*Exhibit "A" Scope of Services*
*Air Conditioning Control System Replacement for*
*Florida Department of Transportation*
*District Four, West Palm Beach Operation Center*

## 1.0 SUMMARY

District Four, Palm Beach Operation Center, needs services to remove and replace the existing Control System for the Air Conditioning (AC) units located at the Administration Building #4412. The type of proposed units will need to be compatible and energy efficient with the AC System.

The existing AC System consists of five Roof Top Units (RTU) with various ages on each unit. The exchange air is returned through an open plenum system. There's been recent repairs to bypass dampers, central control panels and ductwork. The AC System uses Tracer Summit to regulate the HVAC controls and is considered outdated.

## 2.0 SCHEDULE WORK HOURS

2.1    Working hours will be between 7:30 AM – 5:00 PM, Monday through Friday, except for Holidays. Work shall not interfere with the Department's normal day to day operations; any and all exceptions to this shall require written pre-approval by the Project Coordinator.

## 3.0 VENDOR RESPONSIBILITES

1.    **System Description:**

3.1.1    The Vendor will 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 an open protocol bus (Examples: LonTalk, BACnet, MODBUS).

- 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.

- System layout 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.

- System layout 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.

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

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

- The BMS server shall host all graphic files for the control system. All graphics and navigation schemes for this project shall match those that are on the existing campus NiagaraAX or Niagara 4 Framework server.

- A laptop computer including programming software to modify Operating System Server BMS programs and graphics shall be included.

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

- All JACE hardware licenses and certificates shall be stored on local MicroSD memory card employing encrypted "safe boot" technology.

3.1.2   Terminal identification for all control wiring shall be shown on the drawings.

3.1.3   Upon completion of the work, provide a complete sets of one line drawings and other project-specific documentation in 3-ring hard-backed binders and on Flash media.

3.1.4   Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

## 3.2   *QUALITY ASSURANCE*

3.2.1   The Control System Vendor shall have a full service DDC office within 50 miles of the job site. This office shall maintain parts inventory and shall have all testing and diagnostic equipment necessary to support this work, as well as staff trained in the use of this equipment.

3.2.2   The Control System Vendor shall be responsible for the complete installation and proper operation of the control system. The Control System Vendor 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 Vendor be the manufacturer of the primary DDC system components or shall have been the authorized representative for the primary DDC components manufacturer for at least 5 years. All control panels shall be assembled by the Control System Vendor in a UL-Certified 508A panel shop.

3.2.3   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.

## 3.3   *GENERAL*

3.3.1   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.

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

*3.4*   **_OPEN, INTEROPERABLE, INTEGRATED LAYOUT:_**

3.4.1   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.

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

3.4.3   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.

3.4.4   The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs or browser plug-ins. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on the Operating System Server located in the Facilities Office on the LAN. Systems requiring proprietary database and user interface programs shall not be acceptable.

3.4.5   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 layout shall not be acceptable.

*3.5*   **_BAS SERVER HARDWARE:_**

3.5.1   Minimum Computer Configuration (Hardware Independent).

- Central Server. Owner shall provide a dedicated BAS server with configuration that includes the following components as a minimum:
- Processor: Intel Xeon CPU E5-2640 x64 (or better), compatible with dual- and quad-core processors.
- Memory: 2 GB or more recommended for large systems, 8 GB or more recommended for the Windows 64-bit version.
- Hard Drive: 4 GB minimum, more recommended depending on archiving requirements.
- Display: Video card and monitor capable of displaying 1024 x 768 pixel resolution or greater.
- Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector).
- Connectivity: Full-time high-speed ISP connection recommended for remote site access (i.e. T1, ADSL, cable modem).

3.5.2   Standard Client: The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer (10.0 or later) running on Microsoft 7+. No special software shall be required to be installed on the PCs used to access the BAS via a web browser.

*3.6*    **SYSTEM NETWORK CONTROLLER (SNC):**

3.6.1    These controllers are designed to manage communications between the programmable equipment controllers (PEC), application specific controllers (ASC) and advanced unitary controllers (AUC) which are connected to its communications trunks, manage communications between itself and other system network controllers (SNC) 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.

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

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

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

3.6.5    The SNC shall employ a device count capacity license model that supports expansion capabilities.

3.6.6    The SNC shall be enabled to support and shall be licensed with the following Open protocol drivers (client and server) by default:
- BACnet
- Lon
- MODBUS
- SNMP
- KNX


3.6.7    The SNC shall be capable of executing application control programs to provide:
- Calendar functions.
- Scheduling.
- Trending.
- Alarm monitoring and routing.
- Time synchronization.
- Integration of LonWorks, BACnet, and MODBUS controller data.
- Network management functions for all SNC, PEC and ASC based devices.


3.6.8    The SNC shall provide the following hardware features as a minimum:
- Two 10/100 Mbps Ethernet ports.
- Two Isolated RS-485 ports with biasing switches.
- 1 GB RAM
- 4 GB Flash Total Storage / 2 GB User Storage
- Wi-Fi (Client or WAP)
- USB Flash Drive
- High Speed Field Bus Expansion

- -20-60°C Ambient Operating Temperature
- Integrated 24 VAC/DC Global Power Supply
- MicroSD Memory Card Employing Encrypted Safe Boot Technology

3.6.9 The SNC shall support standard Web browser access via the Intranet/Internet.

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

3.6.11 The SNC 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.

3.6.12 Programming software and all controller "Setup Wizards" shall be embedded into the SNC.

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

3.6.14 The SNC shall be provided with a 5 Year Software Maintenance license.

3.6.15 Please review specifications provided as attachments to this scope:
- Exhibit 1 - AC Load Calculations
- Exhibit 2 - Carrier RTU Equipment Selections
- Exhibit 3 - York RTU Equipment Selections
- Exhibit 4 - Johnson Controls Automation
- Exhibit 5 - Zone Damper Controls Diagram
- Exhibit 6A-6B – AC Zoning Layout West & East
- Exhibit 7A-7B – Roof Layout West & East
- Exhibit 8 - Louvered Face Ceiling Diffuer
- Attachment 1- HVAC Investigation Report

## *3.7* *PROGRAMMABLE EQUIPMENT CONTROLLER (PEC)*

3.7.1 HVAC control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device. The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

3.7.2 All PECs 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.

3.7.3    The PEC shall provide LED indication of communication and controller performance to the technician, without cover removal.

3.7.4    The PEC shall not require any external configuration tool or programming tool. All configuration and programming tasks shall be accomplished and accessible from within the Niagara 4 environment.

3.7.5    The following integral and remote Inputs/Outputs shall be supported per each PEC:

- Eight integral dry contact digital inputs.
- Any two digital inputs may be configured as pulse counters with a maximum pulse read rate of 15 Hz.
- Eight integral analog inputs (configurable as 0-10V, 0-10,000 ohm or, 20K NTC).
- Six integral 4-20 ma analog outputs.
- Eight integral 24 Vac Triac digital outputs, configurable as maintained or floating motor control outputs.
- One integral 20 Vdc, 65-mA power supply for auxiliary devices.
- If a 20 Vdc 65-mA power supply terminal is not integral to the PEC, provide at each PEC a separate, fully isolated, enclosed, current limited and regulated UL listed auxiliary power supply for power to auxiliary devices.

3.7.6    Each PEC shall have expansion ability to support additional I/O requirements through the use of remote input/output modules.

## 3.8    ADVANCED UNITARY CONTROLLER (AUC):

3.8.1    The advanced unitary controller (AUC) platform shall be designed specifically to control HVAC - ventilation, filtration, heating, cooling, humidification, and distribution. Equipment includes: constant volume air handlers, VAV air handlers, packaged RTU, heat pumps, unit vents, fan coils, natural convection units and radiant panels. The control shall use LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS defined.

Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device.

The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

3.8.2    **Minimum Requirements**:

3.8.2.1 The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.

- Support downloads to the controller from any brand of Niagara 4 platform.
- Support uploads from the controller to any brand of Niagara 4 platform.
- Support simulation/debug mode of the controller.
- Maintain native GUI.
- Native function-block programming software and all controller "Setup Wizards" shall be embedded within the Niagara 4 environment.

3.8.2.2 The controller shall be capable of either integrating with other devices or stand-alone operation.

3.8.2.3 The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application.

3.8.2.4 The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.

3.8.2.5 The controller shall have Significant Event Notification, Periodic Update capability, and Failure Detect when network inputs fail to be detected within their configurable time frame.

3.8.2.6 The controller shall have an internal DC power supply to power external sensors.

3.8.2.7 The minimum controller Environmental ratings.

- Operating Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C).
- Storage Temperature Ambient Rating: -40 degrees to 150 degrees F (-40 degrees to 65.5 degrees C).
- Relative Humidity: 5% to 95% non-condensing.

3.8.2.8 The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).

3.8.2.9 The controller shall have a mix of digital inputs (DI), digital Triac outputs (DO), analog outputs (AO), and universal inputs (UI).

- Analog outputs (AO) shall be capable of being configured as digital outputs (DO).
- Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.
- Input and Output wiring terminals shall be designated with color coded labels.
- Universal inputs shall be capable of being configured as binary inputs, resistive inputs, voltage inputs (0-10 VDC), or current inputs (4-20 mA).

3.8.2.10 The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.

*3.9*   ***ADVANCED VARIABLE AIR VOLUME CONTROLLER (AVAV):***

3.9.1   The advanced 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.

Control shall be accomplished using LonMark or BACnet based devices where the application has a LonMark profile or BTL Listed PICS defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. For each LonWorks device that does not have LonMark certification, the device supplier shall provide an XIF file for the device.

The controller platform shall provide options and advanced system functions, programmable and configurable using Niagara 4 Framework, that allow standard and customizable control solutions required in executing the "Sequence of Operation".

**3.9.2**   **Minimum Requirements:**

3.9.2.1 The controller shall be fully programmable with full functionality on any Niagara 4 brand platform.

- Support downloads to the controller from any brand of Niagara 4 platform.
- Support uploads from the controller to any brand of Niagara 4 platform.
- Support simulation/debug mode of the controller.
- Maintain native GUI.
- Native function-block programming embedded software and all controller "Setup Wizards" shall be embedded within the Niagara 4 environment.

3.9.2.2 The controller shall be capable of either integrating with other devices or stand-alone room-level control operation.

3.9.2.3 The controller shall have an internal velocity pressure sensor.

- Sensor Type: Microbridge air flow sensor with dual integral restrictors.
- Operating Range: 0 to 1.5 inch H2O (0 to 374 Pa).
- Accuracy: ±2% of full scale at 32 degrees to 122 degrees F (0 degrees to 50 degrees C); ±1% of full scale at null pressure.

3.9.2.4 The controller shall have two microprocessors. The Host processor contains on-chip FLASH program memory, FLASH information memory, and RAM to run the main HVAC application. The second processor for network communications.

- FLASH Memory Capacity: 60 Kilobytes with 8 Kilobytes for application program.
- FLASH Memory settings retained for ten years.
- RAM: 2 Kilobytes.

3.9.2.5 The controller shall have an internal time clock with the ability to automatically revert from a master time clock on failure.

3.9.2.6 The controller shall have Significant Event Notification, Periodic Update capability and Failure Detect when network inputs fail to be detected within their configurable time frame.

3.9.2.7 The controller shall have an internal DC power supply to power external sensors.

   3.9.2.7.1   Power Output: 20 VDC ±10% at 75 mA.

3.9.2.8 The controller shall have a visual indication (LED) of the status of the devise:

3.9.2.9 The minimum controller Environmental ratings:

- Operating Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C).

- Storage Temperature Ambient Rating: 32 degrees to 122 degrees F (0 degrees to 50 degrees C).
- Relative Humidity: 5% to 95% non-condensing.

3.9.2.10        The controller shall have the additional approval requirements, listings, and approvals:

   3.9.2.10.1 UL/cUL (E87741) listed under UL916 (Standard for Open Energy Management Equipment) with plenum rating.

   3.9.2.10.2 CSA (LR95329-3) Listed.

   3.9.2.10.3 Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.

3.9.2.11        The controller housing shall be UL plenum rated mounting to either a panel or DIN rail (standard EN50022; 7.5mm x 35mm).

3.9.2.12        The controller shall provide an integrated actuator option.

   3.9.2.12.1 Actuator type: Series Floating.

   3.9.2.12.2 Rotation stroke: 95 degrees ±3 degrees for CW or CCW opening dampers.

   3.9.2.12.3 Torque rating: 44 lb-inch (5 Nm).

   3.9.2.12.4 Run time for 90 degrees rotation: 90 seconds at 60 Hz.

3.9.2.13        The controller shall have digital inputs (DI), digital Triac outputs (DO), three analog outputs (AO), and universal inputs (UI).

   3.9.2.13.1 Analog outputs (AO) shall be capable of being configured as digital outputs (DO).

3.9.2.13.2 Input and Output wiring terminal strips shall be removable from the controller without disconnecting wiring.

3.9.2.13.3 Input and Output wiring terminals shall be designated with color coded labels.

3.9.2.14 The controller shall provide "continuous" automated loop tuning with an Adaptive Integral Algorithm Control Loop.

3.9.2.15 The controller shall have a loop execution response time of 1 second.

## 3.10   **OTHER CONTROL SYSTEM HARDWARE**

3.10.1 Motorized control dampers that will not be integral to the equipment shall be furnished by the Control System Contractor. Control damper frames shall be constructed of galvanized steel, formed into changes and welded or riveted.

Dampers shall be galvanized, with nylon bearings. Blade edge seals shall be vinyl. Blade edge and tip seals shall be included for all dampers. Blades shall be 16-gauge minimum and 6 inches wide maximum and frame shall be of welded channel iron. Damper leakage shall not exceed 10 CFM per square foot, at 1.5 inches water gauge static pressure.

3.10.2 Control damper actuators shall be furnished by the Control System Contractor. Two-position or proportional electric actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Damper actuators shall be spring return type. Operators shall be heavy-duty electronic type for positioning automatic dampers in response to a control signal. Motor shall be of sufficient size to operate damper positively and smoothly to obtain correct sequence as indicated. All applications requiring proportional operation shall utilize truly proportional electric actuators.

3.10.3 Control Valves: Control valves shall be 2-way or 3-way pattern as shown and constructed for tight shutoff at the pump shut-off head or steam relief valve pressure. Control valves shall operate satisfactorily against system pressures and differentials. Two-position valves shall be ' line' size. Proportional control valves shall be sized for a maximum pressure drop of 5.0 psi at rated flow (unless otherwise noted or scheduled on the drawings). Valves with sizes up to and including 2 inches (51 mm) shall be "screwed" configuration and 2-1/2 inches (63.5 mm) and larger valves shall be "flanged" configuration. All control valves, including terminal unit valves, less than 2 inches (51 mm) shall be globe valves. Electrically-actuated control valves shall include spring return type actuators sized for tight shut-off against system pressures (as specified above) and, when specified, shall be furnished with integral switches for indication of valve position (open-closed). Pneumatic actuators for valves, when utilized, shall be sized for tight shut-off against system pressures (as specified above).

3.10.4 Control Valve Actuators: Actuators for VAV terminal unit heating coils shall be "drive-open; drive-closed" type. All actuators shall have inherent current limiting motor protection. Valve actuators shall be 24-volt, electronic type, modulating or two-position as required for the correct operating sequence. Actuators on valves needing ' fail-safe' operation shall have spring return to Normal position. Modulating valves shall be positive positioning in response to the signal. All valve actuators shall be UL listed.

3.10.5 All control valves 2-1/2 inches (63.5 mm) or larger shall have position indication. All hot water control valves shall be Normally-Open arrangement; all chilled water control valves shall be Normally-Closed arrangement.

3.10.6 Wall Mount Room Temperature sensors: Each room temperature sensor shall provide temperature indication to the digital controller, provide the capability for a software-limited occupant set point adjustment (warmer-cooler slider bar or switch) and limited operation override capability.

Room Temperature Sensors shall be 20,000-ohm thermistor type with a temperature range of -40 to 140 degrees F (-38 to 60 degrees C). The sensor shall be complete with a decorative cover and suitable for mounting over a standard electrical utility box. These devices shall have an accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

3.10.7 Duct-mounted and Outside Air Temperature Sensors: 20,000-ohm thermistor temperature sensors with an accuracy of $\pm$; 0.2 degrees C. Outside air sensors shall include an integral sun shield. Duct-mounted sensors shall have an insertion measuring probe of a length appropriate for the duct size, with a temperature range of -40 to 160 degrees F(-38 to 71 degrees C) The sensor shall include a utility box and a gasket to prevent air leakage and vibration noise. For all mixed air and preheat air applications, install bendable averaging duct sensors with a minimum 8 feet (2438 mm) long sensor element. These devices shall have accuracy of 0.5 degrees F (.024 degrees C) over the entire range.

3.10.8 Humidity sensors shall be thin-film capacitive type sensor with on-board nonvolatile memory, accuracy to plus or minus two percent (2%) at 0 to 90% RH, 12 - 30 VDC input voltage, analog output (0 - 10 VDC or 4 - 20mA output). Operating range shall be 0 to 100% RH and 32 to 140 degrees F (0 to 60 degrees C). Sensors shall be selected for wall, duct or outdoor type installation as appropriate.

3.10.9 Carbon Dioxide Sensors (CO2): Sensors shall utilize Non-dispersive infrared technology (N.D.I.R.), repeatable to plus or minus 20 PPM. Sensor range shall be 0 - 2000 PPM. Accuracy shall be plus or minus five percent (5%) or 75 PPM, whichever is greater. Response shall be less than one minute. Input voltage shall be 20 to 30 VAC or DC. Output shall be 0 - 10 VDC. Sensor shall be wall or duct mounted type, as appropriate for the application, housed in a high impact plastic enclosure.

3.10.10 Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.

3.10.11      Differential Analog (duct) Static Pressure Transmitters Provide a pressure transmitter with integral capacitance type sensing and solid-state circuitry. Accuracy shall be plus or minus 1% of full range; range shall be selected for the specific application. Provide zero and span adjustment capability. Device shall have integral static pickup tube.

3.10.12      Differential Air Pressure Switches: Provide SPDT type, UL-approved, and selected for the appropriate operating range where applied. Switches shall have adjustable set points and barbed pressure tips.

3.10.13      Water Flow Switches: Provide a SPST type contact switch with bronze paddle blade, sized for the actual pipe size at the location. If installed outdoors, provide a NEMA-4 enclosure. Flow switch shall be UL listed.

3.10.14      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.

3.10.15      Pipe and Duct Temperature sensing elements: 20,000-ohm thermistor temperature sensors with and accuracy of ±1% accuracy. Their range shall be -5 to 250 degrees F (-20 to 121 degrees C). Limited range sensors shall be acceptable provided they are capable of sensing the range expected for the point at the specified accuracy. Thermal wells with heat conductive gel shall be included.

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

3.10.17      Variable Frequency Drives: The variable frequency drive (VFD) shall be designed specifically for use in Heating, Ventilation, and Air Conditioning (HVAC) applications in which speed control of the motor can be applied.  The VFD, including all factory installed options, shall have UL & CSA approval. VFD's shall include communications capability with DDC BMS via built-in interface card (MODBUS or BACnet). Honeywell SmartVFD is basis of design.

3.10.18      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.

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

3.10.20      Transducers: Differential pressure transducers shall be electronic with a 4-20 mA output signal compatible to the Direct Digital Controller. Wetted parts shall be stainless steel. Unit shall be designed to operate in the pressure ranges involved.

3.10.21    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.

3.10.22    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.

## 3.11    BAS SERVER & WEB BROWSER GUI - SYSTEM OVERVIEW

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

3.11.2    The intent of the thin-client layout 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.

3.11.3    The BAS server software shall support at least the following server platforms (Windows 7, 8.1, Server 12). The BAS server software shall be developed and tested by the manufacturer of the system stand-alone controllers and network controllers/routers.

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

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

3.11.6    Thin Client - Web Browser Based: The GUI shall be thin client or browser based and shall meet the following criteria:
- Web Browser's for PC's: Only the current released browser (Explorer/Firefox/Chrome) will be required as the GUI and a valid connection to the server network. No installation of any custom software shall be required on the operator's GUI workstation/client. Connection shall be over an intranet or the Internet.

- Secure Socket Layers: Communication between the Web Browser GUI and BAS server shall offer encryption using 128-bit encryption technology within Secure Socket Layers (SSL). Communication protocol shall be Hyper-Text Transfer Protocol (HTTP).

## 3.12   WEB BROWSER GRAPHICAL USER INTERFACE:

3.12.1  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 operates 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.

3.12.2  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.

3.12.3  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.

3.12.4  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.

3.12.5  Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Strong Password. Access to different areas of the BAS system shall be defined in terms of Role-Based Access Control privileges.
- Geographic Assignment of Roles: Roles shall be geographically assigned using a similar expandable/collapsible navigation tree.

## 3.13   GRAPHICAL PROGRAMMING:

3.13.1  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.

## 3.14   LONWORKS NETWORK MANAGEMENT:

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

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

3.14.3  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.

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

3.14.5  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.

## 4.0  *THE VENDOR WILL:*

### 4.1  **GENERAL:**

4.1.1  Install system and materials in accordance with manufacturer's instructions.

4.1.2  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.

4.1.3  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 Vendor.

4.1.4  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.

### 4.2  **WIRING:**

4.2.1  All electrical control wiring to the control panels shall be the responsibility of the Control System Vendor.

4.2.2  All wiring shall be in accordance the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways.

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

4.2.4  Incorporate electrical noise suppression techniques in relay control circuits.

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

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

4.2.7  Use manufacturer-specified wire for all network connections.

4.2.8  Use approved optical isolation and lightning protection when penetrating building envelope.

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

## 4.3    ACCEPTANCE TESTING:

4.3.1    Upon completion of the installation, the Control System Vendor 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.

4.3.2    The Control System Contractor shall perform tests to verify proper performance of components, routines and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

4.3.3    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.

## 4.4    OPERATOR TRAINING:

4.4.1    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.

4.4.2    The Control System Vendor shall provide 48 total hours of comprehensive training in multiple sessions for system orientation, product maintenance and troubleshooting, programming. These classes are to be spread out during the 1st year warranty period. The first class starting after final commissioning and the last class is to be in the last month of 1-year warranty period.

## 4.5    WARRANTY PERIOD:

4.5.1    Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.

4.5.2    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.

4.5.3    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 5 Year Software Maintenance license. All SNC and BAS Servers are included in this coverage. Labor to implement upgrades in years two through five are not included in standard warranty.

4.5.4   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.

4.6   **OPERATION & MAINTENANCE MANUALS:**

4.6.1   O&M manuals shall include the following elements, as a minimum:

- As-built control drawings for all equipment.
- As-built Network Communications Diagram.
- General description and specifications for all components.
- Completed Performance Verification sheets.
- Completed Controller Checkout/Calibration Sheets.