SECTION 23 09 00 - BUILDING MANAGEMENT SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Building Management System (BMS), utilizing direct digital controls.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Products Normally Supplied But Installed by Others:
   1. Control valves.
   2. Flow switches.
   3. Wells, sockets and other inline hardware for water sensors (temperature, pressure, flow).
   4. Automatic control dampers, where not supplied with equipment or by mechanical.

B. Products Not Furnished or Installed But Integrated with the Work of This Section:
   1. Smoke detectors (through alarm relay contacts). Fire alarm system monitoring only by BMS system.

C. Work Required Under Other Divisions Related to This Section:
   1. Provision and wiring of smoke detectors and other devices relating to fire alarm system.
   2. Campus LAN (Ethernet) connection adjacent to Network Area Controller (JACE).
   3. Smoke control system installation.

1.3 SYSTEM DESCRIPTION

A. Scope: Furnish all labor, materials and equipment necessary for a complete and operating Building Management System (BMS), 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 a BACnet/MSTP open protocol bus. Controllers shall be of one manufacturer and the latest version as of the date of the bid.
   1. 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. This may be a new system or an expansion.
   2. 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.
   3. 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 computer on the owner's LAN.
   4. Only systems that utilize the Niagara 4 Framework shall satisfy the requirements of this section.
   5. The N4 supervisor shall be a PC with minimum Intel Xeon CPU E5-2640 (or better) with 16 GB RAM 2 (256GB) SSD hard drives in a RAID 1 configuration.

It shall include a minimum 32X CD-ROM drive and 4-USB 3.0 ports. A minimum 21", HDMI, DVI-D video interfaces, minimum 1024 x 768 resolution, 4x3 Widescreen, LED color monitor with a minimum 60 Hz refresh rate shall also be included.

The N4 supervisor operating system shall be Windows 10 PRO 64 bit for workstation grade hardware and Windows Server 2016 for server grade hardware as a minimum. Utilize latest OS compatible with latest release of Niagara N4. Remove all other OS entries. Workstation and Server grade must be identified by the manufacturer and not a designer designation.

a. With VM support
b. With the most recent service packs and system updates.
c. Selected based on availability and project requirements.
d. Acceptable Manufacturers are:
    a) Dell
    b) Lenovo
    c) HP (Hewlett Packard)
e. Connection to the BAS LAN network shall be via an Ethernet network interface card, 1Gb LAN.
f. The N4 supervisor shall support all Network Control Units (NCU), OWSs, and 3rd party mechanical / electrical systems connected to the Facility Management Control / Building Automation System Local Area Network.
g. N4 supervisor to include Niagara 4 license as required to accommodate all DDC controllers and control points provided for this project.
h. Include 5-year SMA (Software Maintenance Agreement). Labor for software maintenance is not included. NOTE: a 5 year SMA is required.

6. The JACE shall handle the communications and licenses and be provided by the contractor. A rack mounted supervisor and license will be purchased and installed by others. The integrator shall be responsible for the entire site integration.
7. 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 computer, engineering and programming software required for the ongoing maintenance and operation of the BMS.
8. 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=*". All open NIC statements shall follow Niagara Open NIC specifications.
9. All NAC hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.
10. All NAC provided as part of this project shall be the appropriate JACE-8000 model licensed with all necessary drivers.
11. All NAC's provided as part of this project shall be licensed to accommodate a minimum of 10% additional controllers and points.
12. Access: The owner will be granted permanent full administrative access to the entire system with no limitations or expiring licenses or renewals required. This access level allows the ability to add and/or delete accounts.

1.4 SPECIFICATION NOMENCLATURE

A. Acronyms used in this specification are as follows:
1. Actuator: Control device that opens or closes valve or damper in response to control signal.
2. AI: Analog Input.
3. AO: Analog Output.
4. Analog: Continuously variable state over stated range of values.
5. BMS: Building Management System.
6. DDC: Direct Digital Control.
7. Discrete: Binary or digital state.
8. DI: Discrete Input.
9. DO: Discrete Output.
10. FC: Fail Closed position of control device or actuator. Device moves to closed position on loss of control signal or energy source.
11. FO: Fail open (position of control device or actuator). Device moves to open position on loss of control signal or energy source.
12. GUI: Graphical User Interface.
13. HVAC: Heating, Ventilating and Air Conditioning.
14. IDC: Interoperable Digital Controller.
15. ILC: Interoperable Lon Controller.
16. LAN: Local Area Network.
17. Modulating: Movement of a control device through an entire range of values, proportional to an infinitely variable input value.
18. Motorized: Control device with actuator.
19. NAC: Network Area Controller (JACE).
20. NC: Normally closed position of switch after control signal is removed or normally closed position of manually operated valves or dampers.
21. 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.
22. OSC: Operating System Computer, host for system graphics, alarms, trends, etc.
23. Operator: Same as actuator.
24. PC: Personal Computer.
25. 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.
26. P: Proportional control; control mode with continuous linear relationship between observed input signal and final controlled output element.
27. 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).
28. PICS: BACnet Product Interoperability Compliance Statement.
29. 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).

30. Point: Analog or discrete instrument with addressable database value.
31. SMA: Software Maintenance Agreement. Maintenance agreement that provides future releases of Niagara 4 software at no licensing cost to owner. Labor to implement software upgrades is not covered under the Software Maintenance Agreement.
32. WAN: Wide Area Network.

1.5 PRELIMINARY DESIGN REVIEW

A. The BAS contractor shall submit a preliminary design document for review within 45 days of the NTP. This document shall contain the following information:
   1. Provide the graphic block programming tool to be used and relevant supporting documentation to ensure compliance with Part 3 of this specification.
   2. Provide the web page graphic tools to be used to develop the web pages consistent with our latest standards.
   3. Provide a description of the proposed system along with a system architecture diagram with the intention of showing the contractors solution to meet this specification and samples of graphics consistent with NCDPS latest design guidelines attached to and made part of this project.
   4. Provide product data sheets and a technical description of all direct digital controller hardware required to meet specifications listed herein.
   5. Provide an overview of the BAS contractor's local/branch organization, local staff, recent related project experience with references, and local service capabilities.
   6. Provide information on the BAS contractor's project team including project organization, project manager, project engineer, programmers, project team resumes, and location of staff.

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B. Coordinate a meeting with a control team project manager, programmer, design engineer, and owner to review sequences within that time. NCDPS Central Engineering Electronics Engineering Group shall receive notification and invitation to this meeting. Offer concerns or suggestions for improvement.
   Agenda items for the meeting:
   1. Sequences
   2. Trends to be set up
   3. Alarms and required delays/buffers to avoid nuisance alarms.
   4. Review procedures for BACnet equipment startup by manufacture and understanding interfacing for control and monitoring. BACnet points numbers and names will be coordinated. Points to be viewed and how will be discussed. The mechanical contractor will be responsible for having an equipment control expert knowledgeable on the specific equipment at the meeting.

1.6 SUBMITTALS

A. Submit under provisions of Division 1 specifications.

B. Product Data: Manufacturer's data sheets on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.

3. Installation methods.

C. Submit documentation of contractor qualifications, including those indicated in "Quality Assurance" if requested by the A-E.

D. The control system submittal shall consist of shop drawings, manufacturers' catalog data sheets and installation instructions. Submit in electronic format. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.

E. As a minimum, shop drawings shall contain:
1. A table of contents.
2. Equipment schedules.
3. Valve and damper schedules when applicable. Valve schedules shall include GPM, valve size, calculated Cv, valve Cv, pressure drop, close-off pressure, configuration (2-way or 3-way), and valve actuator data.
4. VAV box controller schedule. Schedule shall include box size, K-Factor, and flow setpoints.
5. Schematic diagrams of all controlled equipment.
6. Sequences of operation for all controlled equipment. To be written in a more programming style than engineer’s narrative sequence. Do not cut and paste engineer’s sequence.
7. Controller wiring diagrams, including terminal number identification for all control wiring.
8. Wiring details for all field devices.
9. A network architecture diagram showing a high-level overview of the installed system.
10. A detailed control system bus layout depicted on building floorplans. Indicate controller locations.
11. Control panel layout diagrams depicting all panel mounted components.
12. Any other details required to demonstrate that the system has been coordinated with other trades and will properly function as a system.
13. Manufacturer’s data sheets for all installed components.

F. All system manuals available to the controls vendor shall be provided to the owner as submittals to permit full networking, installation, programming, graphic generation, and checkout of the installed system. As a minimum but not limited to the following. Failure to provide these manuals shall result in rejection of the submittal in toto:
1. Operator’s Manuals
2. Programming Manuals
3. Graphic Creation and Integration Manuals
4. Niagara Platform Manuals
5. Module Installation, Diagnostic

G. Upon completion of the work, provide 3 complete sets of ' as-built' drawings and other project-specific documentation in 3-ring hard-backed binders and one electronic copy.

H. Any deviations from these specifications or the work indicated on the drawings shall be

clearly identified in the Submittals.

1.7 QUALITY ASSURANCE

A. The Control System Contractor shall have a full service DDC office within [150] miles of the job site. This office shall be staffed with applications engineers, software engineers and field technicians. The Control System Contractor shall be staffed with a minimum of ten (10) Niagara 4 certified software engineers and/or technicians. The Control System Contractor shall also be staffed with a minimum of ten (10) control system manufacturer certified software engineers and/or technicians. The Control System Contractor 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 Control System Contractor shall be responsible for the complete installation and proper operation of the control system. The Control System Contractor 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 Control System Contractor 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 3 years. All control panels shall be assembled by the Control System Contractor in a UL-Certified 508A panel shop. Control panels shall be assembled such that all necessary I/O points are pre-wired from DDC controllers to terminal blocks. Wire ducts shall be installed within the panel as needed to accommodate field wiring.

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 manufacturer's latest standard design and have been tested and proven in actual use.

D. **Preferred Brand Alternate No. 1**: Distech ECB Series.

E. **Familiarity with working environment**: The DDC contractor and the wiring sub-contractor on retro-fit jobs must be acquainted with working in a prison environment. The must have proof of having experience or training and follow all requirements set by NCDPS.

1.8 SOFTWARE OWNERSHIP

A. The Owner (NCDPS Central Engineering) shall have full ownership and full access rights for all network management, operating system computer, engineering and programming software required for the ongoing maintenance and operation of the BMS.

B. Contractor shall provide a complete backup of programs, graphics, and documentation, in an editable format without password restriction (other than what is inherently required by the controller or equipment. In that case, password shall be provided.)

1.9 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.

1.10 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure 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.

1.11 SEQUENCING

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

PART 2 PRODUCTS

2.1 GENERAL

A. The Building Management System (BMS) 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. An N4 supervisor is to be on site for graphic storage and trending data storage and located on a new rack mount by Central Engineering Staff as noted above.

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

2.2 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, IP, or MS/TP.

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 BMS computer database is required for all system database parameter storage. This data shall reside on the N4 supervisor located in the Facilities Office on the LAN. Systems requiring proprietary database and user interface programs shall not be acceptable.

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. Systems employing a "flat" single tiered architecture shall not be acceptable.
   1. 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.
   2. 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 or dial-up connected user interfaces.

2.3 NETWORK AREA CONTROLLER (NAC)

A. Basis of design is the JACE- 8000. These controllers are designed to manage communications between the Advanced Application Controllers (B-AAC), Application Specific Controllers (B-ASC) and Advanced Unitary Controllers (AUC) which are connected to its communications trunks, manage communications between itself and other system network controllers (NAC) and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The JACE shall be an embedded controller and server platform for connecting multiple and diverse devices and subsystems, internet connectivity, webserving capability, integrated control, supervision, data logging, alarming, scheduling and network management. Data and graphical displays shall be streamed to a standard network browser via Ethernet or wireless LAN, or remotely over the internet. The operating sytem shall be EC-Net 4 web-based building management platform powered by the Niagara Framework.

C. The controllers shall be fully programmable to meet the unique requirements of the facility it shall control.

D. The controllers shall be capable of peer-to-peer communications with other NAC's and with any OWS connected to the BAS, whether the OWS is directly connected, connected via cellular modem or connected via the Internet.

E. The communication protocols utilized for peer-to-peer communications between NAC's will be Niagara 4 Fox, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between NAC's is not allowed.

F. The NAC shall employ a device count capacity license model that supports expansion capabilities.

G. The NAC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
   1. BACnet
   2. Lon
   3. MODBUS
   4. SNMP

5. KNX

H. The NAC shall be capable of executing application control programs to provide:
1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of LonWorks, BACnet, and MODBUS controller data.
7. Network management functions for all NAC, PEC and ASC based devices.

I. The NAC shall provide the following hardware features as a minimum:
1. Two 10/100 Mbps Ethernet ports.
2. Two Isolated RS-485 ports with biasing switches.
3. 1 GB DDR3 SDRAM RAM
4. 4 GB Flash Total Storage / 2 GB User Storage
5. Wi-Fi (Client or WAP)
6. USB Flash Drive
7. High Speed Field Bus Expansion
8. -20-60°C Ambient Operating Temperature
9. Integrated 24 VAC/DC Global Power Supply
10. MicroSD Memory Card Employing Encrypted Safe Boot Technology. Minimum 4GB flash and total storage/2GB user storage.
11. Have a USB type A port for station backup and restore functions
12. Backward compatibility to run an EC-Net station (minimum requirement is 3.8.111)
13. Platform:
    a. Processor Tl AM3352 1000MHz ARM® Cortex™ -A8
    b. Removable micro-SD card with 4GB flash total storage/2GB user storage
    c. Real-time clock
    d. Batteryless
    e. Secure boot
14. Operating System:
    a. EC-Net 4 4.1 or later
    b. EC-NetAX 3.8.111 or later
    c. EC-Net Access 2.3.118 or later
15. Communications: Wi-Fi Client or WAP
16. Wi-Fi Communication Protocol:
    a. IEEE802.11 a/b/g/n
    b. IEEE802.11 n HT20 @ 2.4GHz
    c. IEEE802.11n HT20/HT40@5GHz
17. Client Authentication Method: WPAPSK/WPA2PSK support

(2) Ethernet 10/100MB Ethernet ports

BACnet Listing BTL, B-BC listed with version 4.4.93 or latest

MTTF: 10 years+

J. The NAC shall support standard Web browser access via the Intranet/Internet. It shall

support a minimum of 16 simultaneous users.

K. The NAC shall provide alarm recognition, storage, routing, management and analysis to supplement distributed capabilities of equipment or application specific controllers.

L. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via cellular modem, or wide-area network.
   1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but not limited to:
      a. Alarm.
      b. Return to normal.
      c. To default.
   2. Alarms shall be annunciated in any of the following manners as defined by the user:
      a. Screen message text.
      b. Email of complete alarm message to multiple recipients.
      c. Mobile device text message.
      d. Pagers via paging services that initiate a page on receipt of email message.
      e. Graphics with flashing alarm object(s).
   3. The following shall be recorded by the NAC for each alarm (at a minimum):
      a. Time and date.
      b. Equipment (air handler #, access way, etc.).
      c. Acknowledge time, date, and user who issued acknowledgement.

M. The NAC shall support the following security functions.
   1. Module code signing to verify the author of programming tool and confirm that the code has not been altered or corrupted.
   2. Role-Based Access Control (RBAC) for managing user roles and permissions.
   3. Require users to use strong credentials.
   4. Data in Motion and Sensitive Data at Rest be encrypted.
   5. LDAP and Kerberos integration of access management.

N. The NAC shall support the following data modeling structures to utilize Search; Hierarchy; Template; and Permission functionality:
   1. Metadata: Descriptive tags to define the structure of properties.
   2. Tagging: Process to apply metadata to components
   3. Tag Dictionary

O. The NAC shall employ template functionality. Templates are a containerized set of configured data tags, graphics, histories, alarms, etc. that are set to be deployed as a unit based upon manufacturer's controller and relationships. All lower level communicating controllers (PEC, AVAV, CVAV, VFD's, etc.) shall have an associated template file for reuse on future project additions.

P. The NAC shall be provided with a Software Maintenance Agreement as indicated in Paragraph 1.3.

2.4 BUILDING AUTOMATION SYSTEM CONTROLLERS (DDC)

A. HVAC control shall be accomplished using BACnet based devices where the application has a BTL Listed PICS defined. The controller platform shall provide options and advanced system functions, programmable and configurable using the Niagara 4 Framework or through manufacturer supplied software, that allow standard and customizable control solutions required in executing the "Sequence of Operation". For systems that do not provide the ability to program DDC controllers through the Niagara 4 Framework, provide (4) copies of controller engineering/programming software, including any necessary licenses required for use of software.

B. While BACnet is the selected communications platform there may be cases were Lonworks will be utilized on system expansions or renovations. All DDC controllers shall incorporate a common hardware platform between the BACnet and Lonworks communication models. Model I/O options and termination layouts shall be identical regardless of communication option selected.

C. All controllers shall include a network connection for local viewing of operation, AHU, FCU, UV, VAV for example.

D. DDC controller manufacture shall offer both custom programmable controllers and plug-and-play pre-configured application specific controllers.

E. DDC controller manufacturer shall offer models with built in LCD with live color graphics for operator interface directly to controller. [Designer to confer with NCDPS Controls team to determine whether this will be included as a requirement, estimated add is $75.]

F. DDC controllers shall utilize a graphical block oriented programming interface tool. This software tool shall license free and not require any reoccurring costs for continued operation.

G. All controllers shall have sufficient input and output capability for the terminal system being controlled and monitored plus allow two spare inputs and outputs, VAV box controllers require one set. Plant controllers to have min of 10% spare capacity. Controller enclosure shall be size to accommodate a second controller of the same size.
   1. Advanced Application Controller (B-AAC) - a controller designed for more complex sequences of operations such as built up AHU's, central plant operations, electrical monitoring, and control and management for chillers, boilers and generators. The B-AAC's are to allow for the flexibility of custom control programming to meet the needed sequences of operation. B-AAC's shall be selected based upon I/O requirements. Additional I/O may be added via expansion modules.
      a. All B-AAC's shall be application programmable and shall at all times maintain their certification. All control sequences within or programmed into the B-AAC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
      b. The B-AAC shall provide LED indication of communication and controller performance to the technician, without cover removal.
      c. B-AAC's shall have mixture of I/O including dry contact digital inputs,

universal inputs (configurable as of 4-20 mA, 0-10 VDC, thermistor and RTD in the range 0 to 350,000 ohm), universal outputs (4-20mA, 0-10 VDC, or digital), and digital outputs (24 VAC TRIAC).

2. Advanced Variable Air Volume Controller (AVAV) - a controller designed specifically for room-level VAV control - pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO2, occupancy, and emergency control. Equipment includes: VAV terminal unit, VAV terminal unit with reheat, series fan powered terminal unit, parallel fan powered terminal unit, supply and exhaust air volume terminals and constant volume dual-duct terminal unit.
   a. The AVAV shall be application programmable and shall at all times maintain their certification. All control sequences within or programmed into the PEC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
   b. The controller shall have an internal velocity pressure sensor.
   c. The AVAV shall provide LED indication of communication and controller performance to the technician, without cover removal.
   d. AVAV's shall have mixture of I/O including dry contact digital inputs, universal inputs (configurable as of 4-20 mA, 0-10 VDC, thermistor and RTD in the range 0 to 350,000 ohm), universal outputs (4-20mA, 0-10 VDC, or digital), and digital outputs (24 VAC TRIAC).
   e. The controller shall provide an integrated actuator option.

3. Configurable VAV Controller (CVAV) - the configurable VAV controller platform shall be designed specifically for room-level VAV control – pressure-independent air flow control, pressure dependent damper control, supply and exhaust pressurization/de-pressurization control; temperature, humidity, complex CO2, occupancy, and emergency control. Equipment includes: VAV terminal unit, VAV terminal unit with reheat, series fan powered terminal unit, parallel fan powered terminal unit, supply and exhaust air volume terminals, and constant volume dual-duct terminal unit.
   a. The CVAV shall be application specific configuration and shall at all times maintain their certification. All control sequences within or programmed into the CVAV shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
   b. The controller shall have an internal velocity pressure sensor.
   c. The CVAV shall provide LED indication of communication and controller performance to the technician, without cover removal.
   d. CVAV's shall have mixture of I/O including dry contact digital inputs, universal inputs (configurable as of 4-20 mA, 0-10 VDC, thermistor and RTD in the range 0 to 350,000 ohm), universal outputs (4-20mA, 0-10 VDC, or digital), and digital outputs (24 VAC TRIAC).
   e. The controller shall provide an integrated actuator option.

H. UV, FCU Controller

1. Advanced Application Controller (AAC) - a controller designed for more conventional sequences of operations such as small AHUs, fan coil units, unit ventilators with real time clock, 8 analog outputs, 10 universal inputs,. AAC's are to allow for the flexibility of custom control programming to meet the needed sequences of operation. AAC's shall be selected based upon I/O requirements. Additional I/O may be added via expansion modules.
   a. All AAC's shall be application programmable and shall at all times maintain their certification. All control sequences within or programmed into the AAC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery to be retained.
   b. The AAC shall provide LED indication of communication and controller performance to the technician, without cover removal.
   c. AAC's shall have mixture of I/O including dry contact digital inputs, universal inputs (configurable as of 4-20 mA, 0-10 VDC, thermistor and RTD in the range 0 to 350,000 ohm), universal outputs (4-20mA, 0-10 VDC, or digital), and digital outputs (24 VAC TRIAC).

2.5 DDC Sensors and Point Hardware

A. Temperature Sensors
   1. Acceptable Manufacturers: Veris, Distech, Honeywell, ACI
   2. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of –30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
   3. Room Sensor: Standard space sensors shall be available in an [off white] [black] enclosure made of high impact ABS plastic for mounting on a standard electrical box. Basis of Design: Veris TW Series
      a. Where manual overrides are required, the sensor housing shall feature both an optional sliding mechanism for adjusting the space temperature setpoint, as well as a push button for selecting after hours operation.
      b. Where a local display is specified, the sensor shall incorporate an LCD display for viewing the space temperature, setpoint and other operator selectable parameters. Using built in buttons, operators shall be able to adjust setpoints directly from the sensor.
   4. Duct Probe Sensor: Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Useable in air handling applications where the coil or duct area is less than 14 square feet. Basis of Design: Veris TD Series
   5. Duct Averaging Sensor: Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet. The averaging sensor shall be constructed of rigid or flexible copper tubing. Basis of Design: Veris TA Series
   6. Pipe Immersion Sensor: Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Provide sensor probe length suitable for application. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel for non-corrosive fluids below 250 degrees F

and 300 series stainless steel for all other applications. Basis of Design: Veris TI Series

7. Outside Air Sensor: Provide the sensing element on the building's north side. Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure. Operating range -40 to 122 F, Basis of Design: Veris TO Series
8. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Wall Transmitter
1. Acceptable Manufacturer: Veris, Distech, Vaisala, Hy-Cal, Honeywell
2. Transmitters shall be accurate to +/- [1] [2] % at full scale.
3. Transmitter shall have replaceable sensing element.
4. Sensor type shall be thin-film capacitive.
5. Sensor element shall contain multipoint calibration on-board in nonvolatile memory
6. Operating range shall be 0 - 100% RH noncondensing, 50 to 95 F
7. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC.
8. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
9. Transmitter shall be available in an [off white] [black] enclosure made of high impact ABS plastic for mounting on a standard electrical box.
10. Transmitter shall have LCD display
11. Transmitter shall be available with a certification of NIST calibration
12. [Transmitter shall have integrated temperature sensor]
13. Basis of Design: Veris HWL Series

C. Humidity Duct Transmitter
1. Acceptable Manufacturer: Veris, ACI, Vaisala, Hy-Cal, Honeywell
2. Transmitters shall be accurate to +/- [1] [2] % at full scale.
3. Transmitter shall be fully encapsulated in potting material within a stainless steel probe.
4. Transmitter shall have replaceable sensing element.
5. Sensor type shall be thin-film capacitive.
6. Sensor element shall contain multipoint calibration on-board in nonvolatile memory
7. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
8. Output shall be 4-20 mA or 0-5/0-10 VDC.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Transmitter shall be available with a certification of NIST calibration
11. [Transmitter shall have integrated temperature sensor]
12. Basis of Design: Veris HD Series

D. Humidity Outdoor Transmitter
1. Acceptable Manufacturer: Veris, ACI, Vaisala, Hy-Cal, Honeywell
2. Transmitters shall be accurate to +/- 2% at full scale.
3. Transmitter shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.

4. Transmitter shall have replaceable sensing element.
5. Sensor type shall be thin-film capacitive.
6. Sensor element shall contain multipoint calibration on-board in nonvolatile memory
7. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
8. Output shall be 4-20 mA or 0-5/0-10 VDC.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
10. Transmitter shall be available with a certification of NIST calibration
11. [Transmitter shall have integrated temperature sensor]
12. Basis of Design: Veris HO Series

E. Carbon Dioxide Wall Transmitter:
1. Acceptable Manufacturer: Veris, Honeywell, Distech
2. Sensor type shall be Non-dispersive infrared (NDIR).and gold plated optics shall be provided.
3. Accuracy shall be ±30 ppm ±2% of measured value with annual drift of ±10 ppm.
4. Repeatability shall be ±20 ppm ±1% of measured value
5. Response Time shall be <60 seconds for 90% step change
6. Outputs shall be field selectable [Analog: 4-20mA or 0-5/0-10VDC] [Protocol: Modbus or BACnet] with [SPDT Relay 1A@30VDC] [temperature setpoint slider]
7. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
8. Temperature Range: [32° to 122°F (CO2 only)] [50° to 95°F (with humidity option)]
9. Output range shall be programmable 0-2000 or 0-5000 ppm
10. Transmitter shall be available in an [off white] [black] enclosure for mounting on a standard electrical box.
11. Transmitter shall have LCD display for commissioning and provide additional faceplate to conceal LCD display where occupants may misinterpret CO2 readings.
12. Calibration method: Self calibration method eliminates the need for manual calibration and calibrates the sensor based on baseline calibrations measured during unoccupied periods in the space. Sensor shall not require manual calibration over a minimum product rated life of 15 years.

F. Carbon Dioxide Duct Transmitter:
1. Acceptable Manufacturer: Veris, Honeywell, Distech
2. Sensor type shall be Non-dispersive infrared (NDIR) and provide gold plated optics.
3. Accuracy shall be ±30 ppm ±2% of measured value with annual drift of ±10 ppm. Calibration method: Self calibration method eliminates the need for manual calibration and calibrates the sensor based on baseline calibrations measured during unoccupied periods in the space. Sensor shall not require manual calibration over a minimum product rated life of 15 years.
4. Repeatability shall be ±20 ppm ±1% of measured value
5. Response Time shall be <60 seconds for 90% step change
6. Outputs shall be field selectable Analog: 4-20mA or 0-5/0-10VDC with SPDT Relay 1A@30VDC

7. Transmitter shall accept 12-30 VDC or 24 VAC supply power.
8. Temperature Range: 32° to 122°F
9. Output range shall be programmable 0-2000 or 0-5000 ppm
10. Enclosure shall not require remote pickup tubes and make use of integrated H-beam probe to channel air flow to sensor.
11. Enclosure lid shall require no screws and make use of snap on features for attachment
12. Enclosure shall be made of high impact ABS plastic
13. Transmitter shall have LCD display

G. Air Pressure Transmitters.
1. Acceptable Manufacturers: Veris, Distech, KMC, Modus, Dwyer, BAPI
2. Sensor shall be microprocessor profiled ceramic capacitive sensing element
3. Transmitter shall have 14 selectable ranges from 0.1 – 10" WC
4. Transmitter shall be +/- 1% accurate in each selected range including linearity, repeatability, hysteresis, stability, and temperature compensation.
5. Transmitter shall be field configurable to mount on wall or duct with static probe
6. Transmitter shall be field selectable for Unidirectional or Bidirectional
7. Maximum operating pressure shall be 200% of design pressure.
8. Output shall be field selectable 4-20 mA or 0-5/0-10 VDC linear.
9. Transmitter shall accept 12-30 VDC or 24 VAC supply power
10. Response time shall be field selectable T95 in 20 sec or T95 in 2 sec
11. Transmitter shall have an LCD display
12. Units shall be field selectable for WC or PA
13. Transmitter shall have provision for zeroing by pushbutton or digital input.
14. Transmitter shall be available with a certification of NIST calibration
15. Basis of Design: Veris model PXU.

H. Liquid Differential Pressure Transmitters:
1. Acceptable Manufacturers: Veris, Setra, Kele, Rosemount, Foxboro
2. Transmitter shall be microprocessor based
3. Transmitter shall use two independent gauge pressure sensors to measure and calculate differential pressure
4. Transmitter shall have 4 switch selectable ranges
5. Transmitter shall have test mode to produce full-scale output automatically.
6. Transmitter shall have provision for zeroing by pushbutton or digital input.
7. Transmitter shall have field selectable outputs of 0-5V, 0-10V, and 4-20mA.
8. Transmitter shall have field selectable electronic surge damping
9. Transmitter shall have an electronic port swap feature
10. Transmitter shall accept 12-30 VDC or 24 VAC supply power
11. Sensor shall be 17-4 PH stainless steel where it contacts the working fluid.
12. Performance:
    a. Accuracy shall be ±1% F.S. and ±2% F.S. for lowest selectable range
    b. Long term stability shall be ±0.25%
    c. Sensor temperature operating range shall be -4° to 185°F
    d. Operating environment shall be 14° to 131°F; 10-90% RH noncondensing
    e. Proof pressure shall be 2x max. F.S. range

f. Burst pressure shall be 5x max. F.S. range

13. Transmitter shall be encased in a NEMA 4 enclosure
14. Enclosure shall be white powder-coated aluminum
15. Transmitter shall be available with a certification of NIST calibration
16. [Transmitter shall be preinstalled on a bypass valve manifold]
17. Basis of Design: Veris PW

I. Current Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in split core models, and offer either a digital or an analog signal to the automation system. Acceptable manufacturers: Veris, Kele

J. Current Status Switches for Constant Load Devices

1. Acceptable Manufacturers: Veris, RE Technologies
2. General: Factory programmed current sensor to detect motor undercurrent situations such as belt or coupling loss on constant loads. Sensor shall store motor current as operating parameter in non-volatile memory. Push-button to clear memory.
3. Visual LED indicator for status.
4. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from 0.5 A to 175 A.
5. Normally open current sensor output. 0.1A at 30 VAC/DC.
6. Basis of Design: Veris Model H608.

K. Current Status Switches for Constant Load Devices (Auto Calibration)

1. Acceptable Manufacturer: Veris, RE Technologies
2. General: Microprocessor based, self-learning, self-calibrating current switch. Calibration-free status for both under and overcurrent, LCD display, and slide-switch selectable trip point limits. At initial power-up automatically learns average current on the line with no action required by the installer
3. Split core sensor, induced powered from monitored load and isolated to 600 VAC rms. Sensor shall indicate status from 2.5 A to 200 A.
4. Display: Backlit LCD; illuminates when monitored current exceeds 4.5A
5. Nominal Trip Point: ±40%, ±60%, or on/off (user selectable)
6. Normally open current sensor output. 0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H11D.

L. Current Status Switches for Variable Frequency Drive Application

1. Acceptable Manufacturer: Veris, RE Technologies
2. General: Microprocessor controlled, self-learning, self-calibrating current sensor to detect motor undercurrent and overcurrent situations such as belt loss, coupling shear, and mechanical failure on variable loads. Sensor shall store motor current as operating parameter in non-volatile memory. Push-button to clear memory and relearn.
3. Visual LED indicator for status.
4. Alarm Limits: ±20% of learned current in every 5 Hz freq. band
5. Split core sensor, induced powered from monitored load and isolated to 600 VAC

rms. Sensor shall indicate status from 1.5 A to 150 A and from 12 to 115 Hz.

6. Normally open current sensor output. 0.1A at 30 VAC/DC.
7. Basis of Design: Veris Model H614.

M. Liquid Flow, Insertion Type Turbine Flowmeter:
1. Acceptable Manufacturer: Onicon, Hersey
2. General: Turbine-type insertion flow meter designed for use in pipe sizes 1 1/2" and greater. Available in hot tap configuration with isolation valves and mounting hardware to install or remove the sensor from pipeline that is difficult to shut down or drain
3. Performance:
   a. Accuracy ±1% of rate over optimum flow range; ≥10 upstream and ≥5 downstream straight pipe diameters, uninterrupted flow
   b. Repeatability ±0.5%
   c. Velocity Range: 0.3 to 20 FPS
   d. Pressure Drop 0.5 psi or less @ 10 ft/sec for all pipe sizes 1.5" dia and up
   e. Pressure Rating: 1000 psi @ 70°F
4. Maximum Temperature Rating: 300°F
5. Materials: Stainless Steel or Brass body; Stainless steel impeller
6. Transmitter:
   a. Power Supply: 12 - 30VAC or 8 - 35VDC.
      a) Output: [Frequency] [4-20 mA] [Scaled Pulse]
   b. Temperature Range: 14° to 150°F
   c. Display: 8 character 3/8" LCD (Optional)
   d. Enclosure: NEMA 4, Polypropylene with Viton® sealed acrylic cover

N. Liquid Flow/Energy Transmitter, Non-invasive Ultrasonic (Clamp-on):
1. Acceptable Manufacturers: Veris, Onicon
2. General: Clamp-on digital correlation transit-time ultrasonic flow meter designed for clean liquids or liquids containing small amounts of suspended solids or aeration. Optional temperature sensors for BTU calculations.
3. Liquid: water, brine, raw sewage, ethylene, glycol, glycerin, others. Contact manufacturer for other fluid compatibility
4. Pipe Surface Temperature: Pipe dia 1/2" to 2":-40-185°F; Pipe dia > 2": -40-250°F
5. Performance:
   a. Flow Accuracy:
      a) Pipe dia 1/2" to 3/4" 1% of full scale
      b) Pipe dia 1" to 2" 1% of reading from 4-40 FPS
      c) Pipe dia 2" to 100" 1% of reading from 1-40 FPS
   b. Flow Repeatability ±0.01% of reading
   c. Velocity Range: (Bidirectional flow)
      a) Pipe dia 1/2" to 2" 2 to 40 FPS
      b) Pipe dia 2" to 100" 1 to 40 FPS
   d. Flow Sensitivity 0.001 FPS
   e. Temperature Accuracy (energy): 32-212°F; Absolute 0.45°F; Difference 0.18°F

f. Temperature Sensitivity: 0.05°F
g. Temperature Repeatability: ±0.05% of reading

6. Transmitter:
   a. Power Supply: 95 to 264 VAC, 47 to 63 Hz or 10 to 28 VDC.
   b. Output: [RJ45] [Modbus TCP/IP] [Ethernet/IP] [BACnet/IP] [Pulse] [4-20 mA] [RS-485 Modbus RTU}
   c. Temperature Range: -40 to +185°F
   d. Display: 2 line backlit LCD with keypad
   e. Enclosure: NEMA 4, (IP65), Powder-coated aluminum, polycarbonate
7. Agency Rating: UL 1604, EN 60079-0/15, CSA C22.2, CSA Class 1 (Pipe > 2")
8. Basis of Design: Veris FST & FSR series

O. Analog Electric/Pneumatic Transducer:
1. Acceptable Manufacturers: Veris, ACI, RE Technologies
2. General: Micro-controlled poppet valve for high accuracy and with no air loss in the system. Field configurable for pressure sensing in multiple applications.
3. Power Supply: 22-30VDC, 20-30VAC
4. Control Input: 4-20mA, 0-10V, 0-5V; jumper selectable
5. Performance:
   a. Accuracy: 1% full scale; combined linearity, hysteresis, repeatability
   b. Compensated Temperature Range: 25° to 140°F
   c. Temp Coefficient: ±0.05%°C
   d. Operating Environment: 10-90% RH, non-condensing; 25° to 140°F
6. Supply Pressure: 45 psig max.
7. Manual Override: Jumper selectable mode, digital pushbutton adjust
8. Alarm Contact: 100mA@30VAC/DC (Optional)
9. Control Range 0-20 psig or 3-15 psig; jumper selectable
10. Pressure Differential 0.1 psig (supply to branch)
11. Pressure Indication Electronic, 3-1/2 digit LCD
12. Housing: Mounted on standard SnapTrack; Optional clear dust cover
13. Basis of Design: Veris EP Series

P. Control Valves
1. Acceptable Manufacturer: Belimo
2. Provide automatic control valves suitable for the specified controlled media (steam, water or glycol). Use characterized ball valves for 2" and under, heating valves fail open. Cooling valves fail closed unless otherwise noted. Provide NEMA 3 enclosure where subject to moisture. Provide valves which mate and match the material of the connected piping. Equip control valves with 24VAC modulating actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
3. Control valves and actuators shall be from the same manufacturer.
4. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow. CV to be approximately ½ of GPM.

5. Trim material shall be stainless steel for steam and high differential pressure applications.
6. Electric actuation should be provided on all terminal unit reheat applications unless electric heat is provided.

Q. Damper Actuators
1. Acceptable Manufacturer: Honeywell, Belimo, Distech
2. Damper actuators shall be Belimo electronic, and shall be direct coupled over the shaft, without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered. Control damper actuators shall be furnished by the Control System Contractor. Provide a minimum of 5 in-lb torque per square foot of damper area. All applications requiring proportional operation shall utilize truly proportional electric actuators. Only actuators with proven equal or lesser failure rate will be considered.

R. Airflow Measuring Stations
1. Acceptable Manufacturers: Ebtron, Tek-air Systems
2. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.
3. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.

2.6 OTHER CONTROL SYSTEM HARDWARE

A. Temperature Control Panels: Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. All electrical devices within a control panel shall be factory wired. Control panel shall be assembled by the BMS in a UL-Certified 508A panel shop. A complete set of ' as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.

B. Low Air Temperature Sensors: Provide SPST type switch, with 15 to 55 degrees F (-9 to 13 degrees C), range, vapor-charged temperature sensor. Approved manufacturers: JCI, Dynacon

C. Relays: Start/stop relay model shall provide either momentary or maintained switching action as appropriate for the motor being started. All relays shall be plugged in, interchangeable, mounted on a sub base and wired to numbered terminals strips. Relays installed in panels shall all be DPDT with indicating lamp. Relays installed outside of controlled devices shall be enclosed in a NEMA enclosure suitable for the location. Relays shall be labeled with UR symbol. RIB-style relays are acceptable for remote enable/disable.

D. Emergency Stop Switches: Provide toggle-type switch with normally-closed contact. Switch shall be labeled "AIR HANDLER EMERGENCY SHUTOFF, NORMAL - OFF.".

E. Control Power Transformers: Provide step-down transformers for all DDC controllers and devices as required. Transformers shall be sized for the load, but shall be sized for 50 watts, minimum. Transformers shall be UL listed Class 2 type, for 120 VAC/24 VAC operation.

F. Line voltage protection: All DDC system control panels that are powered by 120 VAC circuits shall be provided with surge protection. This protection is in addition to any internal protection provided by the manufacturer. The protection shall meet UL, ULC 1449, IEEE C62.41B. A grounding conductor, (minimum 12 AWG), shall be brought to each control panel.

2.7 N4 SUPERVISOR & WEB BROWSER GUI - SYSTEM OVERVIEW

A. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The N4 supervisor shall communicate using Ethernet and TCP. N4 supervisor shall be accessed using a web browser over Owner intranet and remotely over the Internet.

B. 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.

C. The N4 supervisor software shall support at least the following platforms (Windows 10 Pro 64bit and Windows Server 2016). The N4 supervisor 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:
1. Trending.
2. Scheduling.
3. Electrical demand limiting.
4. Duty Cycling.
5. Downloading Memory to field devices.
6. Real time 'live' Graphic Programs.
7. Tree Navigation.
8. Parameter change of properties.
9. Set point adjustments.
10. Alarm / event information.
11. Configuration of operators.
12. Execution of global commands.
13. 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:

1. N4 supervisor Software, Database and Web Browser Graphical User Interface.
2. Software Maintenance Agreement license as specified. Labor to implement future upgrades is not included.
3. Embedded System Configuration Utilities for future modifications to the system and controllers.
4. Embedded Graphical Programming Tools.
5. Embedded Application Software.

F. N4 supervisor Database: The N4 supervisor software shall utilize a Java Database Connectivity (JDBC) compatible database such as: MS SQL 8.0, Oracle 8i or IBM DB2. BAS systems written to Non -Standard and/or Proprietary databases are NOT acceptable.

G. Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:
1. Web Browser's for PC's: Only the current released browser (Edge/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 an intranet or the Internet.
2. Secure Socket Layers: Communication between the Web Browser GUI and N4 supervisor shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

2.8 WEB BROWSER GRAPHICAL USER INTERFACE

A. 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. The Department of Adult Corrections (DAC) is moving towards a standard, clean look and feel for their graphics across all buildings and sites to ensure users can most effectively utilize this tool. Part 3 specifies how these graphics are to look and feel.

B. 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.

C. 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 like Microsoft's Explorer program) 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.

1. Geographic View shall display a logical geographic hierarchy of the system including: cities, sites, buildings, building systems, floors, equipment and objects.
2. Groups View shall display Scheduled Groups and custom reports.
3. Configuration View shall display all the configuration categories (Operators, Schedule, Event, Reporting and Roles).

D. 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:

1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include aerial building/campus views, color building floor-plans, equipment drawings, active graphic set point controls, web content and other valid HTML elements. The data on each graphic page shall automatically refresh.
2. 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.
3. 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.
4. 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.
5. Schedules: Shall be used to create, modify/edit and view schedules based on the systems hierarchy (using the navigation tree).
6. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.
7. 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.
8. 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, including current parameter values.
9. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

E. High Resolution 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, .png, 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:

1. Display Size: The GUI workstation software shall graphically display in a minimum of 1920 by 1200 pixels 32 bit True Color.
2. General Graphic: General area maps shall show locations of controlled buildings in relation to local landmarks.
3. Color Floor Plans: Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, as selected by Owner.
4. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of 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.
5. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:
   a. Each piece of equipment monitored or controlled including each terminal unit.
   b. Each building.
   c. Each floor and zone controlled.
6. Color Coding for Piping:
   a. Steam Supply: Steel gray with red letters and arrows
   b. Steam Condensate Return: Steel gray with orange letters and arrows
   c. Chilled Water Supply: Royal blue with baby blue letters and arrows
   d. Chilled Water Return: Royal blue with orange letters and arrows
   e. Condenser Supply: Light blue with red letters
   f. Condenser Return: Light blue with orange letters
   g. Hot Water Supply: Red with orange letters and arrows
   h. Hot Water Return: Red with baby blue letters and arrows
   i. Geothermal Supply: Aqua with red arrows
   j. Geothermal Return: Aqua with blue arrows
   k. Dual Temperature Supply: Cyan with Red & royal blue letters/arrows
   l. Dual Temperature Return: Cyan with Orange & light blue letters/arrows
   m. Natural Gas Piping: Safety Yellow
   n. Domestic Water, Cold: Green with light blue letters/arrows
   o. Domestic Water Hot: Green with red letters/arrows

F. 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.

1. 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:
   a. Types of schedule shall be Normal, Holiday or Override.
   b. A specific date.
   c. A range of dates.
   d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).
   e. Wildcard (example, allow combinations like second Tuesday of every month).
2. 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.
3. 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'.
4. 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.
5. 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).
6. 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.

G. 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 are to be set up to not be a nuisance but be instructive and will require tuning based on feedback during the warranty period.
   1. 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.

2. 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.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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 N4 supervisor database.
8. 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.
9. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the N4 supervisor 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:
    a. Print: Alarm information shall be printed to the N4 supervisor's PC or a networked printer.
    b. 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.
    c. 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).
    d. Write Property: The write property reporting action updates a property value

in a hardware module.

e. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.

f. Run External Program: The Run External Program reporting action launches specified program in response to an event.

H. Trends: As system is engineered, all hard-wired 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.

1. 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.
2. Local Trends: Trend data shall be collected locally by Multi-Equipment/Single Equipment general-purpose controllers, and periodically uploaded to the N4 supervisor 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.
3. 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.
4. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.
5. 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.
6. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.
7. 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).
8. Access: The owner will granted permanent full Administrative access to the entire system with no limitations or expiring licenses or renewals required. This access level allows the ability to add and/or delete accounts.

I. Security Access: Systems that Security access from the web browser GUI to N4 supervisor 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:

1. 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.
   a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.

b. Edit Privileges shall comprise: Set point, Tuning and Logic, Manual Override, and Point Assignment Parameters.
c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print and Alarm/Event Maintenance.

2. 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.

2.9 GRAPHICAL PROGRAMMING

A. The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. Any system that does not use a drag and drop method of graphical icon programming shall not be accepted. All systems shall use a GPL method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

B. Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

C. Graphic Sequence: The clarity of the graphic sequence shall be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

D. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software:
1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.
2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.
3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors bid.

4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.
8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
10. Live Graphical Programs: The Graphic Programming software shall support a ' live' mode, where all input/output data, calculated data and set points shall be displayed in a ' live' real-time mode.

2.10 BACNET NETWORK MANAGEMENT

A. Systems requiring the use of third-party BACnet network management tools shall not be accepted.

B. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.

C. The Network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices and to view health and status counters within devices.

D. These tools shall provide the ability to "learn" an existing BACnet network, regardless of what network management tool(s) were used to install the existing network, so that existing BACnet devices and newly added devices are part of a single network management database.

E. The network management database shall be resident in the Network Area Controller (NAC), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times and within the control system shall not be accepted.

PART 3 EXECUTION

3.1 WORK INCLUDED

A. Install the system as specified above and herein, and, along with the other supporting documents attached to and made part of this specification including representative page by page web graphics.

1. Provide a Tier 1 Graphical Interface Package. (Package shall comply will all requirements of the BMS Graphical Standards. See Appendix A.)
2. This package consists of:
    a. Page by Page layouts
    b. Navigation menus.
    c. Control Status for each equipment system
    d. Control Parameters for each equipment systems
    e. Standard trends
    f. Input/Output points listings
    g. Sequence of Operations
    h. Alarms and Analytics

B. Graphics: All local graphics and system access shall be integrated into the existing state rack mounted station located at NCCIW. Operators to this site will have full access, control, programming, graphic capabilities, etc.to modify the system in its entirety from this access.

C. System Graphics: The look, layout and feel of the work station graphics shall to the best degree possible mimic what is provided in the attached Graphics package and therefore part of this specification. This includes the menu and submenu structures reflected therein. However, this is intended as a guideline and not an exact representation of what is needed on each screen. As a minimum:
1. The workstation/graphics shall provide full access via the Niagara platform to all underlying system modules, data, parameters, programming, etc.
    a. The Site Graphic shall consist, as a minimum, of the menu format indicated on both the vertical and horizontal plane. If additional information is available, provide under the appropriate menu selection.
    b. Provide links to the O&M manuals, specifications and drawings as indicated in the graphics package.
    c. All O&M manuals shall be electronically archived, and bookmarked by section and product. Owner shall have the chance to review and request the contractor make final changes to the bookmarks, bookmark structure, and, bookmark names.
2. The system graphics (AHUs, zones, Boiler Plant, etc.) are representative in nature and need to be modified specific to this system.
3. The representative Properties pages and information are a minimum that is to be provided with the ability to manipulate setpoints, limits, calibration, etc. as a minimum and with the appropriate access level.
4. All other data points are to be modifiable from the block programming pages.
5. The contractor is to coordinate with the customer (Electronics Controls Group-ECG) for access privileges. This group and Energy Management (EM)are to be provided the highest level access. There shall be no proprietary data. As a minimum:
    a. Level 10 (highest/Administrator)
        a) Test and balance parameters
        b) Hysteresis
        c) Minimum start and stops

d) Ramp up and ramp downs

b. Sequencing enables shall be at the next highest level.

c. Provide the owner (ECG & EM) Administrator passwords at the initial sit down to discuss the submittals and proposed graphics.

d. The site user shall have a password that allows them to lock valves and dampers, and change room setpoints.

D. Point Names and Name Tagging: Shall be provided as identified in the Input and Output points listed in the design drawings and therefore made part of this specification. All name tagging shall comply with the Haystack protocol.

E. Function Block programming standards:

1. Programming shall only be through Only Function Block programming is permissible for programming.
2. Each "line" of block programming will be numbered to allow easy means of tracking of the logic (like a ladder diagram).
   a. The block programming shall be divided into submodules such as:
      a) Occupancy
      b) Fan Control
      c) Cooling Control
      d) Heating Control
      e) Damper Control
      f) Alarm & Safety
      g) Outside dependencies such as heating and cooling requests
   b. Each submodule shall be clearly identified as to function and the sequence of operation provided as text to simplify referencing between the code and sequence of operation required.
3. Connectors & Tags
   a. Connectors shall have reference "tags" to allow that line of logic/data to support submodule progamming as needed. These tags will be referenced by the ladder line number for easy tracking.
4. PID Loop Control: Control Loops shall be PID loop controls with appropriate PID parameters to reach and maintain setpoint with minimal offset/error.
5. Hysteresis: All thresholds/setpoints shall have hysteresis or dead band values to prevent constant resetting of setpoints up or down.
6. Setpoint Ramp Ups/Downs: All significant changes in setpoint adjustments shall be ramped up/down to prevent wild swings in PID loop controls

F. Reports:

1. Provide a report listing all variables that have been overridden, modules that have failed or are no longer communicating, and equipment that has been commanded on, but status indicates off. Provide a summary and then a detailed list. See below:
   a. # Points overridden: 3
   b. # Modules not communicating: 3 of 13
   c. # of Systems commanded on but status indicates Off
   d. List of a.
   e. List of b.
   f. List of c.

2. Emails are to be sent to designated staff at Central Engineering

G. Trending:
1. "Standing" trends shall be provided as identified in the Graphics Package. These shall be set up "permanently" so the user does not have to create their own trends on the fly. The contractor is to meet with the Energy Manager to determine what will be shown on these standing trends.
2. Provide the ability to enter custom dates to access historic data and provide trends accordingly.
3. If available, provide a sliding bar that allows the user to simply slide the bar like a fast forward or fast reverse to access historic or current trend data.
4. On they fly trend capability shall also be provided. The owner shall be capable of saving these custom trends for future use and not have to reenter point and other relevant information.

H. Alarms: Alarms shall be set up as defined in the Alarms, Analysis and Energy Diagnostics tables. All alarm messages are to be populated as identified in these tables.

I. Initial Meeting:
a. Provide the owner the Administrative passwords and demonstrate the owner has full access to all aspects of the system. (The Owner's Representative in this case will be NC Department of Public Safety Central Engineering representatives intimately familiar with the design guidelines and standards, and, BMS operations. As a minimum this will be either an individual from the Electronics Controls Group Team, Energy Management or both):
b. Describe to the satisfaction of the Owner's Representative the following
a) The owner has full rights and privileges to programming, graphic development, data access, etc.
b) Representative graphics and similarity to the graphics provided as part of this package.
c) Representative graphic programs documented as required above.
d) How the algorithm for Optimal Start and Stop will successfully be accomplished.
e) Representative standard trends as required by the attached graphics package, and how integrated into graphic displays.
f) Point-by-Point test sheets that will be used for each system type.
g) Training to be provided by the contractor and as outlined herein.

J. Mid Meeting: The contractor shall meet with ECG and/or EM as integration begins to ensure the above standards continue to be met.

K. Seasonal Changes: The night setback temperatures and Optimal Start Stop parameters will be reviewed by the contractor during the cooling, and, during the heating season to ensure the HVAC systems can recover in time for Scheduled Occupancy and energy savings can be attained. This will be demonstrated via the Standard Trends. Particular care will be paid to setbacks for the weekend conditions since the HVAC systems could be off for extended periods of time. The contractor is to discuss these changes with ECG or EM before proceeding with the review, and, before making the changes.

L. Weather Conditions: Provide local weather conditions shall be obtained from the most local weather stations including Temperature, Humidity, Dewpoint, and rainfall.

M. Zones shall have their own unitary control module as identified within this document.

N. AHUs will have their own controller.

O. The chiller and boiler plants may utilize one controller equal to the ECB-600 controller and its compatible expansion controllers.

P. BACnet Cards: All data from equipment including but not limited to chillers, boilers, variable speed drives, and package units shall have BACnet cards installed. All data from the BACnet module shall be accessible to the customer from the graphical interface. The contractor is to coordinate with ECG or EM to discuss how the presentation of this information via the graphical interface.

Q. Analytics: As an alternate, provide the analytics as identified within the specification package.

3.2 Balance

A. The VAV TCU shall also provide an air flow balancing tool.

B. This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, and close all VAV dampers.

C. Systems not able to provide a web based air balance tool or a portable air flow balancing interface or an Intelligent Space Sensor (ISS) capable of balancing air flow as part of the VAV TCU controller shall provide an individual full time technician during the air flow balancing process to assure full balance compliance.

3.3 Control contractor shall provide a local computer to record trends and store graphics not stored on the Jace. Contractor to run Ethernet cable in conduit to location of owner”s internet access for final termination by owner.

3.4 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.5 GENERAL

A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.

B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.

C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.

D. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

E. Location of controllers to be approved by Owner prior to installation.

3.6 WIRING

A. All control wiring to the control panels shall be the responsibility of the Control System Contractor. 120 VAC wiring to control panels shall be provided by Control Contractor from nearest panel with spare capacity unless otherwise noted to be by Electrical Contractor. 120 VAC surge protector to be provided and installed by Control System Contractor.

B. All wiring shall be in accordance with the Project Electrical Specifications (Division 26), the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways. All conduit installed by controls contractor shall be blue.

C. Excess wire shall not be looped or coiled in the controller cabinet.

D. All wires shall be labeled on each end with professional labeling system using label printer Brady Model BMP41 or equivalent using labels designed for wire marking. Labels shall indicate connection point on each end of wire.

E. Incorporate electrical noise suppression techniques in relay control circuits.

F. There shall be no drilling on the controller cabinet after the controls are mounted inside.

G. Careful stripping of wire while inside the cabinet is required to ensure that no wire strand fragments land on circuit boards.

H. Use manufacturer-specified wire for all network connections. LON network cable jacket shall be blue. Network cable for integration of RS-485 BACnet or Modbus devices shall have an orange jacket.

I. All Input/Output cable shall have a yellow jacket. All output wiring shall be 18 gauge, minimum. All input wiring shall be 22 gauge minimum.

J. Use approved optical isolation, fiber optic converters, and lightning protection when penetrating building envelope.

K. Read installation instructions carefully. Any unavoidable deviations shall be approved by owner's rep prior to installation.

3.7 ACCEPTANCE TESTING

A. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all

necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.

B. The Control System Contractor shall perform tests to verify proper performance of components, routines and points. Repeat tests until proper performance results are achieved. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation. Sample Point-by-point test sheets to be provided at the 45 day meeting. Completed pages shall be sent to the owner as they are completed. Specifically:
   1. Provide a point by point test. That ensures the following occurs. Means and methods will be by the contractor for confirmation of the following:
      a. Disconnect or short sensor as appropriate. Observe failure. Document alarm condition. Document reading on HVAC System Graphic, and, Properties page. Confirm failure mode. Upon sensor reaching status, calibrate.
   2. Logic testing: Describe the logic to be tested and the desired outcome. Confirm operation.

C. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

D. Perform commissioning test where required.

3.8 OPERATOR TRAINING

A. During system commissioning and at such time acceptable performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.

B. The Control System Contractor shall provide 8 total hours of training in two 4-hour sessions for system orientation, product maintenance and troubleshooting, programming and engineering. These classes are to be spread out during the 1st year warranty period. The first class starting after final commissioning and the second class is to be in the last month of 1-year warranty period.

C. Training shall be hands on and not the operator sitting in front of the computer while the trainee observes from behind. As a minimum:
   1. Trainee shall successfully and independently perform a point by point testing for at least two (2) of each type of points in the system.
   2. Trainee shall successfully demonstrate the ability to enter a schedule for a zone, and a group of zones at least three times.
   3. Trainee shall successfully be able to discuss how optimal start/stop works, night setback, hot and chilled water reset. They will also demonstrate an understanding of how the building envelope and its dynamics will impact optimal start/stop, and

night setback limits.

4. Contractor will create at least four scenarios where the HVAC system fails to work properly, and the trainee successfully tracks down the issue. As a minimum include:
   a. A Valve or control point locked on.
   b. A failed sensor.
   c. Heating system failure
   d. Cooling system failure.

D. Control System Contractor shall select the DDC controller platform currently used by NCDPS and with NCDPS Central Engineering Electronics Group having technical personnel certified on the selected platform. Control System Contractor will be required to provide manufacture certified training to 4 NCDPS employees if no employees are currently certified on the selected platform for this job.

3.9 WARRANTY PERIOD SERVICES

A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of two years from the time of system acceptance (not startup).

B. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner.

C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the standard first year warranty period. In addition, all factory or sub-vendor upgrades to software during the first year warranty period shall be added to the systems, when they become available, at no additional cost. In addition to first year standard warranty, software provided by Control System Contractor shall come with a Software Maintenance Agreement as defined in section 1.3. All NAC and N4 supervisors are included in this coverage.

D. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all hardware is functioning correctly.

E. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.

F. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.

3.10 WARRANTY ACCESS

A. The Owner shall grant to the Control System Contractor reasonable access to the BMS during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

3.11 OPERATION & MAINTENANCE MANUALS

A. See Division 1 for requirements. O&M manuals shall include the following elements, as a minimum and include all requirements as identified in Section 1.6 Submittals:

B. As a minimum, shop drawings shall contain:
1. A table of contents.
2. Equipment schedules.
3. Valve and damper schedules when applicable. Valve schedules shall include GPM, valve size, calculated Cv, valve Cv, pressure drop, close-off pressure, configuration (2-way or 3-way), and valve actuator data.
4. VAV box schedule. VAV box schedule shall include box size, K-Factor, and flow setpoints.
5. As-built schematic diagrams of all controlled equipment.
6. Final sequences of operation for all controlled equipment.
7. As-built controller wiring diagrams, including terminal number identification for all control wiring.
8. As-built wiring details for all field devices.
9. As-built network architecture diagram showing a high-level overview of the installed system.
10. As-built control system bus layout depicted on building floorplans.
11. As-built control panel layout diagrams depicting all panel mounted components.
12. Completed Performance Verification sheets.
13. Completed Controller Checkout/Calibration Sheets.
14. Manufacturer’s data sheets for all installed components.

3.12 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION