special wall bracing for panels to accommodate this work.
- A complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system.
- A point list for each control system. List I/O points and software points specified in the Sequence of Operation. Indicate alarmed and trended points.

E. Quantities of items submitted shall be reviewed but are the responsibility of the Contractor.

F. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

G. Project Record Documents. Upon completion of installation, submit three copies of record (as- built) documents of the documents shall be submitted for approval prior to final completion and shall include:

- Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2013 (or newer) compatible files on magnetic or optical media (file format: .DWG, .DXF, or comparable) as well as provided in .PDF format and as 11" x 17" prints.
- Operation and Maintenance (O&M) Manual.
- O&M manuals must be submitted to the contracted commissioning authority prior to substantial completion if applicable.
- As-built versions of submittal product data.
- Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
- Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
- Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
- Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
- Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
- Graphic files, programs, and database on magnetic or optical media.
- List of recommended spare parts with part numbers and suppliers.
- Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software. This shall be provided on a solid state drive (SSD) labeled to the project name and applicable project number.
- Floor plan drawings identifying communication cable pathways through the building, controller locations and concealed sensor locations. Additionally, sensors that are installed in concealed locations shall have a photograph included that shows the location.
- Licenses, guarantees, and warranty documents for equipment and systems.
- Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

H. Training Materials: Provide course outline and materials for each class before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web- based training.

1.7 - WORK BY OTHERS

A. Automatic Control Valves: Furnished by the Controls Contractor, installed by Mechanical under the supervision of the Temperature Control Contractor. All reducers and fittings necessary to install smaller than pipe size valves shall be furnished and installed under applicable piping sections.

B. Automatic Control Dampers: Furnished by the Controls Contractor, installed by Mechanical under the supervision of the Temperature Control Contractor. All sheet metal and duct modifications required to support the installation shall be provided by the Mechanical Contractor.

C. Piping Penetration: Water pressure and differential taps, valve manifolds, flow switches, thermal wells; installed by Mechanical under the supervision of the Temperature Control Contractor.

D. Power Source Wiring; and all 120 volts A.C. power source wiring: Furnished and installed under Division 26: Electrical:

E. Northwest Missouri State University shall contract independently to the approved Master Service Integrator (MSI) for graphic programming, alarming, trending, scheduling, and Front End integration related to this project on the Tridium N4 Supervisor.

1.8 - WARRANTY

A. Warrant work as follows:

- At completion of final test of installation and acceptance by the NWMSU, provide any service incidental to proper performance for a period of one year. Provide one year in warranty service with minimum of 2 maintenance/calibration inspections.
- Unlimited telephone technical support for NWMSU employees shall also be provided during the warranty period. Telephone support shall be available Monday through Friday, 8:00 AM to 5:00 PM.
- Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.
- Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer's acceptance.

1.9 - OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

- Graphics
- Record drawings
- Database
- Application programming code
- Documentation

2 PART 2 – PRODUCTS

2.1 - GENERAL

A. The Direct Digital Control System shall consist of the following:

- Related Work – **Section 230923 – Direct Digital Controllers and Networks**

3 PART 3 – EXECUTION

3.1 - GENERAL

A. Related Work

- Related Work – **Section 230923 – Direct Digital Controllers and Networks**

3.2 - EXAMINATION

A. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

B. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and at the expense of—this contractor.

3.3 - PROTECTION

A. The contractor shall protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.

B. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.4 - COORDINATION

A. Site:

- Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
- Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Submittals. See Specifications for submittal requirements.

- Related Work – **Section 230923 – Direct Digital Controllers and Networks**

C. Test and Balance.

- The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
- The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
- In addition, the contractor shall provide a qualified technician to coordinate and assist in the test and balance process as needed.
- The tools used during the test and balance process will be returned at the completion of the testing and balancing.

D. Life Safety.

- Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown as specified in the Sequence of Operation.
- Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. Interlock smoke dampers to air handlers as specified in the Sequence of Operation.
- Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:

- All communication media and equipment shall be provided as specified.
- Each supplier of a controls product is responsible for the configuration, programming, start up, and testing of that product to meet the sequences of operation.
- The contractor shall coordinate and resolve any incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
- The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
- The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.
- All integration of controls to overarching network as defined in Section **2309203 – Direct Digital Controllers and Network** are to be executed and installed per **Section 250000 – Enterprise Integrated Facility Management and Control Systems**

3.5 - GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install equipment in readily accessible locations as defined by Chapter 1 Article 100 Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.6 - FIELD QUALITY CONTROL

A. All work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

C. Contractor shall have work inspection by local and/or state authorities having jurisdiction over the work.

3.7 - EXISTING EQUIPMENT

A. Wiring. Interconnecting control wiring shall be removed and shall become the property of the contractor unless specifically noted or shown to be reused.

B. Local Control Panels. Remove and deliver existing control panels to Owner.

C. Repair. Unless otherwise directed, the contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Should the contractor find existing equipment that requires maintenance, the engineer is to be notified immediately.

D. Indicator Gauges. Where these devices remain and are not removed, they must be made operational and recalibrated to ensure reasonable accuracy.

E. Room Thermostats. Remove and deliver existing room thermostats to Owner unless otherwise noted. Patch and finish holes and marks left by removal to match existing walls.

F. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Owner.

G. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Owner.

H. Damper Actuators, Linkages, and Appurtenances. Remove and deliver existing damper actuators, linkages and appurtenances to Owner.

I. Control Valves. Replace existing control valves with new. Deliver removed control valves to Owner.

J. Control Compressed Air Systems. Replace existing control compressed air systems with new unless otherwise noted. Deliver removed systems to Owner.

K. Existing System Operating Schedule. Existing mechanical system may be disabled during this work.

L. The scheduling of fans through existing or temporary time clocks or control system shall be maintained throughout the DDC system installation

M. Install control panels where shown.

N. Modify existing starter control circuits, if necessary, to provide hand-off-auto control of each controlled starter. If new starters or starter control packages are required, these shall be included as part of this contract.

O. Patch holes and finish to match existing walls.

3.8 - WIRING

A. Contractor shall provide and install BAS LAN connections. MAC address of new JACE equipment shall be provided to Northwest Missouri State University so reservations can be made. No other LAN connections on the NWMSU Network shall be provided for BAS equipment.

B. Contractor shall provide and install Cat6A Ethernet cabling from the BAS System JACE(s) to the designated NWMSU network switch. This needs to be completed per NWMSU standards for pathway, wire color code, and conductor termination. Contractor shall test and verify the cable is terminated and communicating properly. After communication is verified, contractor is to contact NWMSU Information Technology to verify the Jace is communicating and verify network connections. The contractor shall be responsible for producing the appropriate Trust Certificate and introducing the JACE to the N4 Supervisor server.

C. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

D. All NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and

Division 26 requirements.

E. All low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

F. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.

G. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

H. Do not install wiring in raceway containing tubing.

I. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and supported per the requirements of the NEC.

J. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

K. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to- wire connections shall be at a terminal block.

L. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

M. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

N. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

O. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

P. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

Q. Include one pull string in each raceway 1 in. or larger.

R. Use color-coded conductors throughout with conductors of different colors.

S. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

T. Conceal all raceways except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 in. from high-temperature equipment (e.g. steam pipes or flues).

U. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

V. Adhere to this specification's Division 26 requirement where raceway crosses building expansion joints.

W. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

X. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

Y. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 ft. in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways

shall be used.

Z. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.

3.9 - COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

C. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer’s instructions.

G. All runs of communication wiring shall be un-spliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. All communication wiring pathways shall be documented on the Controls As-Built drawings.

J. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

K. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

- The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 30 pF per foot.
- The maximum length of an MS/TP segment is 4000 ft. with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
- The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated using repeaters.
- An MS/TP EIA-485 network shall have no T connections.

3.10 - INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by wall framing.

D. All wires attached to sensors shall be sealed in their raceways or in the wall to stop air transmitted from other areas from affecting sensor readings.

E. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft. of sensing element for each 1 ft2 of coil area.

G. Do not install temperature sensors within the vapor plume of a humidifier. If installing a sensor downstream of a humidifier, install it at least 10 ft. downstream.

H. All pipe-mounted temperature sensors shall be installed in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells. Surface Mounted Sensors shall not be permitted.

I. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

J. Differential Air Static Pressure.

- Supply Duct Static Pressure. Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if present). If a building static pressure sensor is not present, pipe the low-pressure port to the location of the duct high-pressure tap and leave open to the plenum.
- Return Fan Discharge Static Pressure.
    - ♦ Systems with Relief Air to the Outside: Pipe high-pressure tap to the discharge plenum using a pitot tube. Pipe the low-pressure port to an Outside static pressure sensor located adjacent to the Relief Louver.
    - ♦ Systems with Relief Air to the Mechanical Room: Pipe high-pressure tap to the discharge plenum using a pitot tube. Pipe the low-pressure port to the Mechanical Room adjacent to the Relief Damper.
- Return Duct Static Pressure. Pipe the low-pressure tap to the duct using a pitot tube. Pipe the high-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if present). If a building static pressure sensor is not present, pipe the high-pressure port to the location of the duct low-pressure tap and leave open to the plenum.
- Mixed Air Plenum Static Pressure. Pipe the low-pressure tap to the plenum using a pitot tube. Pipe the high-pressure port to a tee in the Outside Air static pressure sensor line.
- Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location designated by the Design Engineer and terminate to a Space Static Pressure Sensor wall or ceiling mounted.
- For spaces that do not have an operable outside opening, coordinate the space static pressure high and low sensing locations with the Engineer.
- The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
- All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
- All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shut-off valves installed before the tee.
- If any pressure tubing length is more than 25 feet, contractor shall use 3/8” poly tubing.

K. Smoke detectors, freezestats (Low Temperature Detection), high/low-pressure cut-offs, damper end switches and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Pressure and Temperature Safety Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

L. Install humidity sensors for duct mounted humidifiers at least 10 ft. downstream of the humidifier. Do not install filters between the humidifier and the sensor.

3.11 - FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer's instructions.

3.12 - ACTUATORS

A. General. Mount and link control damper actuators according to manufacturer's instructions.

- To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
- Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- Provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

- Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° travel available for tightening the damper seal. Actuators shall be mounted following manufacturer's recommendations.
- Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

C. Fail Safe Position

- Confirm the Fail Safe positioning of all actuators with the Engineer.

3.13 - WARNING LABELS

A. Permanent warning labels shall be affixed to all equipment that can be automatically started by the control system.

- Labels shall use white lettering (12-point type or larger) on a red background.
- Warning labels shall read as follows.

C A U T I O N

This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Permanent warning labels shall be affixed to all motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.

- Labels shall use white lettering (12-point type or larger) on a red background.
- Warning labels shall read as follows.

C A U T I O N

This equipment is fed from more than one power source with separate disconnects.
Disconnect all power sources before servicing.

3.14 - IDENTIFICATION OF HARDWARE AND WIRING

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 2 in. of termination with control system address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum ½ in. letters on laminated plastic nameplates.

D. Identify all other control components with permanent labels. All plug-in components shall be labeled such that label removal of the component does not remove the label.
E. Identify room sensors related to terminal boxes or valves with nameplates.
F. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.
G. Identifiers shall match record documents.

3.15 - CONTROLLERS

A. Provide a separate controller for each applicable non-integrated AHU, RTU, or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
B. Building Controllers and Custom Application Controllers shall be selected to provide the required I/O point capacity required to monitor all of the hardware points listed in the Sequence of Operation.

3.16 - PROGRAMMING

A. Provide sufficient internal memory for the specified sequences of operation and trend logging.
B. Point Naming. The contractor shall be responsible for defining points in the JACE(s) in accordance with the Brick Schema naming convention as directed by NWMSU.
C. The Contractor shall submit a complete Points List containing the Description, Point Name (Acronym), Tag, Point Type, Unit of Measure, Facet Properties, Alarm Properties and Trend Properties, for approval prior to the start of any programming.
   - The contractor shall expose and define in accordance with the Point Naming Standards ALL points available from Packaged Controllers (OEM) to the applicable MSI for integration into the N4 Supervisor.
D. Software Programming.
   - Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used.
     - ♦ Refer to Section 230993 – Control Sequences

     in the sequences of operation. Use the appropriate technique based on the following programming types:
   - Text-based:
     - ♦ Must provide actions for all possible situations
     - ♦ Must be modular and structured
     - ♦ Must be commented
   - Graphic-based:
     - ♦ Must provide actions for all possible situations
     - ♦ Must be documented
   - Parameter-based:
     - ♦ Must provide actions for all possible situations
     - ♦ Must be documented.
   - The controller software shall allow the technician to manually control all output points, read values of all input points and virtual points for all provided controllers. The Service software shall allow

NWMSU to edit, develop new or delete any custom programming. Proprietary cabling shall be provided to interface to all provided field controllers. The Controls Contractor shall provide all software required at the time of Substantial Completion of this project. Any passwords or hardware keys shall be provided with the software at Substantial completion. Providing this software shall not void any warranty coverage for the installation of the Control Systems.

3.17 - CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified that the system is ready for startup.

- The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
- Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.
- Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
- 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.
- Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
- Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules.
- Alarms and Interlocks:
    - Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
    - Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
    - Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action

3.18 - CONTROL SYSTEM COMMISSIONING AND ACCEPTANCE

A. Commissioning.

- Related Work
    - **Section 019113 – General Commissioning Requirements**
    - **Section 250800 – Integrated Automation Commissioning**

B. Acceptance.

- All tests described in this specification shall have been performed to the satisfaction of both the engineer, commissioning authority, and owner, or owner's representative, 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.
- The system shall not be accepted until all forms and checklists completed as part of the commissioning are submitted and approved as required in Part 1, "Submittals."

3.19 - CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall berepaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.20 - TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

B. Provide course outline and materials according to the "Submittals" article in Part 1 of this specification. Provide one copy of training material per student.

C. The instructor(s) shall be factory-trained and experienced in presenting this material.

D. Classroom training shall be done using a network of working controllers representative of installed hardware.

3.21 - DUCT SMOKE DETECTION

A. Submit data for coordination of duct smoke detector interface to HVAC systems as required in Part 1, "Submittals."

B. This Contractor shall provide a dry-contact alarm output in the same room as the HVAC equipment to be controlled.

3.22 - CONTROLS COMMUNICATION PROTOCOL

A. Related Work

- **Section 230901 – Controls System Integration**
- **Section 230923 – Direct Digital Controllers and Networks**
- **Section 230924 – Graphical User Interface Integration**

End of Section 23 09 00

SECTION 230923 - DIRECT DIGITAL CONTROLLERS AND NETWORKS

1 PART 1 - GENERAL

1.1 - RELATED WORK

A. Section 230900 – HVAC Direct Digital Controls

B. Section 230924 – Graphical User Interface Integration

C. Section 230993 - Control Sequences (To Come After RFP and Vendor Selection)

D. Section 250000 – Enterprise Integrated Facility Management and Control System

1.2 - DEFINITIONS

A. The following abbreviations, acronyms, and definitions may be used in addition to those found elsewhere in Contract Documents.

- O-ASC: Application Specific Controller. A networked device or node that contains a complete, configurable application that is specific to a particular task.
- Alarms & Events: The exchange of data between devices related to the occurrence of a predefined condition that meets specific criteria (event).
- O-BC: Overarching Controller. Provide supervisory control, scheduling, trend logging, graphics, & alarm handling.
- B-OWS: BACnet Operator Workstation
- B-BC: BACnet Building Controller. Same as SLC.
- B-AAC: BACnet Advanced Application Controller. Same as PPC.
- B-ASC: BACnet Application Specific Controller
- B-SA: BACnet Smart Actuator
- B-SS: BACnet Smart Sensor
- BBMD: BACnet Broadcast Management Device
- BIBBS: BACnet Interoperability Building Blocks. Specific individual function blocks for data exchange between interoperable devices.
- BTL: BACnet Testing Laboratory.
- Channel: One or more segments not containing a router.
- Domain: A logical collection of devices on one or more channels.
- FLN: Floor Level Network. BACnet MS/TP.
- HMI: Human-Machine Interface. Graphical operator control system interface. Same as Graphical User Interface (GUI).
- LAN: Local Area Network. Same as Floor Level Network.
    - ♦ Maximum Send Time: Event driven communication parameter specifying the time period for which data must not be sent more than once.
    - ♦ Minimum Send Time: Event driven communication parameter specifying the time period for which data must be sent at least once.
- PICS: Protocol Implementation Conformance Statement. Detailed description for a given BACnet device stating its inherent BACnet capabilities.
- Point: Group of data, which corresponds to a hardware input, output, or calculated value.
- PPC: Programmable Process Controller. Same as Advanced Application

Controller (AAC)

- ♦ Repetitious Controls: Controls for critical systems where the control is spread across multiple controllers with separate power sources so there is no single point of failure for the entire system.

- Scheduling: The exchange of data between devices related to the establishment and maintenance of dates and times at which specified output actions are to be taken.
- Send on Delta: Event driven communication parameter specifying the amount of variable change before data is to be sent between the Minimum and Maximum send times.
- SLC: Supervisory Level Controller. Same as Building Controller.
- Segment: A section of uninterrupted cable where multiple devices may be installed.
- Subnet: Logical division of a domain.
- Trending: The accumulation of (time, value) pairs at specified rates for a specified period duration.

1.3 - SUBMITTALS

B. Shop Drawings:

- Submit shop drawings for each hardware device used and submit complete description of software applications used. Submit manufacturer's printed product data sheets for each device or software program used. Datasheets shall be submitted electronically in pdf format with bookmarks provided for each individual device and table of contents listing each device manufacturer and full model number with links to device pages. Organize sheets in order of model number, alphabetically, then numerically. When a manufacturer's data sheet refersto a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
- Submittals shall include points list of each control input and output, controlled devices, locations of devices, and symbol or label of each control point in software.
- Device data sheets shall be submitted with electronic bookmarks as specified in Section 230901 - Control Systems Integration. Refer to PART 1 – GENERAL, subsection SUBMITTALS.
- Device data sheets shall be submitted simultaneously with Control Systems Integration submittal. Refer to submittals section in **230900**.

C. Operating and Maintenance Manuals: Refer to **Section 230900 – HVAC Direct Digital Controls**.

1.4 - SOFTWARE MANUAL:

- As part of operating and maintenance manuals, submit one software manual per workstation plus one extra copy for archive use. Software manuals shall be divided into separate parts with tabs for each part.
- Software manual parts shall include:
  - ♦ Complete description of operating system including all commands, configuration programs, printouts, logs, database functions and passwords. Describe general operating procedures, starting with system overview and proceeding to detailed description of each software command feature with sample printed displays and system function description for each option. Include instructions on verifying errors, status, changing passwords and initiating or disabling control programs.
  - ♦ Complete description of programming language including all commands, configuration programs, control loop functions and testing. Describe general programming procedures, starting with system overview and proceeding to detailed description of each software command feature. Include instructions on creating or modifying any control algorithm or parameter, debugging, etc. This shall include all control functions, algorithms, mathematic equations, variables, setpoints, time periods, messages, and other information necessary to load, alter, test and execute custom or pre-written programs.

- Software Backup: Upon successful completion of acceptance testing, submit to Owner 2 archive copies of all accepted versions of source code and compiled code for all application programs and data files on backup USB flash drives. All control software must be readily accessible by Owner using control system workstation hardware and software.
- Web server/data historian SQL database schema (table format) for trend data and event/alarm data.
- Control Loop Documentation: Submit indexed summary of each control loop program. Summary shall list in tabular form, name of system, name of control loop, all I/O points used, and reference to sheet number in shop drawings to describe control sequence programmed. For each control loop submit complete printed listing of source code used, all setpoints, high/low alarm points, time event schedules, proportional gains, integrals, derivative values, and other database values.
- Control Systems Points List Summary: Provide detailed summary for each point in the system. Summary shall be cross-index listing of all points in alpha/numerical order with list of control loops which use each point. For each point, include an abbreviated point name, expanded point description, detailed description of each input instrument or output device, and detailed description of exact location of all field hardware. Location descriptions shall include room names, column numbers, elevation (above ceiling, bottom of duct, etc.).

1.5 - WARRANTY

A. Refer to **Section 230900 – HVAC Direct Digital Controls.**

1.6 - FCC COMPLIANCE

D. Digital equipment furnished under this contract shall be tested and made to comply with limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against interference when operated in commercial environments. Literature shall so note and equipment shall be so labeled to show this compliance.

2 PART 2 - PRODUCTS

2.1 - DIRECT DIGITAL CONTROL (DDC) CONTROLLERS:

A. General:

- DDC controllers shall be microprocessor based, field programmable controllers, capable of performing control and energy management functions, and shall be UL listed as Signaling Systems. Each controller shall include its own microprocessor, power supply, input/output modules, and termination modules as required to perform intended function.
- DDC controller shall receive discrete electrical and/or analog electronic field input signals, convert signals for use by controller, perform control sequences, convert controller information into output signals, and provide control output signals to actuators and field control devices. Inputs and outputs, including communication connections, shall be electrically or optically isolated from controllers.
- DDC controller with analog input modules shall be capable of accepting any form of linear or non-linear voltage (0-5 VDC or 0-10 VDC), current (4-20 mA) or resistive input (0-1000 ohm).
- DDC controller with discrete input modules shall be capable of accepting discrete inputs from any device with isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible status lights (LEDs) to indicate input point status.
- Provide input modules capable of interfacing with pulsed output type sensors as required.
- DDC controller with discrete output modules shall have isolated, dry-type contacts (no grounds or no voltage) of either normally open (NO) or normally closed (NC) configuration. Provide visible

status lights (LEDs) to indicate output point status.

- DDC controller shall have capability to scale, offset, and display proper analog value without field hardware modification. DDC controller shall convert analog input signals to digital values (A/D conversion) and convert digital values to analog outputs (D/A conversion) for modulating control purposes. Some application specific controllers may utilize tri-state or Triac outputs for floating point control of control devices. Floating point control should be limited to non-critical room temperature control and mechanical space heating and cooling.
- Failsafe hardware shall be provided such that control systems failures result in immediate return to local control. If DDC controller uses database values from other DDC controllers and communication network fails or malfunctions, control loop outputs shall continue to function using last value received from control systems.
- Failure of network or control devices (i.e. building level controllers, floor level controllers, application specific controllers, routers, repeaters, etc.) shall be alarmed at the Operator Workstation as a Level 3 Critical Alarm.
- All DDC Hardware shall meet the following requirements:
    - ♦ All DDC controllers shall be connected to an ASHRAE 135 MS/TP, BACnet over ARCNET or BACnet/IP control network and communicate via ASHRAE 135 exclusively.
    - ♦ MS/TP controllers shall operate at a minimum baud rate of 38.4 kbps.
    - ♦ All DDCP shall implement all required functionality of the application network interface via BACnet objects, properties, and services.
    - ♦ All DDC controllers shall conform to the BACnet Testing Lab's Device Implementation Guidelines and be BTL Listed.
    - ♦ Application programs and configuration settings shall be stored in a manner such that a loss of power does not result in a loss of the application program or configuration settings.
    - ♦ All settings and parameters used by the application shall be fully configurable to the greatest extent possible, via properties of BACnet objects that can be written to via BACnet services or via properties of BACnet objects that can be written to via BACnet services for the following:
    - ♦ Setpoint
    - ♦ Alarm limit
    - ♦ Schedule modification
    - ♦ Trend modification
    - ♦ All other settings and parameters that cannot be written to via BACnet services shall be fully configurable via either properties of BACnet objects that can be written to with a configuration tool, or via hardware settings on the controller itself to support the application.
- Each DDC panel shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in point schedules. If DDC controller does not have sufficient capacity, provide additional slave I/O panels to achieve required point count.
- Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC panel. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control.

B. BACnet Routers:

- BACnet MS/TP to BACnet/IP or BACnet/ARCNET to BACnet/IP Routers shall perform layer 3 routing of BACnet MS/TP or BACnet/ARCNET packets over an IP network in accordance with ASHRAE 135 Annex J. The router shall provide the appropriate connection to the IP network and connections to the BACnet MS/TP or BACnet/ARCNET network. BACnet Routers shall be capable of configuration via DHCP and Write-Broadcast- Distribution-Table messages but shall not rely on these services for configuration.
- One router in the IP subnetwork shall be designated as the BBMD (BACnet Broadcast

Management Device) and shall be indicated as so on the Network Architecture.
- BACnet router functionality can also be incorporated into BACnet Building Controllers.

C. BACnet Gateways:
- Provide gateways to connect BACnet to non-BACnet devices, and non-BACnet DDC controlled equipment.
- Provide with each gateway an interoperability schedule, showing each point or event on the non-BACnet side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (BIBBS), defined in ASHRAE 135 Annex K. Provide two- year minimum warranty for each gateway, including parts and labor.
- The following minimum capabilities are required:
  - Gateways shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.
  - Gateways shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.
  - Gateways shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.
  - Gateways shall meet the requirements of Data Sharing Read Property (DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management Dynamic Device Binding-B (DM-DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with ASHRAE 135.
- Gateways shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on SSD media and the ability to modify, download, backup, and restore gateway configuration.

D. BACnet Overarching Network Controls (O-BC)
- Overarching Network design standard is of Tridium Niagara 4 Framework and will be managed by a Master Service Integrator firm in concordance with below listed specification.
  - Section 250000 – Enterprise Integrated Facility Management and Control System

E. BACnet Building Controller (B-BC)
- BACnet Building Controllers (B-BCs) shall provide direct connection to high speed, BACnet/IP Local Area Network (LAN) and Campus Ethernet network and serve as communications router for other controllers on slower speed BACnet MS/TP or BACnet over ARCNET Floor Level Network (FLN) within a designated building.
- Communication between B-BC for specified buildings or sites for campus integration shall be through BACnet/IP communication up to O-BC's.
- B-BC's shall have sufficient processor capabilities, hard-drive storage and RAM to implement all types of custom software applications and shall provide supervisory control, scheduling, trend logging & alarm handling functions as follows:
  - Scheduling:
    - Each B-BC shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.
  - Trending:
- Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
- B-BC shall periodically upload trended data to networked BAS Web Application Server for long term archiving.
- Archived data shall be stored in standard database format and shall be made available for use in

third-party spreadsheet or database programs.

- ♦ Alarm Generation:

- Alarms may be generated within the system for any object change of value or state either real or calculated. This includes analog object value changes, binary object state changes, and various controller communication failures.
- B-BC shall periodically upload alarm logs to networked BAS Web Application Server for long term archiving.
- B-BC's shall have uninterrupted real time clocks capable of time of day, week, and year information to the system as needed to perform software functions. Clock shall be programmed to reset twice per year to allow for Daylight Savings Time. Clocks in multiple DDC Controllers shall be synchronized to automatically match designated B-BC's or Web server. Accuracy shall be within 1 second per day.
- Batteries shall maintain volatile memory and real time clocks for a period of at least 72 hours during power failure. Batteries shall be maintenance free and have minimum life of 2 years. When power has been restored, the following shall occur automatically:
  - ♦ Orderly startup of controlled equipment (user defined)
  - ♦ Continuation of control algorithms
  - ♦ Database revision
  - ♦ Logging of power interruption and restoration times
  - ♦ Battery recharging
- Provide local visual indication and system annunciation of low battery power for each battery.
- Each B-BC shall include its own micro-processor, power supply, input/output modules, and termination modules as required to perform intended function.
- BACnet UDP port number to always be set to 47808 (BAC0).

F. BACnet Building Advanced Application Controllers (B-AAC

- B-AACs are defined as having sufficient processor capabilities and RAM to implement all types of custom software applications.
- B-AACs shall be capable of communicating to BAS network via BACnet MS/TP connected to Building Controller or via BACnet/IP directly.
- All B-AACs controlling major mechanical equipment/systems and lab equipment monitoring shall communicate via BACnet/IP as indicated on BAS Network Architecture drawings.
- Provide at least one extra communication port at each B-AAC for direct connecting a notebook computer or hand-held terminal.

G. BACnet Building Application Specific Controllers (B-ASC):

- B-ASCs are defined as having standard software burned into EPROM, set points in EEPROM or RAM maintained by battery, and are designed to handle specific types of control sequences.
- Application specific DDC Controller shall be capable of communicating to control system network via low/medium speed network connected to B-BC.
- Control outputs may be in the form of floating-point control or true analog output control of end devices. Floating point control shall be limited to non-critical room temperature control or mechanical space heating and cooling.
- Provide communication ports integral room temperature sensors/thermostats for interface with local terminal equipment controllers or a low range wireless (Bluetooth®) Commissioning tool that provides a temporary wireless connection between the MS/TP network and the laptop computer used to commission.

H. Power Supplies:

- Power supplies shall operate on nominal 120 V, 60 Hz, single-phase power. DDC Controllers shall be provided with surge and noise protection. Power fluctuation shall not affect control system. Include surge protection on telephone line.
  - ♦ Isolation transformers shall be included when connections are being made between 2

separate buildings.

2.2 - DIRECT DIGITAL CONTROL SOFTWARE

A. General:
- DDC Controller control strategies shall be Owner definable from engineering workstations.
- Software functions and algorithms shall be sufficient to enable implementation of control sequences as specified and shall be able to maintain continuous control as intended.
- Control functions shall include both mathematical and logical operators. Control algorithms shall include proportional, integral and derivative control (PID). Adaptive (self-tuning) PID loop parameters, if offered by DDC Controller manufacturer, shall not be used unless adaptive limits are used to adjust limit values based on system status; or written request is submitted and approved by Engineer.
- Allow operators to assign unique identifiers of their choice to each connected point. Identifiers shall have at least 8 alpha/numeric characters. References to these points in programs, reports and command messages shall be by these identifiers. Identifiers must comply with the BRICK schema RDF naming convention.
- Provide access control (user defined passwords) for system operation. There shall be minimum of 3 access levels. First level shall allow system monitoring only. Second level shall allow monitoring, set point adjustment, and scheduling revision. Third level shall allow modification of control algorithms. System shall log out of account after 10 minutes of inactive operation.
- Each DDC Controller shall contain self-diagnostics that continuously monitor proper operation of panel.
- If microprocessor malfunctions, control loop outputs shall continue to function using last value received from microprocessor.

B. O-BC Overarching Controller Software:
- Related Work:
  - Section 250000 – Enterprise Integrated Facility Management and Control System

C. B-BC Building Controller Software:
- Provide DDC Controller software application program modules for performing energy management control functions such as time of day change of database values (programmed start/stop, temperature setbacks, etc.), supply air temperature reset based on space load demand, economizer control, optimum start/stop based on current indoor and outdoor psychometrics, duty cycling and client tailored programs required for special applications such as VAV fan matching and supply fan control, enthalpy control, intermediate season or "dead band" control, totalizing, and holiday programming.
- Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given that operator has appropriate security access level):
  - User interface and online system configuration software embedded in B-BC Controller.
  - Support for Web services at the automation network level.
  - Displaying database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameters.
  - Ability to operate all downstream B-BC’s network points for operation such as schedules, setpoints, occupied/unoccupied, demand levels, E.I>
  - Alarm reporting including sending alarms to remote workstations, User Interface Web Server or Data Historian on network.
  - Alarm buffer to retain alarms in order of importance without losing any alarms.
  - Creating and displaying historical trend logging of any value, limited only by available memory.

- ♦ Creating new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.
- ♦ Adding new hardware points without overall BAS shutdown.
- ♦ Maintain equipment sequences derived from ASHRAE Guideline 36 for equipment function and operation.

D. B-ASC Controller Software:
- Manufacturer's standard software for B-ASC's may be used only if control sequences can be implemented without modification. If control sequence cannot be accomplished with standard software, provide battery backed RAM or EEPROM DDC Controller (B-AAC) capable of being programmed for specified control sequence.
- Provide software for portable PC units to communicate with terminal controllers at the building level network. Software shall allow access to modify, delete or create control strategies at the equipment location.
- Provide manufacturer's standard operating system for real time control of system interactions, including database information requests/transfers by system hardware or by operators. Operating system shall also have the following additional capabilities (given that operator has appropriate security access level):
  - ♦ Support for Web services at the automation network level.
  - ♦ Displaying database (point) value including measured values, controlled variables, setpoints, gain factors, and any other adjustable parameters.
  - ♦ Changing or overriding any database value.
  - ♦ Creating new variable database values (soft points) based on arithmetic calculation (including summation or totalizing) on other database values.
  - ♦ Adding new hardware points without overall BAS shutdown.

2.3 - OPERATOR'S WORKSTATION - HARDWARE

A. Operator Workstations shall communicate with control systems Web Server via standard web interface software. Proprietary software shall not be required for proper monitoring and control of HVAC systems as specified in section 230924 - Graphical User Interface Integration.
- Reference Section 250000 – Enterprise Integrated Facility Management and Control System for guidance on enterprise management through the overarching campus network control.

B. Owner will furnish operator's workstations for operator interface to control systems for monitoring, control, and database management. Provide network interface cards, all required cables and other associated hardware for connecting each of Owner's workstations to control systems network and other remote devices specified.

2.4 - ENGINEERING WORKSTATION

A. Refer to Operator Workstation section for requirements.

2.5 - WEB APPLICATION SERVER

A. Graphical user Interface Integration.
- Refer to Sections 250924 and 250000

2.6 - DDC ENGINEERING (PROGRAMMING) - SOFTWARE

A. Provide engineering software for all engineering and operator’s workstations.

B. Software shall have the same characteristic and capabilities as DDC Controllers. In addition, operator's workstations shall have the following features.

C. User Programmability:
- Engineering workstation software shall include field-engineering tools (software & hardware) for programming all controllers supplied.
- All application software shall be interactive, fully prompted, and menu driven and shall provide the following functionality as a minimum:
  - Determine control strategies, which have been defined for specific piece of equipment.
  - Add control loops to system using English language type program language equal to BASIC or other easily learned language or function block programming. (PASCAL, C, or other assembly type languages are not acceptable.)
  - Add points to system.
  - Create, modify, or delete control strategies.
  - Create, modify, or delete system graphics.
  - Assign sensors and/or actuators to control strategy.
  - Tune control loops through adjustment of control loop parameters.
  - Enable or disable control strategies.
  - Generate hard copy records of control strategies on printer or soft copies to files compatible with Microsoft Office applications.
  - Select points to be alarmable and define alarm state(s).
  - Select points to be trended over a period of time and initiate recording of values.
  - Override Input/Output points for each individual controller.

2.7 - OPERATOR WORKSTATION - SOFTWARE

D. Custom Database Functions:
- Operator shall be capable of generating long term historical trend logs and displaying information in tabular or graphic formats. Provide all software options for standard and custom report generators.

E. Color Graphics: Overarching Only:

B. Refer to **Section 250000 – Enterprise Integrated Facility Management and Control System**
- Provide color graphics software package compatible with manufacturer's standard software. Provide mouse or other special hardware required to operate software. Software shall be capable of user editing of text fields, graphics, alarms, and real-time variables.
- Software shall be capable of importing files in AutoCAD format, directly or via translators.

F. Color Graphics: Building Level B-BC's:
- Provide network tree with graphical summaries software package compatible with manufacturer's standard software. Provide mouse or other special hardware required to operate software. Software shall be capable of user editing of text fields, summaries, alarms, and real-time variables.
- Software shall be capable of importing files in AutoCAD format, directly or via translators.
- Building layouts and graphics will exist in O-BC

2.8 - NETWORK HARDWARE

G. Provide network interface hardware for each device connected to network. Each device shall have sufficient performance as not to degrade specified processing speed.

H. Provide network cabling with sufficient performance as not to degrade specified communication speed. Cabling shall be compatible with proposed system and shall comply with requirements specified in **Section 230900 – HVAC Direct Digital Controls**

I. Provide other network support devices that are required for proper operation of network, such as file servers, signal repeaters, network hubs, etc.

J. Provide network diagnostic tool for measuring/confirming bandwidth usage on IP layer.

PART 3 – EXECUTION: Step 2: (Vendor Selection Required will further determine execution)

3.1 GENERAL

A. Refer to **Section 230900 – HVAC Direct Digital Controls** for details regarding general conditions of work performed.

3.2 OVERALL BAS ARCHITECTURE

A. Provide hardware/software to update database in less than 1 second for fast-acting control loops such as pressure control, air or water flow rate control, and air handling unit temperature control, or 10 seconds or less for other control loops.

B. Control software algorithm and inputs and outputs for a single system or piece of equipment shall reside on a single controller and shall not be distributed amongst multiple controllers. If multiple pieces of equipment are to be interlocked, a single "Master" controller shall provide control for all interlocked pieces of equipment, i.e. an AHU and interlocked return fan and exhaust fans.

C. Control loop software algorithm for each analog control loop shall reside on same controller as inputs and outputs required for that specific control loop.

D. Networks that operate via polled response or other types of protocols that rely on central processors, file servers, or other such devices to maintain or manage peer-to-peer communications, shall have redundant components to maintain network in event of failure at central device. Provide automatic changeover (without operator intervention) to redundant device upon failure of any central type processor.

E. B-BC's shall receive communication from Overarching DDC controller O-BC through ethernet network utilizing BACnet/IP and transmit to Floor Level controllers through BACNet/IP – ethernet connection, BACnet/MS/TP or BACnet/ARCNET protocol.

F. Floor Level Network (FLN) network shall be multi-drop digital transmission network utilizing BACnet MS/TP (38.4kbs) communication.

G. Each multi-drop trunk shall be within manufacturer's allowable line lengths without signal degradation. Multi-drop trunks shall be interfaced to system via standard EIA or other industry recognized interfaces so that single failure does not disrupt or halt network.

H. Communications between Building Level DDC Controllers and operator's workstations shall be peer-to-peer, allowing multiple users to access and use system simultaneously with no loss of system performance.

I. Provide levels of connected networks to connect all DDC Controllers, including terminal DDC Controller. Communications to terminal devices shall be similar to capabilities and functions of other DDC Controllers and shall be transparent to operator.

J. Quantity of nodes (devices connected) on any one FLN (MS/TP) shall not exceed 50% of maximum node capacity published by equipment manufacture and Building Controller processor usage shall not be greater than 30% nominal. Provide additional hardware to meet this requirement.

K. Alarm reports from DDC Controllers shall not be impeded by use of either remote or local monitor, or

control stations on network either in access mode or programming mode.

L. Provide transient voltage surge suppression devices for controllers and other electronic devices requiring separate line voltage power source.

3.3 DIRECT DIGITAL CONTROLLERS

A. DDC Controller Usage:
- Select DDC Controller to provide speed of response required for each control loop type. Pressure, flow rate, and air handling unit temperature control must be via Building Level DDC Controller. Application specific DDC Controller may be used for other control loop types.
- Each B-BC DDC Controller shall have sufficient I/O capacity to perform specified control sequences and/or include points listed in any point schedules. If DDC Controller does not have sufficient capacity, provide additional slave panels to achieve required point count.
- Analog and critical safety discrete control loops shall have inputs and outputs into/from same DDC Controller. Analog control loops for major equipment (chilled water, hot water, convertors, air handling units, etc.) shall have PID control. Air terminal control loops may utilize floating point control from tri-state or Triac outputs from the controller, but require some type of feedback device to prove position.
- Provide at least one Building Level DDC Controller per mechanical equipment room and, if required, at each PC workstation location.
- For valves and dampers within 100 ft of associated DDC Controller, mount current to pneumatic (I/P) converter within DDC Controller panel or in adjacent panel. Otherwise mount I/P converters at valve or damper. Provide pressure gauges on main air, and all control output signals.

B. Point Capacity:
- Provide point capacity required plus spare I/O point capacity in each B-AAC. Spare I/O point capacity is defined as terminal connections, which are ready to accept digital or analog inputs, dry contacts for digital outputs, and variable voltage or current terminals for analog outputs. Universal type points are acceptable for both discrete and analog type points. Spare points do not include any input or output conversion devices.
- Spare points in each B-AAC shall be as follows:
  - 3 Universal Inputs
  - 3 Universal Outputs

C. Building Controllers
- Provide one BBMD in each IP subnet.
- BACnet UDP port number to always be set to 47808 (BAC0).

D. Application Specific Controllers: Is this needed)
- ASC controllers serving critical spaces that require maintained space pressurization shall have an acceptable solution to the Auto-Zero/Auto-Calibration sequence if the submitted controller sensors require periodic automatic calibration. Control contractor shall provide one of the following solutions to eliminate loss of room pressurization:
  - Auto-zero module
  - Pressure transmitters/flow measuring sensors that require annual calibration in place of standard transmitters that require daily/weekly calibration.
  - Control contractor shall provide a solution to the mechanical/controls engineer for approval.

E. Gateways
- Gateways may be used for communication with non-BACnet control hardware subject to all of the following limitations:
  - Non-BACnet control hardware shall not be used for controlling built-up units.

- Non-BACnet control hardware shall not perform system scheduling functions.

F. Cabinets:
- Provide local control cabinets for DDC Controllers. DDC Controller cabinets for air terminals may be used directly if enclosures are rated for NEMA 1. All cabinets shall utilize a single master key. Provide 2 spare key sets to Owner.
- All control cabinets shall be labeled. Labels shall be keyed to the unique identifiers shown on the As-Built drawings

G. Controller Firmware
- Provide latest version of controller firmware. Include firmware updates for period of one year after system acceptance, coinciding with warranty period. If the upgrade of firmware causes the need to upgrade or reconfigure/reprogram related systems, controllers or software, Contractor shall notify Owner prior to upgrade and provide additional work scope in coordination with other Contractors, as required, at no cost to Owner.

H. Critical System Controls
- Multiple controllers will be required for system redundancy and to provide a high availability and fault tolerant solution where the loss of a single controller will shut down the entire system. Multiple controllers will be required for any system that incorporates the use of N+1 equipment or multiple mechanical systems headered together to serve a common area.
  - Critical system controls shall utilize a master controller to share the system pump/AHU fan speed control signal to individual pump controllers or AHU controllers in the system. Multiple controllers shall be designed and programmed to prevent domination by one controller during normal operation. When a single pump or AHU controller fails, or communication network fails, or power source fails, remaining pump/AHU controllers shall continue to operate to provide water/air flow to critical areas.
  - Multiple controllers serving a common system shall each be powered from separate stepdown transformers. Power to the transformers shall be supplied from separate breakers at separate panels.
- Provide UPS power for critical systems using multiple controllers.

I. Broadcasting: The propagation of data from a device to the control network. Software objects that broadcast data to the network may include the following parameters:
- Send on Delta: An adjustable parameter that defines a requirement to broadcast when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data, this parameter defaults to a change of state. The broadcast of data is initiated when this criteria and the minimum send time requirement have been met. Also referred to as a "Change of Value."
- Minimum Send Time: An adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.
- Maximum Send Time: An adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.

3.4 OPERATOR/ENGINEERING WORKSTATIONS

A. Locate workstations as indicated on plans and Network Architecture.

B. Locate operator's workstations as follows:
- As specified by owner

C. Furniture is provided by others. Provide all necessary connections and extensions to integrate hardware with furniture system.

D. Security access levels for the engineering workstation software shall be setup as follows:
- Guest (View-only) access level shall have the ability to perform the following tasks:
  - View Data
  - View Trends
- Operator access level shall have the ability to perform the following tasks:
  - View Data
  - Acknowledge Alarms
  - View Reports
  - Override Points
  - Change Setpoints
  - View Trends
  - Edit Schedules
- Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:
  - Add Devices
  - Address Changes
  - Create Applications
  - Download Applications
  - Configure ASCs
  - Setup Trends
  - Setup Reports
  - Modify Alarm Settings
- Administrator access level shall have the same access as Operator level with the ability to perform the following additional tasks:
  - Add Devices
  - Address Changes
  - Create Applications
  - Download Applications
  - Configure ASCs
  - Setup Trends
  - Setup Reports
  - Modify Alarm Settings
  - Create User Accounts
  - Modify Permissions
  - Programming

E. Provide security access level setup for 10 users. Coordinate usernames, access levels and passwords with Government.

F. System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

3.5 DDC SOFTWARE INSTALLATION

A. Operating system (OS): Contractor shall install the OS on workstations and laptops and configure user names and passwords.

B. Virus Protection software: Contractor shall install the virus protection software on each server, laptop and workstation and shall configure weekly virus scans.

C. Contractor shall install and configure all software packages required to maintain and configure all types of controllers provided as part of this project on each engineering workstation.

D. Software from panels shall be permanently stored on USB drives and on at least one hard disk at operator's workstation or Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

E. Provide the latest version of all standard software, including operating system and control software. Include any software updates for period of one year, coinciding with warranty period. Beta released software shall not be used.

3.6 INITIAL PROGRAMMING

A. Control Contractor shall provide initial programming of controllers to accomplish sequences specified.

B. Provide back-up documentation per software manual submittals for all programs, in both written and electronic media formats.

C. Outputs, whether sequenced or not, shall have separate programmable hardware outputs. For air handling units, minimum outside air, maximum (economizer) outside air, return air, relief air, smoke dampers, heating valves, cooling valves, humidifier valves, etc., shall each have separate output.

D. BACnet Naming and Addressing
- Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For MS/TP, assign from range as indicated by vendor documentation.
- Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.
- Every BACnet Building Controller (B-BC) and BACnet Router UDP port number shall be set to 47808 (BAC0).
- Assign unique Device "Object Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface. BACnet allows up to 4,194,302 possible unique devices per internetwork.
- The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application. Examples include "Zone 1 Temperature" and "Fan Start/Stop".
- All naming to follow BRICK schema and adhere to ASHRAE Standard 223P for RDF ontology.

E. Minimum BACnet Object Requirements
- For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service: all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.
- The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.

- Support and provide Description and/or Device Type text strings matching signal type and engineering units shown on the points list.
- Support and provide Inactive Text and Active Text property descriptions matching conditions shown on the points list.
- For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. Enable the writeable Date List property and support all calendar entry data types.
- Use Schedule Objects for all building system scheduling.
- Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint and all constraints associated with Object, such as Proportional Constant, Integral Constant, and Derivative Constant for Loop Object, using BACnet read/write services.

F. Minimum BACnet Service Requirements
- Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below.

Priority Level	**Application**
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)
15	(User Defined)
16	Default

G. Data Sharing:
- Data communication from Building Controllers to Engineering Workstation and BAS web server shall be programmed to use Change of Value (COV) data sending and not continuous data polling to limit network traffic.
- Data communication parameters for analog values shall be operator configurable and setup as follows:

a. Minimum Send Time: 2 seconds

b. Maximum Send Time: 60 seconds

c. Send on Delta (COV) :

1). Space Temperature: ±0.5°F

2). Process Temperature: ±0.5°F

3). Air Pressure, AHU: ±0.05“ W.C.
4). Relative Humidity: ±0.5%
5). Air Flow: ±200 cfm
6). Water Flow: ±50 gpm
7). Water Pressure ±0.2 psi
8). Space Pressure: ±0.01“ W.C.

- Digital data points shall be sent whenever a state change occurs.

H. Historical Trending:
- All inputs and analog outputs shall be trended and shall fully configured and operational. Sample time shall be one minute.
- Program historical file for run-times and quantity of start/stops of motor driven equipment
- Trend logs are to be stored at the building controllers and uploaded to the BAS web server or data historian when the building controller trend buffer size reaches 90% full or every 30 minutes (FA).

I. Alarm/Event Management:
- All alarm handling shall be fully configured with consistent alarm messages and priorities or category numbers to identify the system from which the alarm originates.

J. Provide programming of menus to assist new users in accessing screen displays of each point group. Point groups (user definable) shall be initially arranged by DDC Controller for major equipment and by floor and area for terminal devices. Terminal devices shall also be grouped by air handling system where applicable.

K. Controls Contractor shall verify with Owner if any standard naming conventions are being used and continue with those naming conventions when applicable.

L. Program historical file for run-times and quantity of start/stops of motor driven equipment.

M. Program maintenance alarms based on run-times and quantity of start/stops for motor driven equipment.
- Provide the following additional alarms:
  - Controller loss of communications for each controller.
  - Controller battery alarm for each controller (where available)
  - Out-of-range, bad, or missing data (fault) for each device.

N. Program alarms using the following levels:
- Level 1 - Maintenance Alarm, requiring attention within 1 to 2 days. (Examples: 2-3°F temperature variance from set point; 15-25% relative humidity variance; etc.)
- Level 2 - Low Level Alarm, requiring attention within 8 h, preferably during the same shift. (Examples: More than 3°F variance from set point, 30 percent relative humidity or more variance from set points; excess start/stops per day; etc.)
- Level 3 - Critical Alarm, requiring immediate attention. (Examples: Non-operation of primary equipment; H-O-A overrides; failure of controllers, routers and repeaters.)
- Level 1 and 2 alarms shall not interrupt current user operation, but shall be logged into alarm summary file, indicating status, acknowledgment, and by whom. Level 3 alarms shall interrupt user via audible and/or flashing warning until acknowledged, without losing any work in progress. When alarms are acknowledged, program shall display point group or appropriate graphic display. Level 3 alarms shall also be logged into alarm summary file in similar manner as Level 1 and 2 alarms.

O. Time Schedules:
- Provide time schedules for HVAC components/systems as indicated in Control Sequences.

- All time schedules shall be fully configured with weekly schedules and all holidays identified by the Owner.
- Time schedules are to reside in the Building Controllers.

3.7 POINT LIST

A. Provide points required to implement control sequences specified, whether or not they are listed in schedules. In addition to control points, provide additional points listed in point schedules or defined in Control Sequences.

B. All points shall be programmed with a point name and detailed description. Control contractor shall submit point naming convention to NWMSU for approval prior to system programming.

C. All point naming will conform to ASHRAE Guideline 223P of RDF based convention and utilize the standard of “Brick Schema”

D. Work jointly with Owner to develop unique equipment point naming convention prior to start of programming. Only applicable in the instance that no “Brick Schema” naming convention exists.

E. “Brick Schema” will be utilized for analytical and modeling data as well as future installations.

End Of Section 230923

SECTION 230924 - GRAPHICAL USER INTERFACE INTEGRATION:

1 PART 1 - GENERAL

1.1 - RELATED WORK

A. Section 230900 – HVAC Direct Digital Controls

B. Section 230923 - Direct Digital Controllers and Networks

C. Section 250000 – Enterprise Integrated Facility Management and Control System

1.2 - SYSTEMS DESCRIPTION

A. Building Automation System (BAS, Overarching) Graphical User Interface (GUI) shall be accomplished via a web-server environment.

B. Controls system web servers shall communicate with individual Building Systems via BACnet/IP protocol on the Enterprise Ethernet network. Refer to Control System Architecture drawing and Control Systems Integration specification.

C. Provide remote alarm paging via text message, alphanumeric message and emailintegral to web server software.

D. Operator workstations connected to building Ethernet network shall be able to access information as determined by Graphical User Interface (GUI) software through standard web browsing software (Internet Explorer, Mozilla Firefox or Netscape Navigator). GUI software shall allow transparent access to each connected building and building component/system for control and/or monitoring.

1.3 - REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01-91-00 Commissioning. Testing of these systems is required, in cooperation with Owner and Commissioning Authority. Refer to Section 019100 Commissioning for detailed commissioning requirements.

1.4 - SUBMITTALS

A. Refer to Section 230900 – HVAC Direct Digital Controls.

1.5 - OPERATION AND MAINTENANCE MANUALS

A. Refer to Section 230900 – HVAC Direct Digital Controls.

1.6 - RECORD DRAWINGS

A. Refer to Section 230900 – HVAC Direct Digital Controls.

1.7 - OWNERSHIP OF PROPRIETARY MATERIAL

A. Refer to Section 230900 – HVAC Direct Digital Controls.

1.8 - WARRANTY

A. Refer to Section 230900 – HVAC Direct Digital Controls.

PART 2 – PRODUCTS

2.1 SERVER - HARDWARE

A. Contractor shall provide Control Systems Web Application Servers for operator control/monitoring of building control systems. Web Application Servers shall be located in IDF room.

B. System databases (data historian) may be provided on server hardware separate from graphical web interface server as necessary to provide optimum system performance and flexibility.

C. User Interface Web Application Server Hardware (server) shall be a standard unmodified digital computer of modular design currently being manufactured. Modular components of the server shall be products of a single manufacturer which advertises service in all 48 contiguous states. All desktops, laptops, and computer monitors are required to have achieved Bronze registration or higher under the Electronic Products Environmental Assessment Tool (EPEAT).

D. Server hardware shall meet the following minimum requirements.
- Processor speed: Minimum 250% of the stated requirements of the software to be installed on server.
- Random Access Memory (RAM): Minimum 250% of the stated requirements of the software to be installed on server.
- Communications ports: One serial port, one enhanced parallel port and two USB port in addition to any ports required for the keyboard and mouse.
- Hard Drives and Controller: Controller and Drives shall provide a minimum of 250 percent of the usable disk space required for monitoring, control and data archiving with an average seek time of 7 milliseconds or less using hardware RAID (Redundant Array of Inexpensive Disks) at level 5 (RAID-5).
- CD/DVD-RW Drive: Combo CD-RW with 32x read, 24x write and 16x rewrite and DVD- RW with 12x read; 4x re-write; 2x write.
- Video output card: Support at least 16 bit color at a minimum resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.
- Network Interface Card (NIC): Two (2) Gigabit Ethernet Network Interface Cards (NICs) with automatic switchover and load sharing.
- Monitor: 19-inch rack-mount LCD monitor w/ keyboard (mouse required if keyboard does not incorporate touchpad) with a minimum resolution of 1024 by 768 pixels, non-interlaced, a maximum dot pitch of 0.28 millimeters, and a minimum refresh rate of 70 Hz. Include cantilever shelf and all hardware required for mounting monitor drawer in two post rack. Provide rack-mountable KVM switch and associated cabling where multiple servers are housed in common rack.
- Hot-swappable redundant power supplies
- Redundant Fans
- Operating system (OS) shall fully support all installed software and peripherals.
- Virus Protection Software shall consist of the project site's standard virus protection software complete with a virus definition update subscription.
- Latest version of Microsoft Office Professional
- Latest version of Adobe Acrobat
- Coordinate additional software requirements with Owner.
- All required cables for connecting to network and other remote devices

2.2 USER INTERFACE WEB SERVER - SOFTWARE

A. Web server shall provide dynamic, real-time graphical control/monitoring interface for all HVAC, plumbing, lighting control and electrical systems shown on System Diagrams or included in Control Sequences. Refer Section 230901 - Control Systems Integration

A. Graphical displays shall also include alarm displays, scheduling displays and trending displays. Data associated with an active display shall be no more than 5 seconds out-of-date.

B. Control systems web servers shall be provided with all software applications and licenses required to provide web access to minimum of 10 simultaneous clients.

C. Overarching O-BC Operator web access Graphical User Interface (GUI) shall be interactive, fully prompted, menu driven and shall provide the following functionality as a minimum:
- HVAC Systems:
  - ♦ GUI shall allow for hierarchical graphical navigation between individual buildings and building control systems within individual buildings, graphical representations of systems, access to real-time data for each system, ability to override points in a system, and access to all supervisory monitoring and control functions including building/equipment schedules. Each system display shall clearly distinguish between the following point data types and information: Real-time data, User-entered data, Overridden or operator-disabled points, Devices in alarm (unacknowledged), and Out- of-range, bad or missing data.
  - ♦ Software shall allow the user to create, modify, and delete displays and graphic symbols.
  - ♦ Operator shall be able to monitor/control all data points as listed in DDC Point Schedules and shown on flow diagrams via graphic displays.
  - ♦ Operator shall be able to view and modify all Occupied/Unoccupied schedules.
- Alarm and Event Management:
  - ♦ Refer to Section 250000 – Enterprise Integrated Facility Management and Control System

D. Scheduling:
- Refer to Section 250000 – Enterprise Integrated Facility Management and Control System

E. Trending & Data Archiving:
- Trend logs are not to be server based using polling. Trend logs are to be initially stored at the BAS controller and periodically uploaded to the Web Server data historian for long-term storage.
- Users logged into the system shall not have direct access to any of the raw trend data located in the BAS controllers or Web Server data historian.
- Trend log files shall be appended with new sample data, allowing samples to be accumulated. Systems that write over archived data shall not be allowed, unless limited file size is specified.
- Web interface shall provide ability to graphically view trend data using two-axis (x,y) graphs that display up to ten object types at the same time in different colors. Graphs shall show object values relative to time.
- Operator shall be able to change trend log setup information if logged on with the appropriate security access. This includes the information to be logged as well as the interval at which it is to be logged. All input, output, and value object types in the system may be logged.

F. Report Generating:
- Web Server Software shall be provided with commands to generate and format reports for displaying on current Workstation, printing, and storing on disk.
- Reports shall be stored by type, date, and time. The destination of each report shall be selectable by the operator.
- Dynamic operation of system shall not be interrupted to generate a report. The report generation mode, either automatic or requested, shall be operator assignable. The report shall contain the time

and date when the samples were taken, and the time and date when the report was generated.

- Software shall be capable of saving reports to a file. If the file format is not in a format compatible with standard Microsoft Office software, Control Contractor shall provide a means to export or convert the file to a compatible format.
- Software shall allow for automatic or manual generation of reports. For automatic reports, the operator shall be able to specify the time the initial report is to be generated, the time interval between reports, end of period, and the output format for the report. The operator shall be able to modify, or inhibit a periodic report.
- Manual report generation shall allow for operator to request at any time the output of any report.

G. Activity Logging:

- System shall maintain a historical file logging all activity of the system.
- This file shall maintain, as a minimum, a record of all operators logged onto the system, alarm acknowledgments, commands issued and all database modifications. Passwords shall not be logged.
- Activity log shall be maintained at the web application server hardware. System shall automatically provide a mechanism for archiving the log files for long term record storage.
- System shall maintain a minimum of 2 years of log files.

H. User Access Permissions:

- Web Application Server Software shall manage user information and shall recognize at least 100 separate users and have at least 3 levels of user permissions. User permission levels (from most restrictive to most permissive) shall include:
    - Guest (View-only) access level shall have the ability to perform the following tasks:
        - View Data
        - View Trends
- Operator access level shall have the ability to perform the following tasks:
    - View Data
    - Acknowledge Alarms
    - View Reports
    - Override Points
    - Change Setpoints
    - View Trends
    - Edit Schedules
- Engineer access level shall have the same access as Operator level with the ability to perform the following additional tasks:
    - Add Devices
    - Address Changes
    - Create Applications
    - Download Applications
    - Configure ASCs
    - Setup Trends
    - Setup Reports
    - Modify Alarm Settings
    - Create and modify System Graphic Displays
- Administrator access level shall have the same access as Operator level with the ability to perform the following additional tasks:
    - Add Devices
    - Address Changes
    - Create Applications

- Download Applications
- Configure ASCs
- Setup Trends
- Setup Reports
- Modify Alarm Settings
- Create User Accounts
- Modify Permissions
- Programming

• Passwords shall not be displayed.
• System shall provide an Auto Logout Feature that shall automatically logout user when there has been no keyboard or mouse activity for 5 minutes. Time period shall be adjustable by system administrator. Auto Logout may be enabled and disabled by system administrator. Operator terminal shall display message on screen that user is logged out after Auto Logout occurs.

I. O-BC Overarching Graphics and Controls:
• Refer to Section 250000 – Enterprise Integrated Facility Management and Control System

J. B-BC Building Graphics and Controls:
• Graphics shall be configured in system summary and floor summary graphics for “point-and-click” operation to allow user to navigate through the building systems with ease. The user shall be able to define the action of control through control program application pages.
• All symbols used by the Contractor in the creation of summary pages shall be saved to a library file for use by the Owner. Provide additional copy of library file on CD.

2.3 DATA HISTORIAN – DATA ARCHIVING

A. Data historian software may reside on the same physical server as the BAS software or on a separate server. The data historian shall seamlessly integrate to the BAS software without the need for a 3rd party application.

B. System must provide a means to gather, archive and retrieve trend, alarm, and operator\system activity records. Archived information shall be available for the life of the system.

C. Historian shall have minimum of five (5) simultaneous user licenses.

D. Historian database shall be Microsoft SQL Server. Microsoft Access databases are not allowed.

E. System must allow archival to/from a mass storage device.

F. Historian shall homogeneously combine historical data from multiple collection intervals for a given point (e.g., 15 minute and change of value trends shall be blended into a common view).

G. System shall be able to perform exception reporting (e.g., show all values below or above a certain value).

H. System shall be able to perform advanced analysis of BAS alarms to include the following information:
• Number of alarms for a given period
• Detailed alarm information; initial alarm, alarm cleared, duration, and highest level achieved during alarm.
• Statistical information: longest alarm duration, average duration, and total duration.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to **Section 230900 – HVAC Direct Digital Controls.**

3.2 SOFTWARE

A. Software shall be permanently stored on a flash drive or other mobile SSD storage device and on Web Application Server. Provide auto re-boot feature on power up from system failure. System failures shall not necessitate manual reprogramming to restore normal system function.

B. Provide the latest version of all standard software, including, operating system and application software. Include any software updates, and hardware updates associated with such software upgrades, for period of one year coinciding with warranty period. No beta released software shall be used.

3.3 OPERATOR WORKSTATIONS

A. Refer to **Section 230900 – HVAC Direct Digital Controls**

3.4 CONTROL SYSTEMS WEB SERVER – SOFTWARE PROGRAMMING

A. Alarm and Event Management:
- Refer to **Section 250000 – Enterprise Integrated Facility Management and Control System**

B. Scheduling:
- Refer to **Section 250000 – Enterprise Integrated Facility Management and Control System**

C. Trending & Data Archiving:
- Web Servers shall provide data archiving for all analog inputs, analog outputs, analog values, setpoints and calculated energy data.
- Archived data shall be maintained for a minimum of 2 years.
- All trend log information shall be displayed in standard engineering units.
- Configure routing for all alarms. Coordinate alarm routing with Owner.
- For O-BC trend requirements Refer to Section 250000 – Enterprise Integrated Facility Management and Control System.

D. Report Generating: Software shall have a report generation utility programmed for generating the following standard reports:
- Energy usage Report: An energy usage summary, operator selectable, for a unit and building. Report shall be divided by utility and shall be capable of reporting on at least four separate utilities. Report shall include the following information:
  - ♦ Beginning and ending dates and times
  - ♦ Total energy usage for each utility for the current and previous day
  - ♦ Total energy usage for each utility for the current and previous month
  - ♦ Maximum 15-minute interval average rate of consumption for each utility for the current and previous day and current and previous month
  - ♦ Average Outside air (OA) temperature and OA relative humidity (rh) for current and previous month and current and previous day
  - ♦ Calculated degree days

E. **O-BC Only** Reporting Requirements:
- Refer to Section 250000 – Enterprise Integrated Facility Management and Control System

3.5 GRAPHICS PROGRAMMING

A. B-BC Graphical requirements:

- Navigation Scheme: System graphic displays of HVAC, plumbing and electrical systems and points shall be hierarchical displays using a building-to-equipment point-and-click navigation scheme. Each display shall show the building/Area name and number.
- Summary graphical screens shall utilize color meanings and shall be consistent across all displays. summaries of similar type shall be of same color for graphics (example: AHU's shall be purple, Terminal devices yellow, etc.).
    - ♦ Real-time data
    - ♦ User-entered data (setpoints)
    - ♦ Overridden or operator-disabled points
    - ♦ Devices in alarm (unacknowledged)
    - ♦ Out-of-range, bad, or missing data
- State indication shall be determined by status indicating equipment such as current sensing switches, auxiliary contacts, or position switches. Commands to field devices shall be shown separately.

B. Graphics shall be configured to automatically update values without any action by the operator.

C. All standard graphic features, such as title block, navigation buttons, etc., shall always be located in the same general area on each Graphic. For example, the navigation buttons shall always start at the left frame of the graphic. The Home, Charts and Alarm buttons shall always start in the upper right corner of the graphic.

D. Display all control loop and alarm setpoints on respective system graphic. Provide ability to change control loop setpoints, alarm setpoints and start/stop equipment from system graphic, provided user has appropriate access. If system graphic seems too cluttered, provide separate, text-based, System Overview page.

E. Display time, date, outside temperature and humidity on each display in same location on each graphic. Provide command to direct specific displays without accessing main menu. Provide means of displaying directory of screens. Arrange displays by group and type.

F. Each graphic shall have a shortcut to the main menu graphic and to previous graphic.

G. Main menu graphic shall be automatically displayed when user logs on to system.

H. Graphics shall include, but not be limited to:
- User defined name for location and "BRICK Schema" naming.
    - ♦ BAS Network Architecture
- Chilled water system showing all components and control loops .
    - ♦ Individual Chillers
- Emergency Generators
- BAS Network Architecture indicating status of all devices/controllers.
- Summary graphic screens for each building.
- Control Program graphic for each equipment or device that contains controllable points.

1. Submit sample graphics (one per type) for review and approval by Owner prior to starting graphics programming.

3.6 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section **019113 General Commissioning Requirements.**

3.7 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section **019113**. Functional performance testing shall be performed by contractor and witnessed and documented by Commissioning Authority.

End of Section 23 09 24

SECTION 250000 – ENTERPRISE INTEGRATED FACILITY MANAGEMENT AND CONTROL SYSTEM

1 PART 1 – GENERAL

1.1 - RELATED WORK

A. Section 230900 – HVAC Direct Digital Controls

B. Section 230923 – Direct Digital Controllers and Network

C. Section 230924 – Graphical User Interface Integration

D. Section 230993 - Control Sequences (To Come After RFP and Vendor Selection)

1.2 - INTENT

The intent of this specification is to define a System Integration and Automation Strategy and Topology to form an Enterprise Facility Management and Control Systems (EFMCS) that is a common platform that will allow for a consistent graphical user interface, system integration and control platform to manage the smart building infrastructure. This system will require the services of a Master System Integrator (MSI) This section defines the following major systems, subsystems and components that make up the IoT and Integrated Automation Topology:

A. INTEGRATION PLATFORM
- Niagara Framework Web Supervisor N4.x
- Niagara Workbench

B. OPERATIONAL TECHNOLOGY NETWORK (OTN)
- Facility Network with defined VLANs and systems security for cloud hosting of applications.

This section also defines the services and qualifications of a Master System Integrator and integration of multiple facility systems.
The Systems Integration Matrix and specifications further define the necessary coordination.

2 PART 2 - INTEGRATION PLATFORM

2.1 - INTENT

A. The intent of this section is to define the Integration of the Building Systems and Control Systems into the Integration Platform as provided by the Master Systems Integrator (MSI). This platform will allow for a consistent graphical display of all systems shown in the overall topology.

B. Reference associated divisions 14, 21, 23, 26, 27, 28, 33 or otherscontrolled with Integrated Automation.

C. Refer to drawings (insert drawing number here) for a diagrammatic representation of the System Architecture/Topology.

D. Refer to the System Integration Matrix for detailed description of the systems to be integrated and the responsibilities of each associated division.

2.2 - SUMMARY

A. This section describes the Master Systems Integrator's (MSI) scope for the Integration Platform for the project.

B. Coordinates the responsibilities of the Mechanical and Electrical and Control trade contractors pertaining to control products or systems, furnished by each trade, that will be integrated by this Division.

C. All labor, material, equipment, and software not specifically referred to hereinor on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the owner.

D. It is the owner's goal to implement an O*pen System* that will allow products from various suppliers to be integrated into a unified system to provide flexibility for expansion, maintenance, and service of the system. The owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

2.3 - MASTER SYSTEMS INTEGRATOR (MSI):

A. The Master Systems Integrator (MSI) shall connect the building stakeholders with their building control systems and provide useful, meaningful, and important information and control capabilities. The MSI is responsible for the integration of building control services such as HVAC, Life Safety, Electrical Distribution, Lighting Control, Security, various Cloud Services, IAQ and other controlled assets as shown in the systems architecture. The MSI shall provide a unified database and graphical user interface tools by collaboration with the owners building control needs. Division 23 shall provide certain Niagara based products, controls, and programming services that require extensive coordination with this division. Division 26 shall provide an integrated Lighting Control System that requires extensive coordination with this division.

B. Roles & Responsibilities: Services required but not limited to:

- Install Niagara Web Supervisor server software platform licensed to be capable of handling the entire portfolio in a location defined by the owner. Provide an Unlimited Niagara Supervisor license unless otherwise specified.
- Co-ordinate with owner on proper use of IT within the Enterprise to include but not limited to Authentication, Security Certificates, SSL, Active Directory and or any owner IT requirements. Jointly develop integrated software plan with the owners' building team and vendors to make sure all systems will communicate properly.
- Review and meet with building team to ensure the building control system information will be accessible and useful.
- Develop the software layer responsible for integration, aggregation and communications to the building control systems.
- Standardize software tagging library, templates and menu hierarchy system, develop strategy for long term template maintenance.

- Create and maintain graphical controls, monitors and dashboards as defined by the functional requirements of the system.
- Configure alarm interface / controls, scheduling and user management capabilities.
- Commission connected systems for usability and sustainability (all the software tools should be incorporated).
- Document software maintenance strategy and upgrade procedures
- Configure and set up the Building Operations Center Console. Set up displays and software to manage displays. Add browser connection from console to Niagara Web Supervisor Server Software. PC Hardware and Displays will be provided by the owner. Mount displays, PC, Keyboards etc. in console.

C. Qualifications:

Specific Requirements per Company

- Experience in implementing Niagara framework similar for projects of similar size and scope.
- Must have a successful history in the design and installation of Niagara Framework
- Must have 5 years consecutive licensing capabilities with the Niagara Framework.
- Must have a minimum of 2 employed individuals who meet System Requirements per individual.
- Firms shall have specialized in and be experienced with the installation of the Niagara Framework for not less than five years from the date of final completion on at least three (3) projects of similar size and complexity. Submittals shall document this experience with references.

D. Specific Requirements: per individual

- Must have 3 years' experience with the firm represented
- Proof of Niagara 4 Certification.
- List and describe a Niagara Enterprise (more than one building) integration project and the programmer's involvement
- List and describe a Niagara integration project involving multiple communication protocols or databases.
- List and describe a Niagara integration project involving multiple platforms such as HVAC, Lighting Control, Security, Life Safety, Utilities and other building control and or monitoring systems.

2.4 - APPROVED MASTER SYSTEMS INTEGRATORS

A. (OEM) Authorized Master System Integrator.

1. Lippert Mechanical in partnership with BuildingLogix provided through OMNIA Contract Region 14ESC-TX Contract Number 02-93

2.5 - SYSTEM DESCRIPTION

A. The Integration Platform shall include, but not be limited to, the following components/sub systems to provide a fully functional platform required for integrating the systems shown on the system architecture/topology on drawing- (insert drawing number here):

- Niagara Web Supervisor
- Niagara Workbench
- Associated Niagara drivers and applications
- Niagara based hardware platforms (JACE)
- Installation, engineering, programming
- Commissioning – Refer to Section 019113 – General Commissioning Requirements

B. The intent of this specification is to provide a system that is consistent with BMS systems throughout the owner's facilities running the Niagara 4 Framework.

C. The MSI shall furnish all labor, materials and equipment necessary for a complete and operating Integration Platform, utilizing Direct Digital Controls as shown on the drawings and as described herein. Drawings are diagrammatic only. All controllers furnished in this section shall communicate on a peer-to-peer bus over an open protocol bus (Examples: LonTalk, BACnet, MODBUS). The MSI shall submit a Data Plan that includes database standards, graphics, dashboards, data tagging and program guidelines for the Engineer’s review.

D. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet and MODBUS

E. System architecture shall provide secure Web access using any of the current versions of Microsoft Internet Explorer, Mozilla Firefox, or Google Chrome browsers from any designated computer on the owner's LAN.

F. All control devices furnished with this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset for this project. The use of configurable or programmable controllers that require additional software tools or tools that require a specific Niagara 4 license brand to operate for post-installation maintenance shall not be acceptable.

G. Any control vendor that shall provide additional BMS server software shall be unacceptable. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.

H. The integration platform server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the Niagara 4 Framework server.

I. A laptop computer shall be provided by the owner for installation of engineering/programming software (Niagara 4 Workbench) by the MSI.

J. Owner shall receive all Administrator level login and passwords for engineering toolset at first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.

K. OPEN NIC STATEMENTS - All Niagara 4 software licenses shall have the following NiCS: "accept.station.in=*"; "accept.station.out=*"and "accept.wb.in=*"and "accept.wb.out=*". In any case, the end user shall maintain the right to instruct the contractor to modify any software license, regardless of supplier, as desired by the end user. The contractor shall not install any “brand- specific” software,

applications or utilities on Niagara Framework-based devices. All hardware and field-level devices installed shall not be limited in their ability to communicate with a specific brand of Niagara Framework JACE. They shall also be constructed in a modular fashion to permit the next generation and support components to be installed, in replacement of or in parallel with existing components. All controllers must be able to be programmed within the Niagara Workbench. At the completion of the project, the owner shall be given all existing platform and station login credentials to include; super user (admin) user names; passwords and passphrases

L. All products of the Integration Platform shall be provided with the following agency approvals. Verification that the approvals exist for all submitted products shall be provided on request, with the submittal package. Systems or products not currently offering the following approvals are not acceptable.
- Federal Communications Commission (FCC), Rules and Regulations, Volume II -July 1986 Part 15 Class A Radio Frequency Devices.
- FCC, Part 15, Subpart B, Class B
- FCC, Part 15, Subpart C
- FCC, Part 15, Subpart J, Class A Computing Devices.
- UL 504 - Industrial Control Equipment.
- UL 506 - Specialty Transformers.
- UL 910 - Test Method for Fire and Smoke Characteristics of Electrical and Optical-Fiber Cables Used in Air-Handling Spaces.
- UL 916 - Energy Management Systems All.

2.6 - SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:
- Actuator: Control device that opens or closes valve or damper in response to control signal.
- AI: Analog Input.
- AO: Analog Output.
- Analog: Continuously variable state over stated range of values.
- BMS: Building Management System.
- DDC: Direct Digital Control.
- Discrete: Binary or digital state.
- DI: Discrete Input.
- DO: Discrete Output.
- FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
- FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
- GUI: Graphical User Interface.
- HVAC: Heating, Ventilating and Air Conditioning.
- IDC: Interoperable Digital Controller.
- ILC: Interoperable Lon Controller.
- LAN: Local Area Network.
- OTN: Operational Technology Network
- Modulating: Movement of a control device through an entire range of values, proportional to an

infinitely variable input value.
- Motorized: Control device with actuator.
- NAC: Network Area Controller.
- NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
- NO: Normally open position of switch after control signal is removed; or the open position of a controlled valve or damper after the control signal is removed; or the usual position of a manually operated valve.
- OSS: Operating System Server, host for system graphics, alarms, trends, etc.
- Operator: Same as actuator.
- PC: Personal Computer.
- Peer-to-Peer: Mode of communication between controllers in which each device connected to network has equal status and each shares its database values with all other devices connected to network.
- P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
- PI: Proportional-Integral control, control mode with continuous proportional output plus additional change in output based on both amount and duration of change in controller variable (reset control).
- PICS: BACnet Product Interoperability Compliance Statement.
- PID: Proportional-Integral-Derivative control, control mode with continuous correction of final controller output element versus input signal based on proportional error, its time history (reset) and rate at which it's changing (derivative).
- Point: Analog or discrete instrument with addressable database value.
- WAN: Wide Area Network.

2.7 - SUBMITTALS

A. Eight copies of shop drawings of the entire Integrated Platform shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

B. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol. Though the Division 23 contractors shall provide these diagrams for their portions of work, the Master Systems Integrator shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Virtual Local Area Network (VLAN).

C. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or EMU.

D. Upon completion of the work, provide a complete set of 'as-built' drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Eight copies of the 'as-built' drawings shall be provided in addition to the documents on compact disk. Division 23 and 26 contractors shall provide as-builts for their portions of work. The Division 25 contractor shall be responsible for as-builts pertaining to overall BMS architecture and network diagrams. All as built drawings shall also be installed into the integrated platform server in a dedicated directory.

2.8 - SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:

- FMCS- Facility Management and Control System
- TCS- Temperature Control System
- IDC- Interoperable Digital Controller
- IBC- Interoperable BACnet Controller
- GUI- Graphical User Interface
- WBI- Web Browser Interface
- POT- Portable Operator's Terminal
- PMI- Power Measurement Interface
- DDC- Direct Digital Controls
- LAN- Local Area Network
- WAN- Wide Area Network
- OOT- Object Oriented Technology
- PICS- Product Interoperability Compliance Statement

2.9 - QUALITY ASSURANCE

A. The Master Systems Integrator shall have a full service DDC office within 50 miles of the job site. This office shall be staffed with applications engineers, software engineers and field technicians. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.

B. Single Source Responsibility of Supplier: The Master Systems Integrator shall be responsible for the complete installation and proper operation of the control system. Master Systems Integrator shall exclusively be in the regular and customary business of design, installation and service of computerized building management systems similar in size and complexity to the system specified. The Master Systems Integrator shall be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be assembled by the Control System Contractor in a UL-Certified 508A panel shop.

C. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in the production and installation of HVAC control systems. Products shall be the manufacturer's latest standard design and have been tested and proven in actual use.

2.10 - PRE-INSTALLATION MEETINGS

A. As required by any of the following: the General Contractor/Construction Manager/Owner/Owner's Representative or Commissioning Authority based upon construction lead.

2.11 - DELIVERY, STORAGE AND HANDLING

A. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

2.12 - JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

2.13 - SEQUENCING

A. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

3 PART 3 – PRODUCTS

3.1 - MANUFACTURERS

A. Tridium Niagara Framework version N4.x (optionally) including Niagara Security and Niagara Analytics

3.2 - GENERAL

A. The Integration Platform shall be comprised of a network of interoperable, stand-alone digital controllers, a network area controller, graphics and programming and other control devices for a complete system as specified herein.

B. The installed system shall provide secure strong password access to all features, functions and data contained in the overall BMS.

3.3 - OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURE

A. The intent of this specification is to provide a peer-to-peer networked, stand- alone, distributed control system utilizing Open protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. Physical connection of any BACnet control equipment, such as chillers, shall be via Ethernet or IP.

C. All components and controllers supplied under this contract shall be true "peer- to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

D. The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the Niagara Enterprise Web Supervisor VM hosted by the owner. See network diagram for details.

E. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network.

- Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
- Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote connected user interfaces.

3.4 - SERVER HARDWARE

A. The main server shall be cloud based hosted by the MSI or their representative.

B. The MSI shall provide appropriate means of secure VPN connectivity utilizing NWMSU’s local IT infrastructure for connection to cloud server.

- Connectivity provided through means of installing of TOSI box base product with softkey lock.
- For off-site or satellite needs provide TOSI box device with means of cellular connectivity.
- Determined by NWMSU hard key locks can be utilized for third party remote access.

3.5 - FIREWALL and DNS SERVER (Provided by Owner)

3.6 - IoT SERVER SOFTWARE – Niagara Web Supervisor – NWS

A. The IoT Server Software shall allow multiple Niagara-based JACE controllers, along with other IP-based controllers, to be networked together through the Enterprise OT Network. This software shall provide real-time graphical information to standard Web- browser clients and provide server-level functions. These functions include centralized data logging/trending, alarming, tagging, archiving to external databases, alarming, dashboarding, system navigation, master scheduling, database management, and integration with other enterprise software applications through custom APIs where required. A comprehensive graphical engineering toolset for application development shall be provided (Niagara 4

Workbench)

B. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet. The intent of the thin-client architecture is to provide the operator(s) complete access to the BAS system via a web browser. The thin-client web browser Graphical User Interface (GUI) shall be browser and operating system agnostic, meaning it will support HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. Microsoft, Firefox, and Chrome browsers (current released versions), and Windows as well as non-Window operating systems. All browsers shall be in compliance with the owner's IT standard

C. The BAS server software shall support at least the following server platforms (Windows 10, Server 2019). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.

D. The web browser GUI shall provide a completely interactive user interface and shall provide a HTML5 experience that supports the following features as a minimum:
- Trending.
- Scheduling.
- Electrical demand limiting.
- Energy Aggregation and Analytics.
- Downloading Memory to field devices.
- Real time 'live' Graphic Programs.
- Tree Navigation.
- Parameter changes of properties.
- Set point adjustments.
- Alarm / event information.
- Configuration of operators.
- Execution of global commands.
- Add, delete, and modify graphics and displayed data.

E. Software Components: All software shall be the most current version. All software components of the BAS system software shall be provided and installed as part of this project. BAS software components shall include:
- Server Software, Database and Web Browser Graphical User Interface.
- 5 Year Software Maintenance license. Labor to implement not included.
- Embedded System Configuration Utilities for future modifications to the system and controllers.
- Embedded Graphical Programming Tools.
- Embedded Direct Digital Control software.
- Embedded Application Software.

F. BAS Server Database: The BAS server software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. Owner IT will provide any non-Niagara

DB licenses if required.

G. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:

- Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over secured owner's Operational Technology Network.
- Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be TLS 1.2,3 as directed by owner's Cyber Security department.

H. Web Browser Graphical User Interface

- Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic set point controls, configuration menus for operator access, reports and reporting actions for events.
- Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and strong password. Navigation in the system shall be dependent on the operator's role-based application control privileges.
- Navigation: Navigation through the GUI shall be accomplished by clicking on the appropriate level of a navigation tree (consisting of an expandable and collapsible tree control and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Geographic, Network, Groups and Configuration.
    - ♦ Geographic View shall display a logical geographic hierarchy of the system including cities, sites, buildings, building systems, floors, equipment and objects.
    - ♦ Groups View shall display Scheduled Groups and custom reports.
    - ♦ Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

I. Action Pane: The Action Pane shall provide several functional views for each subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

- Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floorplans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
- Dashboards: User customizable data using drag and drop HTML5 elements. Shall include Web Charts, Gauges, and other custom developed widgets for web browser. User shall have ability to save custom dashboards.
- Search: User shall have multiple options for searching data based upon Tags. Associated equipment,

real time data, Properties, and Trends shall be available in result.

- Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an 'accept/cancel' button.
- Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
- Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
- Charting: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. User shall have ability to create HTML charts through web browser without utilizing chart builder. User shall be able to drag and drop single or multiple data points, including schedules, and apply status colors for analysis.
- Logic - Live Graphic Programs: Shall be used to display' live' graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.
- Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.
- Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set points and comfort. Animated. gifs or .jpg, vector scalable, active set point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:
- Display Size: The GUI workstation software shall graphically display in a minimum of 1024 by 768 pixels 24-bit True Color.
- General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
- Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set points. The colors shall be updated dynamically as a zone's actual comfort condition changes.
- Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone using a pictorial representation of components. Selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.
- All graphics shall be compatible with any desktop, mobile device or tablet.
- Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
    - Each piece of equipment monitored or controlled including each terminal unit.
    - Each building.
    - Each floor and zone controlled.
    - See System Integration Matrix for details.

J. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with proper access credentials) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day ' Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the ' Independence Day' Holiday. All schedules that affect the system/area/equipment highlighted in the Navigation Tree shall be shown in a summary schedule table and graph.

- Schedules: Schedules shall comply with the LonWorks and BACnet standards, (Schedule Object,

Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:

- ♦ Types of schedule shall be Normal, Holiday or Override.
- ♦ A specific date.
- ♦ A range of dates.
- ♦ Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
- ♦ Wildcard (example, allow combinations like second Tuesday of every month).

- Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.
- Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an ' individual tenant' group - who may occupy different areas within a building or buildings. Schedules applied to the ' tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the ' tenant group'.
- Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.
- Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).
- Schedule Summary Graph: The schedule summary graph shall clearly show Normal versus Holiday versus Override Schedules and the net operating schedule that results from all contributing schedules. Note: In case of priority conflict between schedules at the different geographic hierarchy, the schedule for the more detailed geographic level shall apply.

K. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an ' Alarms' view. Alarms, and reporting actions shall have the following capabilities:

- Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.
- Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.
- Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.
- Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The

Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

- Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.
- Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A 'network' view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.
- Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement and total number of Alarms in the BAS Server database.
- Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.
- Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Reporting Actions shall be as follows:
    - Print: Alarm information shall be printed to the BAS server's PC or a networked printer.
    - Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts. Note: Email reporting action shall also be used to support alphanumeric paging services, where email servers support pagers.
    - File Write: The ASCII File write reporting action shall enable the operator to append operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).
    - Write Property: The write property reporting action updates a property value in a hardware module.
    - SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.
    - Run External Program: The Run External Program reporting action launches specified program in response to an event.
    - Provide alarm recipients and escalation per direction from owner.

L. Trends: As system is engineered, all points shall be enabled to trend. Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

- Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.
- Local Trends: Trend data shall be collected locally by Multi- Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the HEWS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.
- Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.
- Dynamic Update. Trends shall be able to dynamically update at operator- defined intervals.

- Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and ' pan through' historical data by simply scrolling the mouse.
- Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
- Copy/Paste. The operator shall have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

M. Security Access: Systems Access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges as specified:

- Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function
- Privileges:
  - View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.
  - Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
  - Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.

- Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree. For example, it shall be possible to assign two HVAC Technicians with similar competencies (and the same operator defined HVAC Role) to different areas of the system.

N. Graphical Programming. Niagara 4 Workbench 4.x or current version at commissioning. Refer to **Section 019113 – General Commissioning Requirements** for more details.

3.7 - TAGGING

A. The purpose of a data modeling standard is to provide a consistent, standardized methodology for naming and describing data points associated with the Integrated Automation Topology for this project. This includes the facility automation systems, equipment systems, energy metering systems, other smart devices including mobile assets, and associated descriptive information known as metadata.

- The MSI shall coordinate with the owner for ideal tagging methodology.
- The BRICK schema standard shall be used for this project paired with a Building Location tagging Library. The building location tagging library shall include Compass Directional, which will be bi-directional (i.e., NE, SW, NW, SE) and the Building Level (i.e. 1st floor, 2nd floor, 3rd floor, etc..).

4 PART 4 - OPERATIONAL TECHNOLOGY NETWORK

4.1 - WORK REQUIRED BY CONTRACT DOCUMENTS

A. In general, the Operational Technology Network (OTN) shall be provided, installed, programmed and commissioned by the approved owner’s network contractor. Refer to system architecture/topology drawings.

B. The MSI shall furnish necessary drop locations and network information as requested. MSI will cooperate and participate in necessary testing to ensure data connection to integrated systems.

5 QUALITY ASSURANCE-

5.1 - System Startup and Commissioning

A. Related Work

- **Section 019113 – General Commissioning Requirements**
- **Section 250800 – Integrated Automation Commissioning**

B. System Planning, Startup and Commissioning

- Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
- The MSI shall commission and set in operating condition all major systems integrations with system manufacturer's representatives, as applicable, and the Owner and Architect's representatives.
- Startup Testing shall be performed for each task on the startup test checklist, which shall be initialed by the technician and dated upon test was completion along with any recorded data such as voltages, offsets or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.
- Required elements of the startup testing include:
    - Measurement of voltage sources, primary and secondary
    - Verification of proper controller power wiring.
    - Verification of component inventory when compared to the submittals.
    - Verification of labeling on components and wiring.
    - Verification of connection integrity and quality (loose strands and tight connections).
    - Verification of bus topology, grounding of shields and installation of termination devices.
    - Verification of point checkout.
    - Each I/O device is landed per the submittals and functions per the sequence of control.
    - Analog sensors are properly scaled, and a value is reported
    - Binary sensors have the correct normal position, and the state is correctly reported.
    - Analog outputs have the correct normal position and move full stroke when so commanded.
    - Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
    - Documentation of analog sensor calibration (measured value, reported value and calculated offset).
    - Documentation of Loop tuning (sample rate, gain and integral time constant).

- A performance verification test shall also be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following:
    - Graphics navigation.
    - Trend data collection and presentation.
    - Alarm handling, acknowledgement, and routing.

- Time schedule editing.
- Application parameter adjustment.
- Manual control.
- Report execution.
- Automatic backups.
- Web Client access.

C. Cyber Security
- Provide commissioning engineer for cyber security testing and set up using the Niagara Hardening Guide and under direction of the owner's Corporate Cyber Security Team.
- Attend planning, engineering, and commissioning meetings as required by the owner's Cyber Team.
- Provide Security Dashboard and Active Directory services as described in paragraph F.
- Provide necessary port and configuration data to owner's Cyber and IT teams.

D. Niagara Services and Features
- Provide Security Dashboard Service for each Jace and the Niagara Enterprise Web Supervisor
- Enable audit logs for all functions including system operation and programming and cyber security.
- Set up Alarm Service recipients and escalation levels as directed by owner for 25 users.
- Set up all roles and responsibilities as directed by owner. Coordinate with owners LDAP/Active Directory systems. 25 Users.
- Graphics. Provide Graphics as described in System Integration Matrix and point lists. All graphics shall be designed using Niagara "Responsive Pane" to utilize a single graphic implementation to render on a variety devices and window or screen sizes (mobile, tablet desktop).
- Set up schedules as directed by owner for each system and zone. Provide special schedules as directed by the owner.
- Set up provisioning service to provide daily backups of all JACEs to the NWS.
- Each point will be trended at default rate of 15 minutes unless otherwise directed

6 WARRANTY

6.1 - Warranty Requirements

A. See general Conditions for additional warranty requirements.

B. All components, system software, and parts furnished and installed by the MSI shall be guaranteed against defects in materials and workmanship for 1 year of substantial completion. Labor to repair, reprogram, or replace these components shall be furnished by the BSI at no charge during normal working hours during the warranty period. Materials furnished but not installed by the SI shall be covered to the extent of the product only. Installation labor shall be the responsibility of the trade contractor performing the installation. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the request for warranty service within 24 standard working hours.

C. Software Maintenance Agreement. Provide 5-year SMA for all Niagara software.

D. Warranty can be adjusted or modified by NWMSU or their approved representative at the direction of

the University.

7 TRAINING

7.1 - Training Requirements

A. The MSI shall provide both on-site and classroom training to the Owner's representative and maintenance personnel on the NWS per the following description:

B. On-site training shall consist of a minimum of (40) hours of hands-on instruction geared at the operation and maintenance of the systems. MSI may use a combination of generic, Tridium approved, online and local system specific operator training. The curriculum shall include:

- System Overview
- System Software and Operation
- System access
- Software features overview
- Changing set-points and other attributes
- Scheduling
- Editing programmed variables
- Displaying color graphics
- Running reports
- Workstation maintenance
- Viewing application programming
- Operational sequences including start-up, shutdown, adjusting.

End of Section 25 00 00