SECTION 230923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC – BID ADDENDUM 1

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

1.2 RELATED WORK SPECIFIED ELSEWHERE

Mechanical Division 23
230993 - Sequence of Operations for HVAC Controls
Electrical Division 26

1.3 SCOPE OF WORK

A. Furnish all labor, materials, tools, equipment, and services for a fully integrated and networked energy management control system (EMS) as indicated, in accordance with provisions of contract documents.

B. The EMS shall be an extension of the existing district-wide Energy Management System.

C. Interface to the EMS shall be via the Owner's existing operator workstation and existing web browser interface. All existing and new functions shall be accessible via the local network and the internet.

D. Provide system graphics for all controlled equipment, each controlled device and floor plan and integrated system. New graphics layout and appearance shall match Owner's existing EMS system graphics. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the EMS.

E. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intents of this specification, shall be included in Contractor's bid and provided without additional cost to the Owner.

F. A post-bid interview and technical review with the Owner and the Engineer may be required prior to contract award. During this interview the contractor will be

required to demonstrate that their proposed solution and specific plan regarding the integration of their controllers with the Owner's Operator Workstation and existing control system and network fulfills the contract requirements to the satisfaction of the Owner.

1.4 QUALITY ASSURANCE

A. The EMS shall be installed by competent mechanics and checked out by competent technicians regularly employed by the manufacturer of the equipment or licensed franchises authorized by the manufacturer.

B. Single source responsibility shall include installation, calibration, and check-out of the stand-alone systems and network.

C. The EMS installer shall have an in-place, local support facility with technical staff, spare parts inventory, and all necessary test diagnostic equipment.

1.5 REFERENCED STANDARDS, CODES AND ORDINANCES

A. The latest issue of applicable standards and recommended practices of the following agencies in effect shall form a part of the specification to the extent each agency s relative standards or recommended practices apply to the Systems and its components as specified herein.

1. Federal Communications Commission (FCC)
2. American National Standards Institute (ANSI)
3. American Society of Mechanical Engineers (ASME)
4. Electronic Industries Association (EIA)
5. Institute of Electrical and Electronics Engineers (IEEE)
6. National Electrical Manufacturers Association (NEMA)
7. National Fire Protection Association (NFPA)
8. Underwriters Laboratories (UL)
9. Occupational Safety and Health Administration (OSHA)
10. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

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

1.6 SUBMITTALS & OPERATION AND MAINTENANCE MANUALS

A. Provide eight (8) copies of shop drawings of the entire control system and submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. Control shop drawings shall be on 11"x17" paper and shall contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system.

B. All control system components shall be shown on control shop drawings and shall be identified in respective shop drawing bill of material. Bills of material shall include brief description of each system component, component part number and component device tag.

C. Over- and under-voltage protection apparatus for all system controllers as specified in Power Supplies and Power Conditioning later in this document shall be shown on the control shop drawings and identified in the bills of material.

D. Wiring diagrams and layouts for each control panel and terminal identification for all control wiring shall be shown on the control shop drawings.

E. A complete written Sequence of Operation and input/output points list of all points connected to the DDC system shall be included for each piece of controlled equipment. This information shall be located on the associated system control shop drawing or on the page immediately following if the information will not fit on the system drawing.

F. Label control shop drawings and title blocks descriptive of controlled equipment shown on the shop drawing. Do not label shop drawings to match mechanical drawing numbers.

G. Clearly reference covered specification and drawing on each submittal. Product submittals shall consist of a complete list of equipment and materials, including manufacturer's catalog data sheets and installation instructions. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate specific data for the product being submitted by highlighting or by other means. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work.

H. Product submittals shall include manufacturer's product data and specifications for any Operator Workstation; Web browser user interface server or workstation

and software; portable operator's terminal; uninterruptible power supply; printer; and networking equipment provided as part of the EMS.

I. Submittal shall include a system schematic riser diagram depicting the building OWS; printers; browser user interface computers / peripherals; Network Area Controllers (NAC); standalone EMS controllers, 3rd party controllers; and the networking equipment required to make a complete and functional system.

J. Upon completion of the work, provide three (3) hardcopy sets of Operation and Maintenance Manuals to the Owner's representative. The entire Operation and Maintenance Manual shall also be furnished on compact disk media. The manuals shall include the following for the EMS provided:

1. Table of contents.
2. As-built system record drawings. Computer Aided Drawings (AutoCAD 2006 or newer) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.
3. As-built versions of manufacturers' product data sheets for all products including software.
4. System Operator's manuals with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
5. Licenses, guarantees and warranty documents for equipment and systems.
6. EMS network diagrams.
7. Wiring termination schedules.
8. Interfaces to all third-party products and work by other trades.
9. List of recommended spare parts with part numbers and suppliers.
10. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning and calibration; time between tasks; and task descriptions.

K. As-built software documentation shall be provided on a CD and include the following:

1. Descriptive point lists.
2. Application program listing.
3. Application programs with comments.
4. Printouts of all reports.
5. Alarm list.
6. Printouts of all graphics.

L. The Operation and Maintenance Manual CD shall be self-contained and include all necessary software required to access the project record drawings, data sheets, spare parts list and maintenance procedures. A logically organized table of contents shall provide dynamic links to view and print all project record drawings and product data sheets. Viewer software shall provide the ability to display, zoom and search all documents.

M. On-line Documentation: After completion of all the tests and adjustments listed above, the contractor shall install the following information on the EMS:

1. "AS-BUILT" drawing files
2. Detailed catalog data on all installed system components
3. Address and phone number of factory repair service contact

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner. Spare parts shall be available for at least five years after completion of this contract.

2.2 ACCEPTABLE SUPPLIERS/MANUFACTURERS:

Schneider Electric / Andover (Day Automation) – Secondary Schools
Honeywell – Elementary Schools

2.3 POWER FAIL / AUTO RESTART

A. Provide for the automatic orderly and predefined shutdown of parts of or the entire EMS following total loss of power to parts of or the entire EMS.

B. Provide for the automatic orderly and predefined startup of parts of or the entire EMS following re-establishing of power to parts of or the entire EMS.

C. Maintain the EMS real-time clock operation during periods of power outage for a minimum of 72 hours.

D. Refer to additional Power Fail / Auto Restart requirements in the Sequence of Operation section.

2.4 POWER SUPPLIES & POWER CONDITIONING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

C. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

D. Line voltage units shall be UL recognized and CSA listed.

E. All system controllers, with the exception of the room VAV box controllers, shall be provided with power conditioning, over-voltage and under-voltage protection. Under-voltage protection shall be provided by voltage sensing relays (refer to HVAC field devices) or an uninterruptible power supply sized appropriately by EMS contractor for its protected controllers.

2.5 HVAC FIELD DEVICES:

A. Motorized Control Dampers provided by EMS contractor unless otherwise noted. Refer to section 230910 for specifications.

B. Control Damper Actuators: Spring-return actuators installed for fail-safe action are required for all dampers. Unless otherwise specified in the Sequence of Operation or on the drawings, dampers utilized in outside, relief and exhaust air applications shall be fail-safe closed; dampers utilized in return air applications shall be fail-safe open; combustion air dampers and emergency generator intake and exhaust air dampers shall be fail-safe open. Actuators shall be electric/electronic sized to match the application with adequate power to operate smoothly and provide tight close-off. Two-position or proportional electric/electronic actuators shall be direct-mount type sized to provide a minimum of 5 in-lb torque per square foot of damper area. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator's rotation. Actuators shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS). Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for

proportional actuators in terminal unit applications.) 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring. Operators shall be able to manually position each actuator when the actuator is not powered. Spring-return actuators with more than 60 in.-lb torque capacity shall have a manual crank. Provide one actuator per damper section at a minimum. EMS contractor shall provide all damper actuators unless otherwise specified elsewhere. Low voltage and line voltage wiring to actuators is considered control wiring and shall be provided by the EMS contractor.

C. Control Valves: Spring-return, fail-open action is required for all heating and cooling coil control valves on any equipment that has an outside air source unless otherwise specified in the Sequence of Operation. Select body and trim materials in accordance with manufacturer's recommendations for design conditions and service shown. Water service control valves shall be 2-way or 3-way pattern as specified or shown on the drawings and shall provide tight shutoff against system design pressures and differentials (150% of total pump head for 2-way valves and 100% for 3-way valves). Two-position valves shall be >line= size. Proportional control valves for water service shall be sized for a maximum pressure drop of 3.0 psi at rated flow (except as may be noted on the drawings). Proportional control valves for steam service shall be sized as appropriate for the application and the inlet steam pressure. Valves providing modulating service shall have equal percentage ports. Valves with sizes up to and including 2 inches shall be Ascrewed@ configuration and 2-1/2 inch and larger valves shall be Aflanged@ configuration. All actuators shall be sized for tight shut-off against system pressures and furnished with integral switches for indication of valve position (open-closed). Electric bi-directional actuators are acceptable on VAV terminal units and room reheat coil valve control. All electric actuators for applications other than VAV terminal units and room reheat coil valve control shall be proportional analog 4-20Ma or 0-10Vdc input. Three-way butterfly valves, when utilized, shall include a separate actuator for each butterfly segment. Low voltage and line voltage wiring to actuators is considered control wiring and shall be provided by the EMS contractor.

D. Wall Mount Room Temperature Sensors: Each room temperature sensor shall provide temperature indication to the digital controller and provide the capability for a software-limited set point adjustment and operation override capability. An integral LCD shall annunciate current room temperature and set point as well as override status indication. In addition, the sensor shall include a port for connection to a portable operators terminal. Sensors shall be mounted at 54 inches AFF unless indicated otherwise on drawings.

E. Duct Mount, Pipe Mount and Outside Air Temperature Sensors: 10,000-ohm thermistor temperature sensors with an accuracy of ∀ 0.21C. or two wire RTD

type with nickel wound elements with a minimum of 1000 ohm reference resistance and a minimum accuracy of +/- 0.5 deg F. Outside air sensors shall include an integral sun shield and be mounted on a northern exposure. Immersion sensors shall be provided with a separable brass or stainless steel well, as required by the application. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.

F. 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.

G. Power Monitoring Interface: The Power Monitoring Interface (PMI) device shall include the appropriate current and potential (voltage) transformers. The PMI shall be certified under UL-3111. The PMI shall perform continuous true RMS measurement based on 32 samples-per-cycle sampling on all voltage and current signals. The PMI shall provide outputs to the EMS based on the measurement and calculation of the following parameters: (a) current for each phase and average of all three phases, (b) kW for each phase and total of all three phases, (c) power factor for each phase and all three phases, (d) percent voltage unbalance and (e) percent current unbalance. These output values shall be hard-wired inputs to the EMS or shall be communicated to the EMS over the open-protocol LAN.

H. Water flow meters shall be single turbine insertion-type with frequency output complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown. Accuracy shall be ▪ ± 0.5% of reading at calibrated velocity. Frequency output 0-15V peak pulse. Meters shall be fully compatible for use as a system with BTU meters as specified below. Flow meter shall be Onicon F-1100, or approved equal.

I. BTU meters shall come complete with temperature sensors and thermowells and be fully compatible for use as a system with water flow meters as specified above. Differential temperature accuracy shall be ▪ ± 0.15°F over calibrated range. Non-volatile EEPROM memory shall retain all program parameters and totalized values in the event of power loss. Alphanumeric LCD shall display total energy, total flow, energy rate, flow rate, supply temperature and return temperature. Standard output signal shall be isolated solid state dry contact for energy total. Provide with optional 4-20mA analog output for flow rate. BTU meter shall be Onicon System-10 BTU meter, or approved equal.

J. Temperature Control Panels: Indoor control panels shall be fully enclosed NEMA

1 construction with hinged door, key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel. Pre-wire internal and face-mounted device connections with color-coded stranded conductors, tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring. Each local panel shall have a control power source power switch (on-off) with over-current protection. Provide engraved phenolic nameplates identifying all devices mounted on the face of control panels.

K. Filter differential pressure switches shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have adjustable scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified. Switches shall be piped across the filter sections and set per the filter manufacturer's recommendations.

L. Filter differential pressure sensing device shall be indicating transmitter type designed to provide both visual monitoring at the filter location and electronic monitoring at the EMS. Transmitter shall have easily-read dial gage and two-wire, 4-20mA control signal with rear-mounted terminal strip. Transmitter shall be Dwyer Magnehelic Differential Pressure Indicating Transmitter Model 605, or approved equal with range appropriate for filter bank and shall be piped across the filter sections. EMS alarm point shall be set per the filter manufacturer's recommendations.

M. Water flow switches: Flow-proving switches shall be differential pressure type. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum). Scale range and differential shall be suitable for intended application and NEMA 1 enclosure unless otherwise specified. Paddle-type flow switches are not acceptable.

N. Low limit air stream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Provide one thermostat for each 25 square foot of coil area. Low limit thermostat shall be manual reset and shall be double pole so as to provide input capability for alarm at the EMS.

O. High limit thermostats shall be located as directed and shall be manual reset type set at 120°F in the return and 180°F in the discharge. Thermostats shall be double pole so as to provide input capability for alarm at the EMS.

P. Humidity Sensors: Wall mount sensors shall have a minimum sensing range of 0%-95%. Duct mount sensors shall have a minimum sensing range of 20%-80%.

Duct mount sensors shall have a sampling chamber. Outdoor air humidity sensors shall have a sensing range of 0%-100% RH and shall be suitable for ambient conditions of -40-60deg C (-40-140deg F). Wall and duct mount humidity sensors shall be Vaisala HMD/W60/70 Series Transmitters, or approved equal. Outdoor air mounted humidity sensors shall be Vaisala HMP60 probe with DTR500 shield, or approved equal. Wall mounted sensors shall be mounted at 54 inches AFF unless indicated otherwise on drawings.

N. Air static differential pressure transmitters shall have an overpressure rating of up to 10psi depending on range. The transmitter shall have an accuracy of not less than +/- 1.0% full scale with an operating environment of 0 to 175 deg F. Output shall be a 4 20mA. Transmitters shall be Setra Model 264, or approved equal..

O. Liquid pressure transmitters shall be housed in a NEMA 4 enclosure with a burst pressure rating of 500% rated range and overpressure rating of 300% rated range. The transmitter shall have an accuracy of not less than +/- 1.0% full scale with an operating environment of 0 to 180°F and 10-90% RH Non-Condensing. Output shall be 4-20mA. Transmitters shall be Mamac PR-264, or approved equal.

P. Liquid differential pressure transmitters shall be housed in a NEMA 4 enclosure with a burst pressure rating of 500% rated range, overpressure rating of 300% rated range and maximum static pressure rating of 200% of differential pressure range. The transmitter shall have an accuracy of not less than +/- 1.0% full scale with an operating environment of 0 to 180°F and 10-90% RH Non-Condensing. Output shall be 4-20mA. Transmitters shall be Mamac PR-283, or approved equal.

Q. Steam pressure measurements shall be accurate to +/- 0.13% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Unit shall be provided with isolation and bypass manifold for start-up and maintenance operations. Transmitter shall be Setra model C-207, or approved equal.

R. CO2 Sensors: CO2 sensors shall provide simultaneous analog outputs in volts and milliamps and shall have a gold bifurcated relay that can be operated as normally open or closed; sensor shall incorporate elevation correction adjustment and ABCLogic™ (Automatic Background Calibration) software for self-correction of drift to better than ±10ppm per year. Sensor shall have an accuracy of ±40 ppm or 3% of the reading (whichever is greater) @ 72°F. All adjustments to the sensor including output scaling, elevation adjustment, relay setpoint, relay dead-band, proportional or exponential output, and single-point calibration shall be made via computer connection to an on-board RJ45 jack. Sensor shall have a

detachable base with all field wiring terminals on the base. Sensor shall suitable for wall, duct or outdoor sensing application as required. CO2 sensor shall be the GE Telaire 8001 non-dispersive infrared sensor, or approved equal. Wall mounted sensors shall be mounted at 54 inches AFF unless indicated otherwise on drawings.

S. Control relays shall be plug-in type or encapsulated, UL listed and with coil and contact ratings suitable for the application. Provide NEMA 1 enclosure for relays not installed in local control panel.

T. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

U. Damper blade position limit switch shall be Kele model LS45M91B11 Whisker Switch, or approved equal. Damper actuator switches are not acceptable. Devices which only sense damper shaft position are not acceptable.

V. Door position switch shall be a hermetically sealed reed switch nominally 3" L x 1" H x 0.50" D with matching actuating magnet. Contact and magnets shall be in brushed anodized aluminum tube housing. Contact shall be sealed. Each contact shall connect to three feet of flex stainless steel conduit. Switches shall be GE Sentrol model 2505A, or approved equal.

W. Condensate pan high level alarm switch shall be in inline, low voltage condensate overflow shutoff pre-wired with 4-foot, 18 AWG wires. Switch shall be RectorSeal Safe-T-Switch SS1, or approved equal.

X. Area surface moisture detection system shall be 12V or 24V AC or DC hardwire-powered with up to six surface sensor probes; form C (SPDT) 1 Amp @ 24VAC, 1 Amp @ 30VDC output; 32 to 140°F operating temperature; high humidity or condensation conditions will not cause alarm. System shall be Winland Electronics WaterBug WB-200 with W-S-U surface sensor, or approved equal.

Y. Voltage sensing relays shall be capable of monitoring and reacting to over and under voltage conditions. Adjustable upper and lower voltage trip-points, LED indication of both presence of input voltage and when output is energized and adjustable transfer-of-contacts timing delay. Relay shall be Magnecraft 831VS-120, or approved equal.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Architect or Engineer for resolution before starting rough-in work.

B. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

C. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate this section's work with work of others. EMS Contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2 PROTECTION

A. EMS Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

B. EMS Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site

1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Contractor shall correct conditions without extra charge.
2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Test and Balance

1. Provide Test and Balance Contractor a single set of necessary tools to interface to control system for testing and balancing.
2. Train Test and Balance Contractor to use control system interface tools.
3. Provide a qualified technician to assist with testing and balancing the first five (5) terminal units.

4. Test and Balance Contractor shall return tools undamaged and in working condition at completion of testing and balancing.

3.4 INSTALLATION

A. General Notes:

1. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.
2. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.
3. Install specified temperature control equipment in Mechanical Equipment and Machine Rooms, and Penthouse Mechanical Equipment rooms in local control panels. Refer to Article entitled "Local Control Panels".
4. Install and properly support all ductstats, dial thermometers, thermostat bulbs, temperature and humidity sensors and controllers, etc., in the center of duct cross section, in a straight duct run.
5. Provide averaging type elements for sensing mixed air temperatures in ductwork, with sufficient length or sufficient number of elements, so as to efficiently measure the air temperature through the entire cross section of duct.
6. Test all electric and electronic equipment provided under this Section.

B. Provide DDC/electric-electronic control system, as noted on the drawings and as specified. Provide all necessary relays, mounting brackets, gages, switches and accessories required, even though not specifically called for, so as to result in complete workable systems.

C. All work described in this section shall be installed, wired, circuit-tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the temperature control system manufacturer or its exclusive factory authorized installing contracting field office (representative). The installing office shall have a minimum of five years of installation experience with the manufacturer and shall provide documentation in submittal package verifying longevity of the installing company's relationship with the manufacturer. Supervision, calibration and checkout of the system shall be by the employees of the local exclusive factory authorized temperature control contracting field office (branch or representative).

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

E. Equipment furnished by the HVAC 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 EMS contractor.

F. 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.

3.5 WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations.

B. Low voltage and line voltage wiring to actuators is considered control wiring and shall be provided by the EMS contractor unless shown otherwise on electrical drawings.

C. Line voltage wiring to EMS controllers and equipment panels is considered control wiring and shall be provided by the EMS contractor unless shown otherwise on electrical drawings.

D. NEC Class 1 (line voltage) wiring shall be UL-listed in approved raceway as specified by NEC and Division 26.

E. Low-voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low-voltage power circuits as required to meet Class 2 current limit.

F. NEC Class 2 (current-limited) wires not in raceway shall be plenum-rated and UL listed for the intended application.

G. Install wiring in raceway where subject to mechanical damage and at levels below 10 feet in mechanical, electrical, or service rooms.

H. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

I. Do not install wiring in raceway containing tubing.

J. Run exposed Class 2 wiring parallel to a surface or perpendicular to it and tie neatly at 10-foot intervals.

K. Use structural members to support or anchor plenum cables without raceway. Do not use ductwork, electrical raceways, piping, or ceiling suspension systems to support or anchor cables.

L. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

M. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

N. Include one pull string in each raceway 1 inch or larger.

O. Use color-coded conductors throughout.

P. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

Q. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 6 inches between raceway and high-temperature equipment such as steam pipes or flues.

R. Adhere to requirements in Division 26 where raceway crosses building expansion joints.

S. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

T. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

U. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Do not use flexible metal raceway less than 1/2-inch electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

V. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

3.6 COMMUNICATION WIRING

A. Communication wiring shall be low-voltage Class 2 wiring.

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. Communication wires not in raceway but in concealed and accessible locations such as return air plenums shall be plenum-rated and UL-listed for the intended application.

D. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

E. Verify entire network's integrity following cable installation using appropriate tests for each cable.

F. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

G. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

H. Label communication wiring to indicate origination and destination.

I. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.7 INSTALLATION OF SENSORS

A. Install sensors according to manufacturer's recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

E. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

F. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 1 feet of sensing element for each square foot of coil area. For large duct areas where the sensing

element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the coil.

G. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

H. Install outdoor air temperature sensors on north wall at designated location with sun shield.

I. Differential Air Static Pressure

1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
2. Return Duct Static Pressure. Pipe pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer's recommendations.
3. Building Static Pressure. Pipe pressure sensor's low-pressure port to the static pressure port located on the outside of the building sensing the average atmospheric pressure at four points (North, South, East and West). Pipe high-pressure port to a location behind a thermostat cover. Provide all necessary filtering, surge dampeners, atmospheric and room static pressure sensing heads, etc., required for accurate and stable building pressurization control.
4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

J. Low limit thermostats, high limit thermostats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

3.8 ACTUATORS

A. General. Mount actuators and adapters according to manufacturer's recommendations. Low voltage and line voltage wiring to actuators is considered control wiring and shall be provided by the EMS contractor.

B. Electric and Electronic Damper Actuators. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer's recommendations. Low voltage and line voltage wiring to actuators is considered control wiring and shall be provided by the EMS contractor.

1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
2. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten linkage.
3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
4. Provide necessary mounting hardware and linkages for actuator installation.

C. Valve Actuators. Connect actuators to valves with adapters approved by actuator manufacturer. Low voltage and line voltage wiring to actuators is considered control wiring and shall be provided by the EMS contractor.

3.9 IDENTIFICATION OF HARDWARE AND WIRING

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

B. Label pneumatic tubing at each end within 2 in. of termination with a descriptive identifier.

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

D. Label control panels with minimum ½ in. letters on laminated plastic nameplates.

E. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

F. Label room sensors related to terminal boxes or valves with nameplates.

G. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

H. Label identifiers shall match record documents.

3.10 WARRANTY

A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of final system acceptance. Control system failures during warranty period shall be adjusted, repaired or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

C. Provide updates to operator workstation, web server software, project-specific software, graphic software, database software, and firmware at no charge to the Owner during the warranty period. Do not install updates or upgrades without Owner's prior authorization.

3.11 WARRANTY ACCESS

A. The Owner shall grant to the EMS contractor reasonable access to the EMS during the warranty period. The owner shall allow the contractor to access the EMS from a remote location for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period.

3.12 ACCEPTANCE TESTING

A. Upon completion of the installation, the EMS contractor shall load all system software and start-up the system. The EMS 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 EMS 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.

C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

D. System Acceptance: Satisfactory completion is when the EMS 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.

3.13 OWNERSHIP OF PROPRIETARY MATERIAL

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

1. Graphics
2. Record drawings
3. Database
4. Application programming code
5. Documentation

3.14 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one (1) year of date of Substantial Completion, provide up to three Project site visits, when requested by Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

3.15 OPERATOR INSTRUCTION AND TRAINING

A. Provide training for a designated staff of Owner's representatives. Training shall be eight (8) hours in duration. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, on-site training, or a combination of training methods.

B. Training shall be tailored to the Owner's existing EMS and specific controlled equipment and systems of this project.

3.16 FIELD QUALITY CONTROL

A. Provide the services of a qualified engineer, in the employ of the control systems manufacturer, for the initial start-up and calibration of control systems, and the instruction of Owner's Personnel.

3.17 SOFTWARE INSTALLATION

A. General: The Contractor shall provide all labor necessary to install, initialize, start-

up and debug all system software as described in this section. This includes any operating system software or other third-party software necessary for successful operation of the system.

B. Database Configuration: The Contractor shall provide all labor to configure those portions of the database that are required by the point list and sequence of operation.

C. Color Graphic Slides: Unless otherwise directed by the owner, the Contractor shall provide color graphic displays as depicted in the schematic drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner.

3.18 COMMISSIONING AND SYSTEM STARTUP

A. Point to Point Checkout: Each I/O device (both field mounted and those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated and approved by the Project Manager for submission to the Engineer.

B. Controller Checkout: A field checkout of all controllers shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the Engineer by the completion of the project.

C. System Acceptance Testing:

1. All application software shall be verified and compared against the sequences of operation. Control loops shall be exercised by inducing a setpoint shift of at least 10% and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.
2. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e. graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the Engineer.
3. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the Engineer.
4. Perform an operational test of each third party interface that has been included as part of the automation system. Verify that all points are

properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

END OF SECTION 230923