

FORM OF PROPOSAL

Renovations to Bogue Sound Elementary School

From: _____ Contract: GENERAL

Address: _____

To: Carteret County Board of Education Date: _____

The undersigned, as bidder, hereby declares that the only person or persons interested in this proposal as principal or principals is or are named herein and that no other person than herein mentioned has any interest in this proposal or in the contract to be entered into; that this proposal is made without connection with any other person, company or parties making a bid or proposal; and that it is in all respects fair and in good faith without collusion or fraud.

The bidder further declares that he has attended the mandatory pre-bid conference, examined the site of the work and informed himself fully in regard to all conditions pertaining to the places where the work is to be done, that he has examined the specifications for the work and the contract documents relative thereto and has read all special provisions furnished prior to the opening of bids; that he has satisfied himself relative to the work to be performed.

The Bidder proposes and agrees if this proposal is accepted to contract with the Carteret County Board of Education in the form of contract specified below, to furnish all necessary materials, equipment, machinery, tools, apparatus, means of transportation and labor necessary to complete the construction of the: Renovations to Bogue Sound Elementary School in full in complete accordance with the plans, specifications and contract documents, to the full and entire satisfaction of the Owner and / or Architect, with a definite understanding that no money will be allowed for extra work except as set forth in the General Conditions and the Contract Documents, for the sum of:

GENERAL CONSTRUCTION CONTRACT (ALL WORK)

Base Bid:

_____ Dollars(\$)

Plumbing Subcontractor: _____ (write in "N/A" if not applicable)

Mechanical Subcontractor: _____ (Pre-bid conference attendance mandatory)

MECH BID COST (FOR INFORMATION ONLY) \$ _____

Electrical Subcontractor: _____ (Pre-bid conference attendance mandatory)

ELECT BID COST (FOR INFORMATION ONLY) \$ _____

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ALTERNATES:

Should any of the alternates as described in the contract documents be accepted, the amount written below shall be the amount to be added to the base bid.

ALTERNATE NO. 1 Shall be the amount added to the Base Bid to provide door hardware and access control manufacturers as specified in Section 08700, in lieu of other, equivalent manufacturers:

(Add) _____ Dollars (\$)

ALTERNATE NO. 2: Shall be the amount added to the Base Bid to provide Trane Air Handler Units, Belimo Valves, and B&G Pumps for the hydronic system in lieu of other, equivalent manufacturers.

(Add) _____ Dollars(\$)

ALTERNATE NO. 3: Shall be the amount deducted from the Base Bid to provide, expand, upgrade, install, and re-program the existing JCI system to accommodate the new units, the new demand control ventilation dampers, the new pumps and the associated VFDs to meet the new Sequences of Operation indicated on the plans. Price shall also include any associated expansion cards, wiring, diagnostics, hardware, software, training and site visits necessary to establish the full extent and capabilities of the existing system prior to bid. The system shall be accessible and controllable from the CCS Facilities Maintenance Office located in Beaufort, NC.

(DEDUCT) _____ Dollars (\$)

ALTERNATE NO. 4: Shall be the amount added to the Base Bid to provide Square D electrical gear, as scheduled in lieu of other equivalent equipment manufacturers.

(Add) _____ Dollars (\$)

ALTERNATE NO. 5: Shall be the amount added to the Base Bid to provide light fixtures by Lithonia, as scheduled in lieu of other equivalent equipment manufacturers.

(Add) _____ Dollars (\$)

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UNIT PRICES:

Unit prices quoted and accepted shall apply throughout the life of the contract, except as otherwise specifically noted. Unit prices will include all costs, and shall be applied, as appropriate, to compute the total value of changes in the scope of the installed work, all in accordance with the contract documents. Unit prices listed shall include all overhead and profit costs.

ITEM #	DESCRIPTION	UNIT PRICE
1	Fire Alarm Voice/Strobe Notification device	_____ each
2	Fire Alarm Smoke/Heat Detector device	_____ each
3	Fire Alarm Multi Sensor Smoke/Carbon Monoxide device	_____ each
4	Duct Mounted Smoke Detector device	_____ each

TIME

The Bidder further proposes and agrees hereby to commence work on a date specified in the Architect's Notice to Proceed, and to complete all work according to the schedule of dates set under Article 8 "Time" of the Supplementary Conditions, WHICH ARE DATES CERTAIN, with no allowance for delays except as may be caused by the Owner. Applicable liquidated damages shall be as stated in the Supplementary General Conditions.

HUB PARTICIPATION REQUIREMENTS:

Provide with the bid - Under GS 143-128.2(c) the undersigned bidder shall identify **on its bid** (Identification of HUB Participation Form) the HUB businesses that it will use on the project with the total dollar value of the bids that will be performed by the HUB businesses. **Also** list the good faith efforts (Affidavit **A**) made to solicit HUB participation in the bid effort.

NOTE: A contractor that performs all of the work with its own workforce may submit an Affidavit (**B**) to that effect in lieu of Affidavit (**A**) required above. The HUB Participation Form must still be submitted even if there is zero participation.

After the bid opening - The Owner will consider all bids and alternates and determine the lowest responsible, responsive bidder. Upon notification of being the apparent low bidder, the bidder shall then file within 72 hours of the notification of being the apparent lowest bidder, the following:

An Affidavit (**C**) that includes a description of the portion of work to be executed by HUB businesses, expressed as a percentage of the total contract price, which is equal to or more than the 10% goal established. This affidavit shall give rise to the presumption that the bidder has made the required good faith effort and Affidavit **D** is not necessary;

OR

If less than the 10% goal, Affidavit (**D**) of its good faith effort to meet the goal shall be provided. The document must include evidence of all good faith efforts that were implemented, including any advertisements, solicitations and other specific actions demonstrating recruitment and selection of HUB businesses for participation in the contract.

Note:

Bidders must always submit **with their bid** the Identification of HUB Participation Form listing all HUB contractors, vendors and suppliers that will be used. If there is no HUB participation, then enter none or zero on the form. Affidavit A **or** Affidavit B, as applicable, also must be submitted with the bid. Failure to file a required affidavit or documentation with the bid or after being notified apparent low bidder is grounds for rejection of the bid.

Proposal Signature Page

The undersigned further agrees that in the case of failure on his part to execute the said contract and the bonds within ten (10) consecutive calendar days after being given written notice of the award of contract by the Designer, as agent for the Owner, the certified check, cash or bid bond accompanying this bid shall be paid into the funds of the Owner's account set aside for the project, as liquidated damages for such failure; otherwise the certified check, cash or bid bond accompanying this proposal shall be returned to the undersigned.

Respectfully submitted this day of _____

(Name of firm or corporation making bid)

WITNESS:

By: _____
Signature

(Proprietorship or Partnership)

Name: _____
Print or type

Title _____
(Owner / Partner / President / Vice President)

Address _____

ATTEST:

By: _____

License No. _____

Title: _____
(Corp. Sec. or Asst. Sec. only)

Federal I.D. No. _____

(CORPORATE SEAL)

Addendum received and used in computing bid:

Addendum No. 1 _____ Addendum No. 3 _____ Addendum No. 5 _____ Addendum No. 6 _____

Addendum No. 2 _____ Addendum No. 4 _____ Addendum No. 6 _____ Addendum No. 7 _____

15900 BUILDING AUTOMATION SYSTEMS

PART 1 - GENERAL

1.1. APPLICABLE SECTIONS

- A. 15900 BAS Sensors and Devices

1.2. RELATED DOCUMENTS

- A. The Contract Drawings are directly applicable to this Section, and this Section is directly applicable to them.
- B. The general provisions of the Contract, including General and Supplementary Conditions and/or Division 01 Specification Sections, are directly applicable to this Section, and this Section is directly applicable to them.
- C. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.
- D. Collectively, these items will be referred to as the Contract Documents.

1.3. DEFINITIONS AND ABBREVIATIONS

- A. Where definitions in Division 01 conflict with the definitions herein, Contractor will comply with the most stringent requirement.
- B. BAS Component: a generic reference to any hardware component which is provided by Contractor, including but not limited to controllers, power supplies, transformers, relays, actuators, sensors, or other devices.
- C. Building Automation System (BAS): Also referred to as Building Management System (BMS), Direct Digital Control (DDC).
- D. Building Controller: Controller, which is at, and controlling at, the building-level. Could also be a large portion of a building, such as a wing, depending on hardware capability. Generally, are the middle tier of the overall BAS network, and report up to a Building or Enterprise Supervisor. Also, generally what Device Controllers would be integrated with. See Section 2.5 System Architecture for full definition and specification.
- E. Building-Level Network (BLN): An ethernet, fiber, and/or wireless network dedicated to the BAS, which connects Building Controllers and Building Supervisors. The BLN may be a separate network from Owner's LAN, or as part of the LAN, which has been segmented to be used exclusively by the BAS. See Section 2.5 System Architecture for full definition and specification.
- F. Building Supervisor: Server, which is at, and controlling at, the building-level. Generally used when Building Controllers do not have sufficient hardware capability to support an entire building. Generally, are the middle tier of the overall BAS network, and installed on a Server in lieu of being a stand-alone piece of hardware. Also, generally what Building Controllers would be integrated with. Building Supervisors may be further integrated to an Enterprise Supervisor. See Section 2.5 System Architecture for full definition and specification.
- G. Controller: A generic reference to a BAS Controller, including but not limited to Device Controllers and Building Controllers.
- H. Contract Documents: All documents which compose the project, including but not limited to drawings, specifications, RFPs, scope of work, general conditions, and supplemental conditions.
- I. Control Panels: an assembly composed of an enclosure and one or more BAS Component(s).
- J. Critical: A special area or zone which receives specialized BAS Components.

- K. Device Controller: Also referred to as Field-Level Controller. Controller, which is at, and controlling at, at the device-level. Device in this instance is understood to reference MEP Equipment. Generally, are the lowest tier of the overall BAS network, and report up to a Building Controller. See Section 2.5 System Architecture for full definition and specification.
- L. Device-Level Network (DLN): A copper, ethernet, fiber, and/or wireless network dedicated to the BAS, which connects Device Controllers and Building Controllers. See Section 2.5 System Architecture for full definition and specification.
- M. Enterprise Supervisor: Server, which is at, and controlling at, the enterprise-level. Generally, are the highest tier of the overall BAS network, and installed on a server in lieu of being a stand-alone piece of hardware. Also, generally what Building Controllers and/or Supervisors would be integrated with. See Section 2.5 System Architecture for full definition and specification.
- N. Field-Level: See Device Controllers and Device-Level Network.
- O. Furnish: To supply and deliver to project site, ready for installation.
- P. Install: To place in position for service or use.
- Q. Local Area Network (LAN): Ethernet, fiber, and/or wireless network which connects computers and other networkable devices (printers, etc.), and has a connection to the WAN. See Section 2.5 System Architecture for full definition and specification.
- R. Manufacturer: The brand of the BAS being provided (ex: Distech, Honeywell, etc).
- S. MEP: Mechanical, electrical, and plumbing.
- T. MEP Equipment: Where MEP Equipment is used, it is understood to mean any piece of MEP Equipment which the BAS will in some way, shape, or form, interface with, via hardwired connection or integration. MEP Equipment includes, but is not limited to VAV, AHU, RTU, split systems, hot water heaters, heat exchangers, boilers, chillers, and pumps.
- U. MSI: Master Systems Integrator: see MSI section for full definition and specification.
- V. Owner: The financial provider and user of the BAS, as well as Owner Representatives.
- W. Owner Representatives: Representatives for the Owner which are on staff, contracted, or hired to protect the interests of the Owner, such as Engineers, Architects, Commissioning Agents, and other parties.
- X. Project: The facility/building as defined in the Contract Documents.
- Y. Server: A computer in which BAS software is installed on.
- Z. Sequence of Operation: The steps that MEP Equipment takes to achieve the desired operation to provide optimal comfort and/or ventilation for the Project.
- AA. Substantial Completion: Written authorization by the Owner that the project has reached a point of completion that it can be utilized.
- BB. Supervisor: A generic reference to a BAS Supervisor, including but not limited to Building Supervisors and Enterprise Supervisors.
- CC. Provide: To furnish and install, complete and ready for intended use.
- DD. Vendor: The installer, integrator, and/or contractor for the BAS being provided.
- EE. Wide Area Network (WAN): Ethernet and/or fiber-based network which connects multiple facilities via the internet. See Section 2.5 System Architecture for full definition and specification.
- FF. Warranty Period: The time between Substantial Completion and the duration of Warranty, as specified.

1.4. GENERAL SPECIFICATIONS

- A. Contractor shall provide all hardware, software, configuration, programming, graphics (GUI), checkout, alarms, trending, functional testing, and commissioning necessary to provide a complete and fully functioning BAS. Contractor shall include all hardware, control wiring, wiring accessories, wiring connections, software, and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system, now and in the future.
 - 1. Provide all necessary BAS Components on each piece of MEP Equipment to:
 - a. Perform the specified Sequence of Operation and meet the design/performance intent of the MEP Equipment.
 - b. Comply with BAS Components as shown on the control diagrams.
 - c. Comply with the point lists.
 - d. Comply with the Specifications herein.
 - e. Comply with the design intent of the BAS.
 - 2. Where the Sequence of Operation, control diagrams, points list, or specifications conflict with each other, Contractor will comply with the most stringent requirement.
- B. It is Contractor's responsibility to review all the Contract Documents and report any discrepancies to Owner.
- C. Substitutions
 - 1. Wherever the words "approved equal," "for review," or "for acceptance" are used in regard to manufactured specialties, or wherever it is desired to substitute a different make or type of BAS Component for that specified, submit all information pertinent to the adequacy and adaptability of the proposed BAS Component to Owner and secure their approval before the BAS Component is ordered.
- D. Warranty
 - 1. Warranty period shall be for 24 months after project construction closeout and owner's receipt of the Certificate of Occupancy. The entire BAS and all ancillary equipment required for its operation shall be free from defects in workmanship and material under normal use and service. If within the twenty-four months from the date of acceptance/occupancy the installed equipment is found to be defective in operation, workmanship or materials, Contractor shall replace, repair, or adjust the defect at no cost to Owner.
 - 2. Corrective software and/or hardware modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks.
 - a. Modifications made which are corrective to one piece of MEP Equipment will be replicated to all MEP Equipment for consistency in programming.
 - b. User documentation will be updated in all locations, including but not limited to hard copies, Control Panel hard copies, O&Ms, and PDF copies accessible via download inside the BAS system.
 - c. Maintain revision control (i.e., v1_05) to indicate which is the latest version of all documentation, software, and programming.
 - 3. Owner reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and installation work regardless of any changes made by Owner unless Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

4. At no cost to Owner, during the Warranty Period, Contractor shall provide maintenance services for software including all current software updates, firmware, and hardware. Prior to the closeout of the warranty period, Contractor shall meet with Owner to address any questions or concerns and offer ongoing services to Owner.
 5. Electronic Actuators: Parts and labor for 5 years from the date of substantial completion.
 6. Air and Water Flow Meters: Parts and labor for 3 years from the date of substantial completion.
- E. Extended Warranty
1. Contractor shall include a 3 year (36 Month) Extended Warranty agreement to oversee maintenance, adjustments and owner support for the controls system after expiration of the 24 month Basic Warranty period. This agreement shall include remote support for minor hardware, software or owner issues. Agreement shall also include additional on-site time to address major Control System (Hardware or Software) issues that have one or more pieces of equipment off-line. Contractor shall be on-site to address the major issue within 36 hours on normal work days or the following Monday if 36 hour time limit falls after regular business hours on Friday afternoon or over the weekend.
- F. Training
1. Provide eight hours of training for Owner personnel, and/or maintenance contractor, on the operation and maintenance of the BAS. Owner may wish to video tape the training session.

1.5. CODES AND REFERENCE STANDARDS

- A. Comply with all current federal, state, and local codes, requirements, ordinances, and regulations, in accordance with the authority(ies) having jurisdiction (AHJ).
- B. Comply with the National Electric Code (NEC).
- C. Comply with all manufacturer guidelines and requirements.
- D. Comply with all Owner rules, guidelines, procedures and requirements, including Owner IT.
- E. The latest published edition of a reference shall be applicable to the Project unless identified by a specific edition date.
- F. All materials, installation, and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 2. American National Standards Institute (ANSI)
 3. UL 916: Energy Management Systems
 4. LonMark International
 5. BACnet Testing Lab

1.6. COORDINATION OF WORK AND INTEGRATION

- A. Certain LonMark, BACnet, Modbus, and other products, systems, and interface devices, may be provided by other trades via MEP Equipment. Examine the Contract Documents to ascertain the requirements to install, wire, program, commission, and/or interface to these systems. Particular attention must be paid towards the interface boards submitted by the various MEP Equipment providers. It is this Contractor's responsibility to verify the submitted interfaces will integrate properly into the BAS. Report any discrepancies to Owner. Discrepancies brought to Owner's attention after the procurement of that piece of MEP Equipment will be integrated at no additional cost to Owner. Contractor will provide additional interface(s) needed to integrate piece of MEP Equipment.
- B. Controls contractor is responsible for reviewing the equipment submittals for ALL equipment to be integrated into the BAS system prior to equipment being ordered to verify proper power

voltages, control voltages, control signals, control points, etc. for proper seamless integration and control of the equipment provided by the other contractor.

- C. Contractor shall review MEP Equipment for compliance with control diagrams, Sequence of Operation, and points lists. Report any discrepancies to Owner.
- D. Wherever work interconnects with work of other trades, coordinate with other trades and with Owner to ensure that all trades have the information necessary so that they may properly install all the necessary connections and equipment.
- E. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Verify all locations with Owner and/or General Contractor prior to installation.
- F. Coordinate sources of 120V power with the Electrical Contractor and Owner. Extend power from source(s) as needed.
- G. Coordinate location of data ports/drops to the LAN/WAN with the Electrical Contractor and Owner.
- H. Coordinate shipping of BAS Components to another Contractor or manufacturer for factory-installation.

1.7. SPARE PARTS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Provide one replacement for each unique actuator, Controller, thermostat, wall module, or any other BAS Component provided.

1.8. QUALITY ASSURANCE

- A. The BAS and BAS Components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- B. Control Panels, both new and modified, shall comply with UL 508A.
- C. Electrical Components, Devices, and Accessories: UL listed and labeled as defined in NFPA 70.

1.9. CONTRACTOR QUALIFICATIONS

- A. Qualifications may be requested from Contractor prior to the bidding process. Owner reserves the right to not allow Contractors to bid if they do not meet the qualifications or provide them in a timely manner. Qualifications will be provided for all items below in an orderly format for review by Owner.
- B. Contractor shall have a successful history in the design and installation of the BAS being provided that consists of web-browser monitoring and control of LonWorks, BACnet, and/or Modbus Device Controllers. These projects must be on-line and functional such that Owner can observe the BAS in full operation. Include proper references, contact names, emails, and phone numbers of these reference projects, with a minimum of five projects similar to this Project.
- C. Contractor shall demonstrate experience in BAS installations for not less than five years, in BAS installation projects with point counts equal to this Project, and systems of the same character as this Project.
- D. Contractor shall have specialized in and be experienced with the installation of the proposed product line for not less than five years, on at least ten projects of similar size and complexity.
- E. Contractor shall be factory authorized by manufacturer of product line and be in good standing with the manufacturer.
- F. Contractor shall be located within 50 miles of Project.
- G. Contractor shall be a Certified Tridium Systems Integrator.

- H. Contractor shall have a minimum of three, Niagara Technical Certification Program (TCP) certified personnel.
- I. Contractor shall have a minimum of three personnel who are certified in LonWorks, BACnet, and/or Modbus line(s) of controls to be installed as part of this project.
- J. Be of sufficient size to provide service, including both routine maintenance and emergency support within 24 hours upon receipt of request.

1.10. ACTION SUBMITTALS

A. Product Data Submittal

1. Submit manufacturer's technical product data for each BAS Component, including but not limited to Controller, sensor, actuator, relay and panel, indicating dimensions, capacities, performance, electrical characteristics, and material finishes. Also include installation and start-up instructions.
 - a. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate, mark-through, and highlight only applicable information.
 - b. Generic submittals will be automatically rejected.
2. Submit documentation indicating LonMark, NICs, and/or BTL compliance and include Protocol Implementation Conformance (PIC) Statements.

B. Shop Drawings Submittal

1. Submit shop drawings. Shop drawings will include:
2. Bill of Materials (BOM): indicating equipment served, quantity, manufacturer, point range (i.e. 0-10 in. w.c.), sensor range (i.e. 0-10V), and model number for all BAS Components being provided.
 - a. Disconnect Schedule: additionally, indicating MCA, MOP, voltage, # of phases, size, NEMA rating, # of poles, and neutral (Y/N).
 - b. Starter Schedule: additionally, indicating horsepower, voltage, # of phases, size, NEMA rating, and bypass.
 - c. VFD Schedule: additionally, indicating horsepower, voltage, # of phases, size and NEMA rating, bypass (Y/N), number of contactors (if bypass), disconnect (Y/N), and disconnect type (fused/non-fused).
 - d. Hydronic Valves (Pressure-Dependent): additionally, indicating gpm, line size, calculated Cv and design pressure drop, actual Cv and actual pressure drop, close-off pressure, type (ball/globe/butterfly), connection, valve size, 2/3-way, mixing/diverting (if 3 way), service (2-position/modulating), and fail position.
 - A) Actual pressure drop will correct for any line-size to valve-size restrictions per the manufacturer's data.
 - B) Actuator will be scheduled with the valve per the standard BOM.
 - e. Hydronic Valves (Pressure-Independent): additionally, indicating gpm, line size, selected valve gpm, maximum valve gpm, min/max pressure drops, close-off pressure, type (ball/globe/butterfly), connection, valve size, 2/3-way, mixing/diverting (if 3 way), service (2-position/modulating), and fail position.
 - A) Actual pressure drop will correct for any line-size to valve-size restrictions per the manufacturer's data.
 - B) Actuator will be scheduled with the valve per the standard BOM.
 - f. Steam Valves: additionally, indicating lb/hr, inlet pressure, outlet pressure, line size, calculated Cv and design pressure drop, actual Cv and actual pressure drop, close-

- off pressure, type (ball/globe/butterfly), connection, valve size, 2/3-way, mixing or diverting (if 3 way), service (2-position/modulating), and fail position.
- A) Actual pressure drop will correct for any line-size to valve-size restrictions per the manufacturer's data.
 - B) Provide sizing methodology/calculations for manufacturer selected.
 - C) Actuator will be scheduled with the valve per the standard BOM.
- g. Air Flow Metering Stations (AMFS): additionally, indicating duct size, output, network capable (LonWorks/BACnet), and number of probes/sensors.
 - h. Water/Steam Flow Meters: additionally, indicating line size, output, network capable (LonWorks/BACnet), and flow meter style/type.
 - i. Damper Schedule: additionally indicating, duct size, blade type, leakage, and construction.
 - j. VAV schedule: indicating VAV type, K factor, and max/min/reheat flows.
3. Schematic Flow Diagram: schematic representation of MEP Equipment. Diagram will show all BAS Components on schematic, point name, and point number (i.e. UI-1). Where MEP Equipment varies slightly, schematic will be clearly diagramed to indicate any differences between each piece of MEP Equipment. Stating the schematic as "typical" is not acceptable.
 4. Wiring Diagram: indicating power, signal, and control wiring. Where terminal blocks are provided, provide indication where wiring terminates to terminal block.
 5. Sequence of Operation: Any modifications proposed to the Sequence of Operation will be clearly marked up as part of the shop drawings or submitted as an annotated Microsoft Word document in addition to the shop drawings. A default Contractor Sequence of Operation, included without regard to the Contract Document's Sequence of Operation, will result in a rejected submittal.
 6. Control Panel Diagrams: indicating panel faces, with layouts of any BAS Components to be installed in the panel face, BAS Component locations inside panel, and labeling of BAS Components.
 7. One-line diagram for all controllers showing the network layout. Where Project is to connect with an existing BAS, indicate how the new network will integrate with the new and/or existing BAS Components.
 8. Indicate anticipated device ID, Network number, MAC Addressing, and Max Masters for all BACnet devices. Provide logical schema for BACnet addressing.
 9. Individual floor plans with device (controllers, routers, sensors, etc.) locations with all interconnecting wiring routing including space sensors, Device and Building-Level Network wiring, power wiring, and low voltage power wiring.
 10. Additional Requirements:
 - a. Point names will be consistent between the schematics and wiring diagrams.
 - b. Misc. Points List: where controllers being provided for other purposes are also used to control a miscellaneous point, such as an exhaust fan or lighting contactor, provide a list of those miscellaneous points in a concise format for quick identification of their location and associated Controller.
 - c. Provide a complete list of any deviations of submitted products to the specification in this document.
 - d. Where existing BAS Components are being reused, such as controllers or sensors, clearly indicate (via coloring, line type, etc) the BAS Components being reused as "existing" and new components as "new."

C. Graphics Submittal

1. Provide screen captures of graphical user interfaces developed by Contractor on previous projects. These screen shots shall represent actual work performed by Contractor and not generic work from the line of controls which Contractor represents. Screenshots will be applicable to the MEP systems as part of this project. "Generic" screenshots of MEP systems will not be accepted. Provide client contact information for Owner to validate. Any comments from the submittal process will be incorporated into the actual graphics for the project.
2. Follow Owner's graphics standards.
3. Zoning Map
 - a. Provide submittal of graphic floorplans for markup by Owner to identify required zoning to use for scheduling. Floorplan markup will be used by Contractor to segment equipment that satisfies the identified zones.

D. Point-Naming Submittal

1. Points shall be named consistently. Provide list of point names and point conventions.
2. Point naming shall be consistent with an existing standard, such as Project Haystack.

E. IP Drop Request Submittal

1. Provide list of BAS Component(s) which need an IP drop to the LAN/WAN.
2. Provide location, quantity (if multiple per Control Panel/location), and IP address requirements (DHCP, fixed, etc), and total number of IP address reservations, including room for future growth.
3. Provide list to a minimum of ten business days' notice prior to needing the drop.

F. Schedule/Sequence of Construction Submittal

1. Provide schedule and sequence of construction, as it pertains to the installation of the BAS, for review.

G. Functional Performance Testing (FPT) Submittal

1. Provide FPT agendas and testing procedures for review.
2. FPT should include at a minimum Sequence of Operation, point-to-point verification to graphical interface, historical data logging, and alarms testing procedures.

1.11. START-UP AND ASSOCIATED TESTING SUBMITTALS

A. Point-to-Point Testing/Checkout Sheets Submittal

1. Prior to startup of MEP Equipment, Contractor will provide checkout sheets for each piece of MEP Equipment.
2. Checkout sheets will contain at a minimum:
 - a. Equipment name and location.
 - b. Associated Controller address (MAC or Node ID), name, type, and instance number.
 - c. Point name, type (resistance, amperage, voltage, etc), and range (i.e., -5 to +5 in w.g.).

B. Start-Up Testing Submittal

1. As part of the startup of MEP Equipment, Contractor will provide start-up testing sheets for each piece of MEP Equipment.
2. Start-up testing sheets will contain at a minimum:
 - a. Equipment name and location.
 - b. Sequence of Operation and step-by-step procedure used to check programming and configuration.

- c. Any modifications required to Sequence of Operation for MEP Equipment performance.
 - d. Final graphical screens.
 - e. PID tuning parameters for each loop.
- C. Adjusting and Calibration Submittal
1. As part of the startup of MEP Equipment, Contractor will provide a calibration submittal for each piece of MEP Equipment.
 2. Calibration submittal will contain at a minimum:
 - a. Equipment name and location.
 - b. Point name, type, and range.
 - c. Sensor type and manufacturer's stated accuracy.
 - d. Calibration type (single point, two point, etc).
 - e. Checking, adjusting, and calibration data.
 - f. Sensor installed accuracy.
 - g. Sensor pass, fail, replaced, etc.
 - h. Calibration equipment used and associated certificates of calibration, including expiration dates.

1.12. CLOSE-OUT SUBMITTALS

- A. Operating and Maintenance Manuals
1. Provide all documentation as required in the submittal processes to-date, updated to as-built conditions.
 2. In addition, provide the following:
 - a. Include control response, settings, set points, throttling ranges, gains, reset schedules, adjustable parameters, and limits.
 - b. A table (or similar) of all Testing, Adjusting and Balancing (TAB) values for each piece of MEP Equipment and BAS-calibrated equipment, such as airflow metering stations (AFMS).
 - c. Any O&Ms for equipment not originally included in the submittal, in addition to product data.
 - d. Accurately record actual set points, calibrations/offsets, and settings of controls, final Sequence of Operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing.
 - e. Database of all point names.
- B. As-Built Shop Drawings
1. Provide PDF of shop drawings which have been corrected to reflect the as-built state.
 - a. Incorporate any redlines made in field during installation.
 - b. Update Sequence of Operation to reflect MEP Equipment operation as changed during installation, commissioning, and/or functional performance testing.
 - c. Provide reference to being "as-built" version on each sheet of the shop drawings.
 2. Provide hard copy of appropriate shop drawing page(s) inside each Control Panel.
- C. Software Closeout
1. Provide all usernames, passwords, software, GUI, databases, licenses, and application programming tool(s) to Owner.

2. Provide software backup of entire BAS and associated components on digital media for Owner record. Coordinate file location of automatic backup of software with Owner.

D. Reference 3.11 Closeout for additional requirements.

1.13. MATERIALS AND EQUIPMENT

- A. All materials shall meet or exceed all applicable referenced standards, federal, state, and local requirements, referenced standards, and conform to codes and ordinances of the AHJ.
- B. Materials shall be new, the best of their respective kinds without imperfections or blemishes and shall not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where Contract Documents specifically allow existing materials to remain in place.
- C. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

1.14. COLORS AND LABELING

- A. Where requirements in 15190 conflict with the requirements below, Contractor will comply with the most stringent requirement.
- B. Provide BAS Components consistent with the following color requirements.
 1. Control Panels Blue
 2. Conduit Blue
 3. Input/Output Wiring Yellow
 4. BACnet Copper Wiring Orange
 5. LonWorks Copper Wiring Purple
 6. Modbus Copper Wiring Blue
 7. Ethernet/Fiber Cable Consistent with color of primary communication protocol.
 8. Tubing Black with White Stripe
- C. Provided BAS Components with the following labeling requirements.
 1. Controllers
 - a. Vinyl or nylon label, 1/2 inch or greater in height, black text on white background, adhesive backed, printed with MEP Equipment served by Controller, permanently mounted.
 2. Control Panels
 - a. Two-layer engraved phenolic or engraver's plastic tag, 1 inch or greater in height, adhesive backed, engraved with MEP Equipment served by panel, permanently mounted.
 3. Input/Output Wiring
 - a. Nylon or self-laminated wire-wrap label, 1/2 inch or greater in height, black text on white background, adhesive backed, printed with BAS Component connected to cable and cable number, permanently mounted at termination to terminal block in Control Panel on cable jacket.
 - b. Premade labels or wire marker tape is not allowed.
 4. BAS Component
 - a. Vinyl or nylon label, 1/2 inch or greater in height, black text on white background, adhesive backed, printed with MEP Equipment served and BAS Component purpose (ex. AHU-1 SF Start/Stop), permanently mounted.

PART 2 - PRODUCTS

2.1. MANUFACTURERS AND VENDORS

- A. Subject to the Specifications and requirements herein, the BAS will be provided by (listed in alphabetical order):

NEW CONSTRUCTION

1. Siemens – Tridium Compatible System
 2. ABB Controls – Tridium Compatible System
 3. Distech – Tridium Compatible System
 4. Lynxspring - – Tridium Compatible System
 5. Trane – Tridium Compatible System
- B. Products by the manufacturer listed shall be used for Device and Building Controllers. Sensors, actuators, valves, dampers, and other BAS Components may be manufactured by others as indicated.

2.2. GENERAL

- A. Owner shall receive ownership of all job-specific configuration documentation, data files, software and/or code developed for the Project. This shall include all custom, job-specific software code, databases, and documentation for all configuration and programming that is generated for the Project and/or configured for use with the Device and Building Controllers or Building and Enterprise Supervisors, and any related LAN, WAN, Intranet, and Internet connected routers and devices.
- B. Any and all required IDs and passwords for admin and programming-level access to any BAS Component or software program shall be provided to Owner.
- C. It is Owner's intent to purchase an open system capable of being serviced and expanded by any acceptable system integrator that has and maintains certification to work on Niagara Framework systems. The Niagara Compatibility Statement (NICS) for all Niagara Software shall allow open access and be set as follows: `accept.station.in="" accept.station.out="" accept.wb.out="" accept.wb.in=""`. In any case, Owner shall maintain the right to direct Contractor to modify any software license, regardless of supplier, as desired by Owner.
- D. Contractor shall not install any "brand-specific" software, proprietary JAR files, applications, or utilities on Niagara Framework based devices, unless otherwise permitted. Provide exceptions to Owner for review.
- E. All Device and Building Controllers installed for the project shall not be limited in their ability to communicate with a specific brand/Manufacturer or Vendor of the BAS. 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.
- F. Device and Building Controllers shall have the ability to perform energy management routines via preprogrammed function blocks or template programs.
- G. Browser-based access: A remote/local user using a standard browser will be able access all BAS facilities and graphics via the LAN or direct connection, with proper username and password. Only HTML5 browser-based graphical user interfaces (GUI) is acceptable. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer, Edge, Firefox, or Chrome.
1. Graphics shall be Niagara "virtuals" which allow graphics to be present on both the JACE and Supervisor, allowing for an update in one location to be automatically applied to the other.

- H. Remote data access: The system shall support browser-based remote access over the Internet to the building data.
 - 1. The Contractor shall coordinate with Owner IT to ensure all remote browser access is protected with the latest BAS software updates.
 - 2. The Contractor shall coordinate with Owner IT to ensure a VPN (Virtual Private Network) is installed to protect Owner from cyber-attacks.
- I. Systems Configuration Database: The system architecture shall support maintaining the systems configuration database on a Supervisor server on the LAN. User tools for BLN and/or DLN management shall be provided and licensed to Owner and shall allow unrestricted configuring, updating, maintaining, and expanding of all current devices, configurations and settings.
- J. Database Schema shall be published and provided to Owner to facilitate easy access to BLN and DLN data.
- K. Owner shall be the named license holder of all software associated with any and all incremental work on the project. Contractor will coordinate with Owner IT for any requirements regarding software/hardware licensing.
- L. Where multiple pieces of Niagara equipment exist, use single-JACE sign-on. Coordinate with Owner on requirements.

2.3. DEVICE COUNT AND SOFTWARE MAINTENANCE AGREEMENTS

- A. All Device Controllers, Building Controllers, and Supervisors which have a license structure to where only a certain quantity of BAS Components or devices can connect to it shall be selected such that there is a minimum 25% capacity for future BAS Component or device connections. (i.e. if there are 80 connected devices, the license shall allow for $80 \times 1.25 = 100$ potential device connections (20 extra device connections possible).
- B. All Building Controllers and Supervisors which have a license structure requiring a Software Maintenance Agreement (SMA) shall be for a period of five years.

2.4. SYSTEM PERFORMANCE

- A. Description: The BAS shall comply with the following minimum performance requirements. Performance requirements are based on a fully functioning BAS with all trends and alarms enabled:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 3. Object Command: Reaction time of less than 2 seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within 6 seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

2.5. SYSTEM ARCHITECTURE

- A. The system architecture provided shall incorporate hardware and software resources sufficient to meet the functional requirements of these Specifications. The Building and Device-Level Network shall be based on industry standard open platforms as specified herein, and utilize commonly available operation, management, and application software. All software packages and databases shall be licensed to Owner to allow unrestricted maintenance and operation of the BAS. Contractor shall include all items not specifically

itemized in these Specifications that are necessary to implement, maintain, and operate the system in compliance with the functional intent of these Specifications.

- B. Reference 4.1 Network Diagram for diagram of System Architecture layout.
- C. The system architecture shall consist of a Wide Area Network (WAN), a Local Area Network (LAN), a Building-Level Network (BLN), and one or more Device-Level Network(s) (DLN), as well as an Enterprise Supervisor, a Building Supervisor, Building Controller(s), and Device Controller(s), as applicable.
 - 1. Wide Area Network (WAN): WAN infrastructure provided by Owner. Contractor will coordinate with Owner IT for configuration (ports, firewall, etc) for a successful BAS installation.
 - a. The WAN infrastructure shall be used to connect the Enterprise Supervisor to the Building Supervisor and/or Building Controller(s).
 - 2. Local Area Network (LAN): LAN infrastructure provided by Owner. Contractor will coordinate with Owner IT for configuration (ports, firewall, etc) for a successful BAS installation.
 - a. The LAN infrastructure shall be the connection point to the WAN for the BAS, and also serve as the BLN.
 - 3. Building-Level Network (BLN): BLN shall be a segmented network on the Owner's LAN.
 - a. The BLN shall be used for connection of Building Controller(s) and/or Building Supervisor only. No Device Controller(s) shall be connected to the BLN.
 - 4. Device Level Network (DLN): DLN infrastructure provided by Contractor.
 - a. DLN will be BACnet TCP/IP (Ethernet).
 - b. Contractor will provide one or more DLNs to maintain network speeds as specified herein.
 - c. Additional DLNs of a different protocol than listed may be added to integrate unique pieces of equipment not provided by Contractor, however all Contractor-provided equipment shall be consistent with the DLN above.
 - 5. The LAN will be under construction and not necessarily complete prior to work commencing. As such, a temporary BLN will be provided by Contractor for functionality of the BAS. This may include wireless access points, switches, or other temporary hardware for full functionality. Upon completion of the LAN, which will also serve as the BLN, Contractor shall remove the temporary equipment and provide final installation of devices to the permanent BLN. Testing of the system will be provided to ensure functionality is the same as on the temporary system.
 - 6. The LAN is existing and segmented for the BLN.

2.6. SYSTEM ARCHITECTURE, ADDITIONAL REQUIREMENTS

- A. Niagara Framework will be Niagara 4 (N4), with the latest stable released installed (as identified by Contractor) and will be compatible with any existing Niagara systems. Where the incorrect software version is installed, it shall be corrected at no additional cost to Owner.
- B. Prior to bid, where a modification to the System Architecture is desired, Contractor will obtain permission for the proposed System Architecture. Contractor will provide documentation with proposed modifications and how they will improve the System Architecture as specified. If not approved, Contractor will provide the System Architecture as specified.
- C. Prior to the bid, Contractor may request for additional connections to the WAN/LAN beyond the ones specified herein. Should those connections be disallowed, Contractor shall provide additional BLN(s) or DLN(s) at no additional cost to Owner.

- D. Capacity of any BLN or DLN shall be limited to 70% of the allowable device count to allow for future minor modifications or expansions to the network. Provide calculations on request.
- E. Device Controllers shall communicate on a hardwired network.
- F. Twisted-Pair Based Device Level and/or Building Level Networks (DLN/BLN):
 - 1. BACnet MS/TP networks where the baud rate for equipment is “fixed” and cannot be changed shall be segmented from the main DLN(s). The main DLN(s) will not be slowed to accept Device Controllers with slower baud rates than the majority of the Device Controllers can achieve.
 - 2. ARCnet and/or Token-Ring based DLNs shall not be acceptable.
 - 3. The communication speed between Device Controllers shall be sufficient to ensure fast system response time under any loading condition. At a minimum, network speed shall be minimally 78K bits per second (LonWorks FTT-10A), 19.2K bits per second (Modbus RTU), 76,800 baud (BACnet MS/TP).
 - a. Where speeds must be reduced, provide justification to Owner for approval.
 - 4. Provide a maximum of 40 LonWorks FTT-10A controllers per segment. Provide a maximum of 25 BACnet MS/TP controllers per segment. Provide a maximum of 25 Modbus RTU controllers per segment.
 - a. Controller counts may be increased where specifically recommended/approved by the Manufacturer and system performance will be achieved as specified. If network performance suffers due to excessive controllers, Contractor shall provide additional BLN(s) or DLN(s) at no additional cost to Owner.
- G. Ethernet Based Device Level and/or Building Level Networks (DLN/BLN):
 - 1. Where DLN is an ethernet-based network (vs traditional copper twisted-pair network), the requirements of the BLN shall also apply to the DLN.
 - 2. Ethernet-based BLN or DLN shall be consistent with Owner IT standards and requirements, and at a minimum IEEE 802.3 Ethernet over Fiber or Category 6 cable with switches and routers that support 1000base-T gigabit Ethernet throughput. Provide all routers, switches, and other hardware for functionality.

2.7. DEVICE CONTROLLERS

- A. Provide a Device Controller for each piece of MEP Equipment, or as specifically identified.
- B. General
 - 1. Device Controllers shall fundamentally communicate with the protocol as specified in the System Architecture for the DLN. Device Controllers which communicate over a different protocol and then convert to the specified protocol via a protocol converter, router, or gateway are not acceptable.
 - 2. All Device Controllers shall be able to communicate peer-to-peer without the need for a Building Controller and shall be capable of assuming all responsibilities typically assumed by a Building Controller.
 - 3. Any Device Controller shall be able to act as a Master to allow for the exchange and sharing of data variables and messages with any other Controller connected on the same communication cabling. So called “Slave Controllers” are not acceptable.
 - 4. A dedicated Device Controller will be provided for each piece of MEP Equipment. Controller “sharing,” where one Controller does one or more pieces of MEP Equipment, is not allowed, unless specifically approved by Owner.
 - 5. Each Device Controller shall have a minimum of 10% spare capacity for each point type for future point connection, rounded up to the nearest whole number.
 - 6. Performance

- a. Each Device Controller shall have a minimum of 64KB of RAM and 384KB of non-volatile flash memory.
 - b. Each Device Controller shall have a 32-bit microprocessor operating at a minimum of 68 MHz.
 - c. Real time clock with rechargeable battery and 20 days power backup.
7. The control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The control program shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
8. Provide single Device Controllers with the physical and software resource count for standalone operation of each piece of MEP Equipment. The Sequence of Operation and required points for control shall reside on a single Device Controller.
- a. Remote I/O modules (via a field-wired communications bus designed for remote I/O purposes) are acceptable for points required to achieve the Sequence of Operation.
 - A) BACnet, LonWorks, Modbus, and any other communication protocol designed for Device Controller to Building Controller communication is not acceptable for remote I/O communication.
 - B) Expansion I/O modules plugged directly into the Controller are acceptable for points required to achieve the Sequence of Operation.
 - C) Additional Device Controllers connected via the DLN are not acceptable for points required to achieve the Sequence of Operation.
9. Device Controllers with integral sensors or devices (i.e., a VAV terminal unit controller with integral damper actuator and pressure sensor), shall comply with the specification requirements for those sensors if they were submitted separately. If the Controller's sensors or devices do not comply, the sensors or devices will be provided separately.
10. BACnet Device Controller Specific Requirements:
- a. Each BACnet Controller on the BACnet MS/TP communications trunk shall provide a loading characteristic of 1/8th load.
 - b. Provide BACnet Controllers that are BACnet Testing Laboratory (BTL) listed (v14 or later). Controllers will be marked with the BTL certified logos. Controllers must be within the following categories:
 - A) BACnet Building Controller (B-BC)
 - B) BACnet Advanced Application Controller (B-AAC)
 - C) BACnet Application Specific Controller (B-ASC)
11. LonWorks Device Controller Specific Requirements:
- a. Provide LonWorks Device Controllers that conform to LonMark Certified Interoperability Standards. Components will be marked with the LonMark certified logos.
12. Modbus Device Controller Specific Requirements:
- a. Provide Modbus Device Controllers that conform to the Modbus Conformance Testing Program and be independently verified by an approved third-party for conformance.
- C. Configurable Device Controllers
- 1. Shall contain an application-specific control program which can be configured to meet the Sequence of Operation.
 - 2. Where a configurable Controller cannot be configured to meet the Sequence of Operation, a Programmable Controller will be used. Alternatively, Contractor may submit a

request to modify the Sequence of Operation so that a Configurable Controller may be used in lieu of a Programmable Controller.

D. Programable Device Controllers

1. Shall be fully programmable and the programming software shall have a library of pre-built, tested, and user re-definable control sequences for a wide range of typical HVAC applications.

E. Ethernet Device Controllers

1. Provide with a 2-port or greater integrated switch.
2. Controllers should be able to be "daisy chained" to eliminate multiple dedicated ethernet drops for each Controller.

2.8. BUILDING CONTROLLERS

- A. Provide Building Controller(s) with sufficient expansions to integrate DLNs while maintaining network speed, point count requirements, spare capacity, and other requirements as specified.
- B. Building Controller(s) shall be JACE 8000 series.
 1. Provide with embedded workbench.
 2. Provide with all required expansions for LonWorks FTT-10A, RS485, etc. to achieve the necessary quantity of DLN(s).
- C. Provide sufficient quantity of Building Controllers to maintain average processing power at 70% or less. Where Building Controllers are running above 70% consistently, additional Building Controllers will be provided and DLNs rewired at no cost to the Owner.

2.9. CONTROL PANELS AND ENCLOSURES

- A. Control Panels are an assembly composed of an enclosure and one or more BAS Component(s). Control Panels will be provided for:
 1. All MEP Equipment which requires a Device Controller(s) and does not have an Enclosure for a Device Controller(s) included as part of the MEP Equipment.
 2. All Building Controller(s).
- B. Reference 1.9 Quality Assurance for Control Panel rating requirements.
 1. All Control Panels provided for MEP Equipment shall be assembled and installed in accordance with UL508A. Field wiring to the Control Panel shall be terminated to a field wiring terminal as indicated on the required drawings provided with the Control Panel. Control Panels which are modified after UL508A listing by adding BAS Component(s) not shown on the UL508A panel drawings are 1) not allowed, or 2) require UL508A recertification from an authorized UL508A inspector. In short, 'generic' UL508A Control Panels which have power prewired but contain no BAS Component(s) as listed are not allowed.
- C. Controller(s) installed inside of MEP Equipment shall only be done so in spaces/enclosures designed for a Controller to be installed (i.e. a VAV controls enclosure). The fact a Controller fits inside the space does not constitute being designed for a Controller to be installed. Controller shall not be installed on the outside of any MEP Equipment or in a plenum, even if Controller is plenum rated.
- D. Enclosures shall have continuously welded and ground smooth seams, have doors that open 180 degrees, concealed and continuous hinge, and ground studs on door and body.
- E. Indoor/inside enclosures shall be NEMA/UL Listed Type 1. Enclosure shall be powder-coated steel, consistent with color chart herein. Outdoor/outside Enclosures shall be NEMA/UL Listed 3R or 4X. Enclosure shall be power-coated steel consistent with color chart herein or stainless steel.

- F. All enclosures will be provided with a removable backplate to which BAS Components will be fastened. No BAS Components will be fastened to the enclosure body. BAS Components, such as pilot lights and switches, displays, and operator interfaces may be mounted to the enclosure door, so long as they are designed to do so. No component will sacrifice or downgrade the NEMA rating of the enclosure.
- G. Control Panels will be sized (width, height, and depth) so that all BAS Components, including but not limited to Controllers, relays, power supplies and transformers, fit inside neatly and in an organized fashion. Provide cable tray for all wire to rest in and fasten to backplate. Cable tray shall be sufficiently sized for future expansion and/or service loop for field-wiring.
- H. Control Panels which have more than one BAS Component are required to be provided prewired to numbered terminal blocks. All BAS Components and terminal blocks will be fastened to the removable backplate and wired between the BAS Components and terminal block at Contractor's panel shop. The terminal block will serve as the demarcation point between factory/shop wiring and field wiring. At no point shall field wiring cross the terminal block and be wired directly to a factory/shop-installed BAS Component. Any BAS Component that was intended to be in the field, such as a relay, will not be installed inside the Enclosure in the field.
 - 1. Exception: Enclosures which house only one BAS Component, such as a Controller, are not required to have numbered terminal blocks, and may have field wiring terminated directly to the BAS Component.
- I. Maintain separation between Class 2 wiring and other wiring, such as power, for both field and factory connections.
- J. The design intent of the Control Panels is to have the ability to, in the future, disconnect all field wiring from the terminal blocks, remove the backplate with old control components, install new backplate with new control components and reconnect wire to the terminal blocks. Contractor will maintain design intent with their panel design and installation.
- K. Where the Specification conflicts with Control Panel requirements in Division 16, Contractor will comply with the most stringent requirement.

2.10. CABLE, WIRING, TUBING, AND ACCESSORIES

- A. Comply with Division 16.
- B. BAS cable for input and outputs shall comply to the color chart herein and have "BAS CABLE" (or equivalent) physically written on the cable from the cable manufacturer at regular intervals.
- C. BAS cable for LonWorks shall comply to the color chart herein and have "LONMARK" physically written on the cable from the cable manufacturer at regular intervals. BAS cable for BACnet shall comply with the color chart herein and have "BACNET" physically written on the cable from the cable manufacturer at regular intervals. BAS cable for other protocols will have the appropriate protocol written on the cable.
- D. All control wiring and tubing shall be plenum rated, no riser cable or tubing is allowed. Conform with NFPA 262 Flame Test for approved plenum use without conduit.
- E. Provide with integral ripcord.
- F. Treat cable with a lubricant to increase cable pulling productivity and efficiency and to decrease the risk of cable damage due to excessive pulling strengths. A non-staining lubricant shall be applied to coat the full length of the cable during the manufacturing process. The lubricant shall produce a low coefficient of friction on the cable jacket material that reduces pulling friction by up to 70%. The lubricant shall continue to reduce friction after it has dried; remaining as a slippery film that retains lubricity for months after use. The cable lubricant shall comply with the physical and performance requirements of Telcordia Standard,

TR-NWT-002811, and Generic Requirements for Cable Placing Lubricants. The lubricant shall not contain solvents nor have a flash point.

- G. BACnet and Modbus cable will be continuously shielded. LonWorks cable must be shielded into and out of VFDs, or any other noise-generating piece of equipment. Input/output (I/O) cable need not be shielded.
- H. Ethernet cable shall comply with the color chart herein and be consistent with Owner IT standards and requirements, and at a minimum IEEE 802.3 Category 6 cable.
- I. Tubing for air pressure sensors shall be polyethylene, approved for plenum installations, have high stress-crack resistance and be resistant to ultraviolet light.

2.11. TRANSFORMERS AND DC POWER SUPPLIES

A. Control Transformers

- 1. Class 2, sized and rated for application. Circuit breaker overcurrent protection; fused or internal overcurrent protection is not allowed. Transformers shall be sized so that connected load does not exceed 75 percent of rating. Functional Devices TR series or approved equal.

B. DC Power Supplies

- 1. Class 2, sized and rated for application. Overcurrent protection with auto-reset; fused or internal overcurrent protection is not allowed. Transformers shall be sized so that connected load does not exceed 75 percent of rating. IDEC PS5R-V Series or approved equal.

2.12. SURGE PROTECTION

- A. Provide any power supply surge protection, filters, etc. as necessary for proper operation and protection of all BAS Components.
- B. All BAS Components shall be capable of handling voltage variations 10% above or below measured nominal value, with no effect on hardware, software, communications, and data storage.
- C. Provide Control Panel surge protection for:
 - 1. Building Controllers and/or their associated Control Panels
 - 2. Control Panels with 11 or more hardwired input/output points entering/exiting the panel.
 - 3. Control Panels with network routers, switches, and/or other network/interface devices.
 - 4. Location(s) required by Owner based on submitted controls architecture.
 - 5. Manufactured by Ditech DTK-120HW or approved equal.
- D. Provide surge protection for DLN and/or BLN at every point network enters or leaves the building enclosure.
 - 1. Manufactured by Ditech DTK-2MHL series or approved equal for copper twisted-pair networks.
 - 2. Manufactured by Ditech DTK-110C6A series or approved equal for ethernet networks.

2.13. SOFTWARE

- A. Provide one copy of Tridium Niagara Workbench software.
- B. Provide one copy of ALL programming tools for all Device Controllers. Provide multiple versions of Software as required. Software will be fully licensed and not a "partial" or "light/lite" software version. Any functionality the Manufacturer and/or Vendor has available to them will also be provided to the Owner.
- C. Install software on Owner-chosen computer. Coordinate with Owner on processing, memory, operating system, and other computer requirements.

PART 3 - EXECUTION

3.1. PREPARATION

- A. Examine areas and conditions under which BAS is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Owner and Contractor. Report any issues to Owner and/or General Contractor.
- B. These Specifications call out certain duties of Contractor and any subcontractor(s). They are not intended as a material list of all items required by the Project.

3.2. INSTALLATION

- A. Provide related items and work indicated in the Contract Documents, as specified or not specified, necessary to provide a complete and fully functioning BAS, including but not limited to:
 - 1. All incidentals, equipment, appliances, services, hoisting, scaffolding, supports, tools, supervision, labor, consumable items, fees, licenses, etc.
 - 2. All BAS Components, devices, power supplies, transformers, fittings, sensors, controllers, wiring, accessories, etc.
 - 3. All wiring, including communication network, analog points, digital points, low voltage power, line voltage power, emergency power, etc.
 - 4. All associated power and low voltage connections.
 - 5. All conduit, junction boxes, fittings, panels, enclosures, hardware, etc.
- B. Utilize licensed electricians for all electrical distribution systems.
- C. The Contract Documents show the general arrangement of the respective systems. Follow as closely as actual building construction and the work of other trades will permit.
- D. Maintain redlines of shop drawings throughout installation process. Redlines will be used to generate O&Ms, and any other closeout documentation as specified herein. Shop drawings for O&Ms which are submitted unchanged from the Action Submittal phase will be required to be as-built to actual constructed conditions at no cost to Owner.

3.3. PRODUCT DELIVERY, STORAGE, HANDLING, PROTECTION, AND CLEANING

- A. All products and materials shall be new, clean, and free of defects, damage, and corrosion.
- B. Ship and store products and materials in a manner which will protect them from damage, weather, and entry of debris until final acceptance.
- C. Where BAS Components are required to be factory-mounted on MEP Equipment by others, arrange for shipping of BAS Components to MEP Equipment manufacturer.

3.4. SITE CLEAN-UP

- A. At conclusion of each day's work, and at the request of Owner, clean up and remove from the site all rubbish, debris, and trash accumulated during the day as a result of work of Contractor.
- B. Marks on walls and/or ceiling tiles caused by Contractor shall be cleaned by Contractor.
- C. Ceiling tiles, drywall, carpet, paint, and all architectural finishes damaged by Contractor shall be replaced by Contractor.

3.5. POWER WIRING, CONTROL WIRING, AND CONTROL TUBING

- A. Comply with Division 16.
- B. Extend 120V power circuits from points provided to control voltage transformers. Where dedicated junction boxes have been provided, coordinate the exact locations with the Electrical Contractor. Where they have not, coordinate the spare circuit breakers to be used with the Electrical Contractor and/or Owner.
- C. Install all wiring and cabling in conduit.

- D. Install wire, cable, and accessories with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- E. Wire safeties and limit controls to prevent operation of MEP Equipment in any selector position (off-hand-auto).
- F. Provide sleeves and conduit for passage of wiring through structural masonry, concrete walls and floors, and elsewhere for the proper protection of the BAS. Seal as required.
- G. Splices are not permitted within the BLN or DLN communication cables. Only continuous network topologies or continuous homeruns are allowed for these networks. Splices identified, including damage to cable, will result in cable being re-pulled at no additional cost to Owner.
- H. Limit DLN and BLN cable lengths to no longer than 70% of the longest dimension published by the manufacturer of the cable or Controller, between the most remote network nodes/Controllers.
- I. Shielded wiring will have shields twisted together and taped against jacket of cable. No exposed shields will be allowed. Ground shield at one end of cable.
- J. LonWorks communication network shall transition from unshielded to shielded at device prior to VFD(s), be shielded into and out of the VFD(s), and transition back to unshielded at device after VFD(s).
- K. Power wiring, control wiring, and wiring accessories (i.e. conduit) shall be consistent with color chart herein.
- L. Power wiring, control wiring, and wiring accessories shall comply with Division 16. Where the Specification conflicts with Division 16, Contractor will comply with the most stringent requirement.
- M. Install control transformers and DC power supplies inside Control Panels. Transformers randomly installed in plenum, or connected to junction box via nipple mount, is not allowed.
- N. Install surge protection for wiring as required. Surge protection for 120V shall be installed exterior to Control Panel. Surge protection for communication network will be installed in close proximity to grounding locations and bars. Route communication network such that surge protection can be installed in accordance with manufacturer's instructions. Excessive grounding wiring runs and/or grounding to structural steel for surge protection is not permitted.
- O. Maintain all bend radius requirements with control tubing. Do not kink tubing. Do not use tees, elbows, or other fittings in tubing.
- P. I/O wiring shall be labeled in accordance with 1.15 Colors and Labeling. Wire number shall correspond to wire number shown on Closeout Documentation.
- Q. I/O cabling will be sized in accordance with the load and distance traveled. Input wiring will be minimally 22AWG. Output wiring will be minimally 18AWG.

3.6. NETWORK MANAGEMENT FUNCTIONAL REQUIREMENTS

- A. Contractor shall thoroughly and completely program and configure BAS Components, software, supplemental software, application programming, network communications, operator workstations, computers, printer, and network communications to permit the functional requirements of the BAS herein specified. The setup shall include as a minimum the following network management procedures:
 1. Automatic backup of the BAS database to appropriate media.
 2. Program, load, and debug all software installations, including integration of third-party applications (i.e., analytics and energy management).
 3. Network user auditing routine.

3.7. POINT-TO-POINT TESTING/CHECKOUT

- A. As a part of installation, provide checkout (also called point-to-point testing) of all BAS Components.
- B. Prior to start-up of any MEP Equipment, ensure all points have been properly set up, including but not limited to sensor type and range.
- C. Ensure BAS Component is accessible for maintenance.
- D. Ensure sensors and devices have been installed in the correct location in accordance with actual field conditions and modifications made to the flow diagram in the Contract Documents. Ensure sensors and devices have the proper flow direction, orientation, insertion depth, and any other applicable requirements.
- E. Provide means to increase or decrease sensed value and ensure the BAS responds accordingly.
- F. Checkout will be performed via Owner's final graphic screens. If checkout is performed within the programming function of the BAS, it shall be repeated when the final graphic screens are complete and available for use.
- G. Check operation of valve/damper-actuator combination to confirm that actuator modulates valve/damper smoothly throughout stroke to both open and closed positions. Check valve for proper close off.
- H. Provide documentation of the checkout process for each piece of MEP Equipment.

3.8. START-UP TESTING

- A. At the conclusion of point-to-point testing/checkout, provide start-up testing of all BAS Components.
- B. Provide start-up of all MEP Equipment. Perform start-up in conjunction with any applicable trades.
- C. Provide start-up testing to ensure all configuration and programming conforms with Sequence of Operation.
- D. Start-up testing will be performed via Owner's final graphic screens. If start-up testing is performed within the programming function of the BAS, it shall be repeated when the final graphic screens are complete and available for use.
- E. Tune PIDs to provide reasonable speed response to change in variables while having stable operation.
- F. Provide documentation of the start-up testing process, including any modifications made to the Sequence of Operation, for each piece of MEP Equipment.

3.9. ADJUSTING AND CALIBRATION

- A. Adjust and calibrate all points on the BAS as follows.
- B. Prior to calibration, complete all point-to-point testing/checkout and start-up testing to ensure the BAS is fully functioning.
- C. Calibrations shall be made inside the Niagara wire sheet. Do not calibrate sensors inside the device controller.
- D. Calibrated instrument shall be minimally twice as accurate as the sensor's installed accuracy.
- E. Using calibrated instruments, document actual value (per calibrated instrument) and indicated sensor reading (per the BAS). Adjust using a single point offset or a double-point calibration. Document calibration value(s).
- F. If sensor reading is within the manufacturer's stated accuracy, do not calibrate the sensor. Document actual value and sensor reading.

- G. If sensor is greater than manufacturer's stated accuracy, investigate installation of sensor (i.e., 5-10 pipe/duct diameters downstream, etc), programming of sensor (i.e., SVNTs, range, voltage instead of mA and resistance causing high voltage drop, etc.), transient issues (i.e., turbulence, diffuser blowing on sensor). If investigation uncovers potential source of error, correct sensor installation.
- H. If no errors are found and sensor's accuracy is between 100 and 200% of manufacturer's stated accuracy, provide:
 - 1. Single-point offset for sensors whose readings will vary less than 20% (ex., room temperature).
 - 2. Two-point calibration for sensors whose readings will vary greater than 20%.
 - 3. Document actual value, sensor reading, and offset/calibration values.
- I. If no errors are found and sensor's accuracy is greater than 200% of manufacturer's stated accuracy, replace sensor. Alternatively, provide documentation for approval as to why sensor's error is more than 200% of manufacturer's stated accuracy.
- J. Work with Testing and Balance (TAB) Contractor to input calibrations performed within TAB Contractor's scope of work. Provide dedicated personnel to assist TAB Contractor during their work, provide a fully functioning TAB graphical screen on the BAS for TAB Contractor use, or provide means to adjust TAB via wall module. Assist TAB Contractor with questions regarding TAB graphical screen.
- K. Do not calibrate any sensor which has a guaranteed installed accuracy, such as airflow monitoring stations (AFMS) or water flow sensors.

3.10. FUNCTIONAL PERFORMANCE TESTING (FPT) PROCEDURE

- A. Perform point-to-point testing/checkout, start-up testing, adjusting/calibration testing, configuration, and programming on all MEP Equipment and the BAS as a whole to provide a complete and fully functioning BAS.
- B. BAS shall be complete and fully functioning prior to any Functional Performance Testing (FPT). Assist Owner and/or Owner Representatives, which may include but is not limited to the Engineer, Architect, Commissioning Agent (CxA), and/or Testing and Balance (TAB) Firm, with FPT, which may include but is not limited to verification, commissioning, and/or Graphical User Interface (GUI) acceptance testing. Provide dedicated personnel to those activities as specified herein or as requested by Owner.
- C. Provide documentation as specified to prove the BAS is complete and fully functional prior to FPT activities.
- D. At a minimum, perform the following FPT procedures. The following may be achieved within a Commissioning Plan or another FPT as required within the Contract Documents.
 - 1. Provide Owner an agenda and schedule of FPT activities for approval and coordination as part of Action Submittals.
 - 2. Complete all necessary installation to have a complete and fully functional BAS. Provide written notice that BAS is ready for FPT.
 - 3. Demonstrate BAS systems to Owner. Perform FPT including but not limited to Sequence of Operation, point-to-point verification to graphical interface, historical data logging, and alarms.
 - 4. Owner to provide detailed punch list to Contractor.
 - 5. Contractor to repair issues on Owner punch list within five business days.

3.11. CLOSEOUT

- A. Upon completion of Functional Performance Testing (FPT), Contractor provides all requirements as specified in 1.13 Close-Out Submittals to Owner.

- B. Contractor trains Owner on all aspects of the BAS including architecture, devices, software, and final Sequences of Operation.
- C. Owner issues letter to Contractor declaring that system is Substantially Complete. Date of this letter starts the Warranty Period.
- D. Final Acceptance. Owner issues letter to Contractor accepting system. Final pay app can be issued for release of any remaining contingency funds.

3.12. CONTROL PANELS

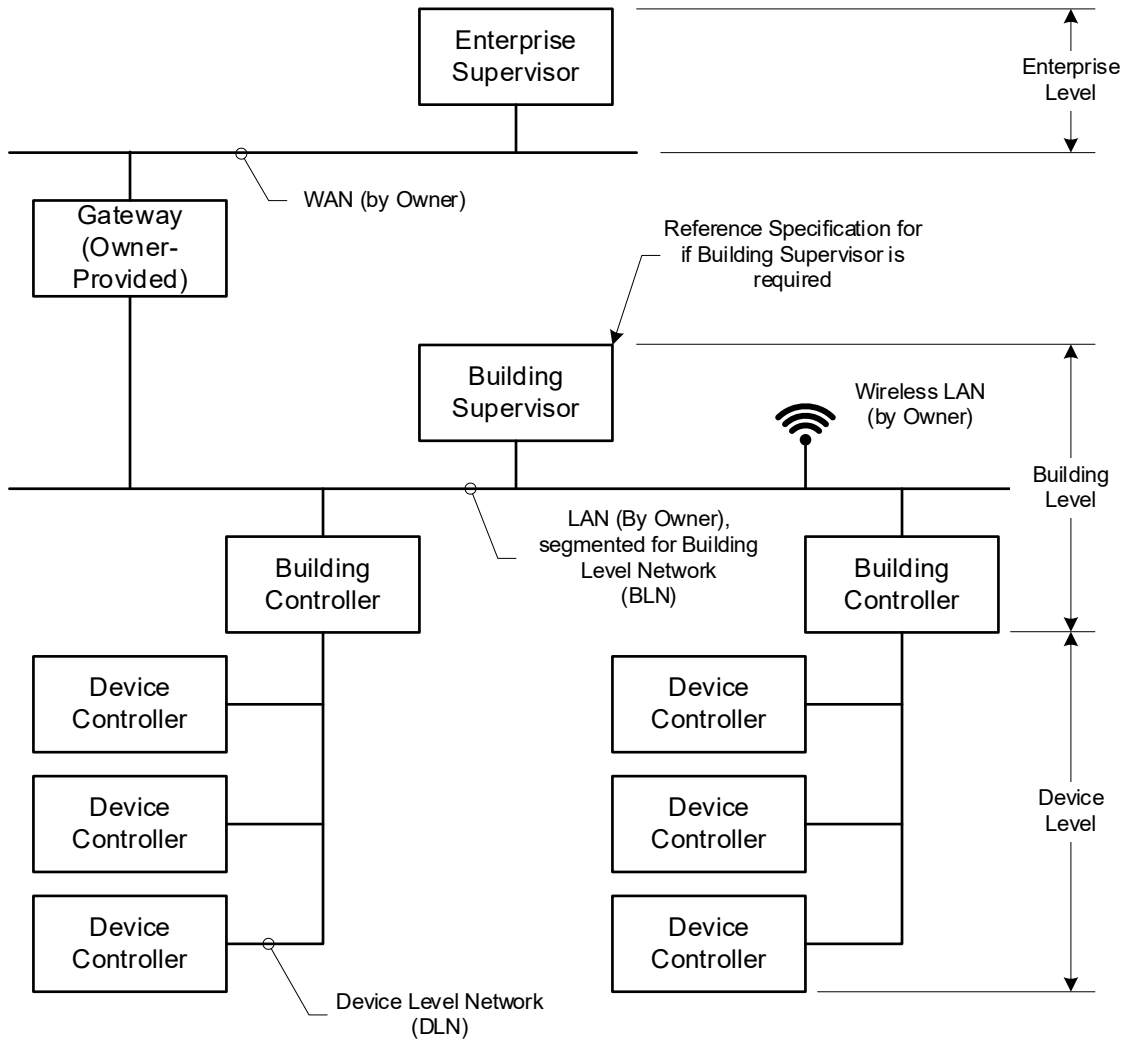
- A. Install Control Panels at locations in accordance with the Contract Documents and/or Owner. Ensure proper service clearances will be achieved at the end of construction. Control Panels without proper service clearances will be relocated at no cost to Owner.
- B. For any Control Panel that exceeds 16 inches in any dimension, provide a trough above/below Control Panel. Trough shall be separated into high and low voltage. Provide a high and low voltage conduit or nipple between trough and Control Panel, sized appropriately for the high and low voltage wiring. All other conduit that serves the Control Panel shall enter/exit the trough. Do not terminate any other conduit(s) to the Control Panel outside of two conduits/nipples identified.
- C. Provide a service loop for all controls wiring. Service loop will be installed in trough (where provided) or inside Control Panel cable tray (where allowed).
- D. Contractor shall extend power to the Control Panel from a junction box or an acceptable location.

3.13. GRAPHICS/OPERATOR INTERFACE

- A. The graphics shall comply with the Owner's standards and requirements.

PART 4 - FIGURES

4.1. NETWORK DIAGRAM



END OF 15900 – BUILDING AUTOMATION SYSTEMS