**PART 1 – GENERAL**

* 1. **SUMMARY**

1. Section Includes: Environmental controls and energy management systems, including equipment, materials, installation, start-up, testing, documentation and training according to construction documents. The project drawings establish the scope of HVAC controls work. This Section complements the requirements of construction drawings for controls and system communications.
2. Related Requirements:
3. Division 01: General Requirements.
4. Section 01 45 23: Testing and Inspection.
5. Section 01 79 00: Maintenance and Operations Staff Demonstration and Training.
6. Section 01 91 13: General Commissioning Requirements.
7. Section 21 13 13: Fire-Suppression Sprinkler Systems.
8. Section 23 05 00: Common Work Results for HVAC.
9. Section 23 05 13: Basic HVAC Materials and Methods.
10. Section 23 30 00: Air Distribution.
11. Section 23 38 13: Kitchen Ventilation System.
12. Section 23 50 00: Central Heating Equipment.
13. Section 23 64 16: Oil Lubricated Centrifugal Water Chillers.
14. Section 23 64 23: Scroll Water Chillers.
15. Section 23 65 00: Cooling Towers.
16. Section 23 70 00: Air Handling Units.
17. Section 23 80 00: Heating, Ventilating and Air Conditioning Equipment.
18. Section 23 81 00: Floor and Wall Mounted Heat Pumps.
19. Section 26 05 00: Common Work Results for Electrical.
20. Section 26 05 13: Basic Electrical Materials and Methods.
21. Section 26 05 19: Low-Voltage Wires (600 Volt AC).
22. Section 26 05 26: Grounding and Bonding.
23. Section 26 09 23: Lighting Control Systems.
24. Section 26 29 13: Adjustable Frequency Drives.
25. Section 27 10 13: Structured Cabling (Existing Site)
26. Section 27 10 15: Premises Wiring New Installation.
27. Section 27 01 26: Test and Acceptance Requirements for Structured Cabling
28. Section 28 31 49: Carbon Monoxide Detection and Alarm Systems.
    1. **REFERENCES**
29. The latest version of applicable codes, standards, and references. Inspections and tests shall be in accordance with the following applicable codes and standards, except as provided otherwise herein.
    * + 1. International Electrical Testing Association – NETA.
        2. National Electrical Manufacturers Association – NEMA.
30. American Society for Testing and Materials – ASTM.
31. Institute of Electrical and Electronics Engineers – IEEE.
32. American National Standards Institute – ANSI.
33. National Electrical Safety Code – NESC.
34. California Building Code – CBC.
35. California Electrical Code – CEC.
36. California Mechanical Code – CMC.
37. Insulated Cables Engineers Association – ICEA.
38. Occupational Safety and Health Administration – OSHA.
39. National Institute of Standards and Technology – NIST.
40. National Fire Protection Association – NFPA.
41. American Society of Heating, Refrigerating, and Air-Conditioning Engineers – ASHRAE

(The HVAC Commissioning Process, ASHRAE Guideline).

1. International Building Code – IBC.
2. International Mechanical Code – IMC.
3. International Electrical Testing Association (NETA) Acceptance Testing.
4. Underwriters Laboratories – UL/CUL.
5. ANSI/ASHRAE Standard 135- BACnet – A Data Communication Protocol for Building Automation and Control Systems.
   1. **SUBMITTALS**
6. Provide in accordance with Division 01 and Section 23 05 00: Common Work Results for HVAC.
7. Shop Drawings:

Shop drawings shall be formatted to fit on 11” x 17” pages, and hardware/software product data shall be formatted to fit on 8.5” x 11” pages.

Shop Drawings shall include but not limited to:

1. Cover page with legend, common notes, symbol schedule, and drawing index.
2. Complete point to point environmental controls and energy management network communication diagram(s) for Direct Digital Controls (DDC) of each system:
   * + 1. Identify all components.
       2. Indicate conduit and wire characteristics, sizes and quantities.
       3. Provide bill of materials.
3. Network Architecture plans showing control panels and intercommunication wiring.
   1. Show system(s) point to point interface connections.
4. Valve Schedules where required.
5. Operations and Maintenance Manuals.
6. Installation Instructions of each control device.
7. PC Workstation.
8. Software flow diagram of each unique system sequence of operation.
9. Provide a full system backup. Graphic files, programs, and database shall be viewable using technician software tools furnished with the system.
10. Software licenses and electronic keys.
11. Supplemental local or factory training schedule for post warranty support.
12. A complete list of recommended spare parts with pricing for the OWNER’s use in keeping the environmental control system downtime to a minimum.
13. As-built submittal: Upon completion of installation, submit as-built documents for approval prior to training and substantial completion.
    * + 1. Provide record documents in a digital format on a suitable digital format such as USB flash drive.
        2. Provide as-builts drawings in Visio format.
        3. Provide electronic copies of as-built documents to Commissioning agent for inclusion in final commissioning report.
        4. Provide two USB flash drives with AutoCAD drawings in a “.dwg” format. One of the drives must be included in the commissioning report: the other must be delivered to OWNER.
    1. **SUBSTITUTIONS**
    2. Energy Management Systems that deviate from these requirements shall not be accepted without written approval from OWNER’S Design Standards and Maintenance and Operations Technical Units. When deviating or proposing substitutions the following information shall be submitted:
14. Substitution request form. State all reasons for the deviation and the benefits to OWNER.
15. Proposed substitutions requests shall provide proof of compliance with EMS system’s characteristics indicated in this specifications section.
    1. Submittals must comply with contract general provisions.
    2. **QUALITY ASSURANCE**
16. Installation of line voltage electrical components shall be performed by State approved/ certified electricians.
17. Energy Management System shall be listed and approved for the intended application by Underwriter's Laboratories (UL), or other Nationally Recognized Testing Laboratory (NRTL), and in compliance with applicable industry standards and codes, including those mentioned under REFERENCES.
18. Provide labor, engineering, design, testing, supervision, material and equipment required.
19. Equipment shall be new. Manufacturer shall have been continuously manufacturing energy management systems for at least 10 years.
    1. **COMMISSIONING**
20. A Commissioning Services Provider (CxSP) retained by OWNER will lead and provide Commissioning (Cx) of power distribution systems and assemblies, including submittal review, installation, testing, documentation, and training as indicated in Specification Section 23 08 13: Environmental Controls EMS Commissioning.
21. CONTRACTOR shall follow the commissioning responsibilities stated in Specification Section 01 91 13: General Commissioning Requirements, and Section 23 08 00: HVAC Systems Commissioning.
22. CONTRACTOR shall provide all tools and personnel, and perform start-up, prefunctional and functional performance testing in the presence of OWNER’s Commissioning Services Provider.
    1. **QUALITY CONTROL**
    2. CONTRACTOR shall have adequate experience installing systems of similar size and complexity with the control product line proposed for this project.
23. Qualifications of Installer: Minimum five years experience installing products and systems of similar scope and complexity.
24. Installer shall submit certification from the equipment manufacturer indicating that installer is an authorized representative of the equipment manufacturer and is trained on network applications.
25. Installer shall maintain a fully equipped service organization capable of furnishing repair service to the equipment and shall always maintain a spare set of major parts for the system.
26. Installer shall furnish a letter from manufacturer of equipment certifying equipment has been installed according to factory standards and that system is operating properly.
27. CONTRACTOR shall have participated in the commissioning of a minimum of 10 projects of similar magnitude to those needed for this project.
28. System startup and testing shall be performed under the direct observation of the Project Inspector CxSP and OAR.
    1. Materials and equipment installed shall be new.
    2. System installation shall not begin until Shop Drawings are submitted and reviewed by the Architect or Engineer of Record.
    3. Components for Direct Digital Control (DDC) shall comply with ASHRAE standards.
    4. The installer shall provide the system components required by code and for the life safety of the service personnel.
    5. System shall be able to interface with open protocol BACnet systems.
    6. Provide all ancillary components for the system to perform the required sequence of operations. Install, test and adjust the system accordingly.
    7. System components shall operate per industry standards. The standards shall be as defined by ASHRAE, SMACNA, AABC, NEBB, TABB, and the literature of the manufacturers listed in this Section.
    8. Provide field engineering tools including software and hardware needed for programing and/or modifying system controller and devices.
    9. **WARRANTY**
29. Components, system hardware and software, and parts and labor shall be guaranteed against defects in materials, fabrication, and execution for three years from date of system acceptance. Provide labor and materials to repair, reprogram, or replace defective components at no charge to the OWNER during the warranty period.
30. Provide a list of applicable warranties for equipment and components, this list shall include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services.
31. CONTRACTOR shall respond to OWNER’s request for warranty service within four hours of initial call to schedule a mutually agreeable time for service. Submit records of the nature of the call, the work performed, and the parts replaced, or service rendered.
    1. **TRAINING**
    2. Provide a competent instructor who is factory trained and has comprehensive knowledge of system components and operations to provide full instructions to designated personnel in the system operation, maintenance, and programming. Training shall be specifically oriented to installed equipment and systems.
       * 1. Provide four hours of onsite OWNER familiarization and training for the installed system. Training shall include system overview, assigning user name and password, time schedules, override commands, emergency operation, and programming and report generation. OWNER employees attending this training session shall be provided with the following documentation:
            1. As-built drawings of System layouts and point to point connection diagrams.
            2. System components cut sheets.
            3. Operations and Maintenance data.
         2. Programmer and maintenance training shall include assigning user name and password, database entry; trend logs application programs, diagnostic routines, reporting, failure recovery, sequence of operation and system response, and calibration. Provide 24-hours of training as follows (40-hours for central plant):
            1. Training session shall accommodate a minimum of 20 persons and be facilitated at CONTRACTOR’s training facility, which should be no more than 50 miles from the Project Site.

Training shall be delivered in 6 hours per session increments.

Obtain OWNER’s approval for training locations exceeding 50 miles. In such cases, the CONTRACTOR shall be responsible for transportation expenses.

CONTRACTOR shall provide training computers for all attendees. Computers shall be ready for live training sessions.

* + - * 1. Training shall cover instruction, theory, and expose the trainees to system’s features, components, architecture, operations, programming, report generation, communications, and any other pertinent information required for the operations and maintenance of the system.

Each training session shall have an itemized agenda covering all aspects of the training to be covered in the sessions. CONTRACTOR shall obtain agendas approval from School District’s HVAC technical unit and Commissioning Agent.

* + - * 1. Instructor(s) shall give the trainees the opportunity to practice on simulated and actual (installed) systems.
        2. The training session shall cover, but not be limited to the following instruction modules or sessions:

System Architecture:

System layout and components interrelations and hierarchical structure.

Controllers interfacing and functions.

Server functionality and data management, error messages, and alarm conditions.

Connectivity and communication losses.

Replacement procedures for system components.

User Operations:

1. Familiarization and navigation with the EMS operating System.
2. Window panes, menus, navigation buttons, alarm response windows, system passwords and accessibility features and options, monitoring and managing data points (inputs, outputs, numeric values, time and date, strings).
3. Views: Provide sufficient information as to train staff on how and where to access programs, functions, adjust or alter diagnostic points and related data, override messages, reports and actions taken.

Trending: Setting trend(s) intervals, accessing data trends and history logs for diagnosis points or groups, and reporting. Working with trended data graphical displays, including but not limited to hiding points, setting display types and colors, viewing and setting scales.

Graphics: Standard symbols and color codes, graphics customization, how and where to access and manage the system with the graphic displays, including changing points and values, using Hand Off Automatic (HOA) switches and viewing results, mapping to or with other graphic sources and functions, including groups, navigation, sequence of operations, and displays and reports.

Alarms: Reading and interpreting alarms, acknowledging and silencing alarms, routing and setting priorities, viewing and responding e-mailed and paged alarms.

**PART 2 – PRODUCTS**

* 1. **ACCEPTABLE MANUFACTURERS**

1. Environmental controls and energy management systems shall be approved products of Carrier.
   1. **SYSTEM ARCHITECTURE**
2. The system shall be capable of providing a high-speed peer-to-peer network of distributed stand-alone DDC controllers that meet ANSI/ASHRAE Standard 135 for open protocol communications.
3. A maximum of 32 controllers shall be connected to any one MS/TP bus. Minimum Speed of 38kb and can support 127 devices per COM port. Provide a minimum of 2 ports.
4. Provide a Building Automation System (BAS) that consists of Network Server/Controllers (NSCs), a family of Standalone Digital Control Units (SDCUs), Administration and Programming Workstations (APWs), and Web-based Operator Workstations (WOWs). The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire facility, WEB enable capabilities, and Wide Area Network (WAN).
5. The Enterprise Level BAS shall consist of an Enterprise Server, which enables multiple NSCs (including all graphics, alarms, schedules, trends, programming, and configuration) to be accessible from a single Workstation simultaneously for operations and engineering tasks.
6. For Enterprise and robust reporting capability outside of the trend chart and listing ability of the Workstation, a Reports Server shall be provided and installed on a Microsoft Windows based computer. The Reports Server can be installed on the same computer as the Enterprise Server.
7. System software shall support a HTTP server designed around the open standards of web technology. The control system server shall be accessed using a Web browser over the control system network, the OWNER’s local area network and over the Internet. No special software other than a Web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to download programming into the controllers.
8. Reports and Logs: Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
9. The system shall be a top-level 100/1000bT Ethernet network that utilizes BACnet/IP.
10. A sub-network of SDCUs using the BACnet MS/TP protocol shall connect the local, and stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.
11. All devices on Ethernet network shall comply to latest OWNER’s IT security policy.
12. The system shall match the existing LonWorks IP, and/or Modbus TCP protocol.
13. Integration to existing Modbus RTU/ASCII (and J-bus), Modbus TCP, LonTalk FTT-10A, and Web Services shall be native to the NSCs. There shall not be a need to provide multiple NSCs or additional software to allow all three protocols to be natively supported.
14. A sub-network of SDCUs using LonTalk FTT-10A, and/or Modbus RTU protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.
15. All connections from costumed made HVAC equipment such as Season-4 unit to EMS network shall be BACnet over Ethernet.
16. Structured language shall be HTML 5.
17. The supplied computer software shall employ object-oriented technology (OOT) for representation of data and control devices within the system. For each global, system or unitary controller, provide a PICS document showing the installed device’s compliance level. Minimum compliance is Level 3 with the ability to support data read and write functionality.
18. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed three seconds for network connected controllers or user interfaces.
    * + 1. For each system point, alarms can be created based on high/low limits or in comparison to other point values.
        2. There is no limit to the number of alarms that can be created or stored in system hardware for any point, up to the system capacity.
        3. System shall generate configured alarms from single or multiple system conditions.
        4. Alarms will be generated from an evaluation of the alarm condition and presented to the user in a fully configurable order, by priority, time, and category.
           1. Alarm views shall be presented to the user upon logging into the system WorkStation and/or WebStation.
        5. Program the alarm management system to create and report alarm events history; the alarm events history data base shall provide the option to select alarm cause and action notes associated with an alarm event. The alarm management system shall also generate checklists for operators’ use when utilizing a suggested mode of troubleshooting.
        6. Provide alarm event history for a feature use to permit assigning of events for resolution to OWNER staff. The system shall notify the user and assigned resolution personnel.
        7. Alarms shall be capable of being routed to any BACnet workstation that conforms to the BACnet Operator WorkStation (B-OWS) device profile and uses the BACnet/IP protocol.
19. The system shall be able to interface with subsystems that utilize ANSI/CEA-709.1: Control Network Protocol Specification.
    1. **EMS SERVER AND USER INTERFACE WORKSTATION**
20. EMS Server: The EMS Server shall include a Dell PowerEdge R340 rack mounted server or owner approved equal with an Intel Xeon E-2288 3.7 GHz, 16M cache processor or better, 16 Gb RAM, RAID 1 configuration with two hot swap 2TB 7200 RPM NLSAS drive and latest version of Microsoft Windows Server operating system software. Server shall be provided with rack mounted Uninterruptible Power Supply; UPS that is capable of supplying power to maintain minimum of 30 minutes of run time. Server shall receive command from UPS for automatic low battery orderly shutdown. Upon restore of power server shall restart without any intervention from users. Server shall be provided with keyboard, 19” monitor and mouse in a rack mounted 1U slide out drawer.
21. Software licensing shall be provided for unlimited simultaneous users of the system, unlimited future point expansion, user graphical display generation and non-vendor controllers. Licenses and electronic keys shall be included with the M&O manuals for project acceptance. Conditional Licenses will not be acceptable.
22. EMS server software shall interface to School District’s Microsoft Active Directory (AD) Single Sign On (SSO).
23. The system shall be programmed to email selected alarms to designated response personnel.
    1. The ability to utilize email paging of alarms shall be a standard feature of the operating system’s mail application interface (MAPI). No special software and no email client software must be running for the system to distribute emails.
    2. The email notification shall be able to be sent to an individual user or a user group.
    3. The NSC shall use Web Services based on open standards, such as SOAP and REST. Use incoming third-party data (temperature forecast, energy cost) over the Web to display and determine site modes, scheduling, and programming.
24. Web-based operation shall be supported directly by the NSCs and shall not require additional software.
25. The supplied system shall incorporate the ability to access all data using HTML5 enabled browsers without requiring proprietary operator interface and configuration programs.
26. Programming of SDCUs shall be capable of being done either off-line or on-line from any operator workstation. All information shall be available in graphic or text displays stored at the NSC. Graphic displays shall feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the DDC system. All operator functions shall be selectable through a mouse.
27. Programming in the NSC shall be in graphical block format. Provide the tools to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded.
28. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.
29. Programming of the NSC shall be available offline from system prior to deployment into the field. All engineering tasks shall be possible, except the viewing of live tasks or values.
30. The programmer's environment shall include access to a superset of the same programming language supported in the SDCUs.
31. Provided NSC devices shall support the graphical function block programming language. The programmer will be able to configure application software for custom program development and write global control programs. The language shall have debugging capabilities in its editor.
32. The system shall be able to save custom programs as libraries for reuse throughout the system. A wizard tool shall be available for loading programs from a library file in the program editor.
33. The system shall be capable providing views of graphical programming in live and real-time from Workstation(s).
34. The system shall be capable of creating ‘binding templates’ allowing the user to bind multiple points to multiple objects all at once.
35. Automatic detecting zone that may be excessively driving the reset logic and generate an alarm.
36. Readily allow operator removal of zones from reset algorithm.
37. Applications shall be able to be assigned different priorities and cycle times for a prioritized execution of different function.
38. The provided system shall be able to create objects that allow common objects such as power meters, VFD drives, etc. to be integrated into the system with simple import actions without the need of complicated programming or configuration setups.
39. The Server software shall allow the creation of a custom, browser-style interface linked to the user when logging into any workstation. Additionally, it shall be possible to create customized workspaces that can be assigned to user groups. This interface shall support the creation of “hot-spots” that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface shall be able to be configured to become a user’s “PC Desktop” with all the links that a user needs to run other applications. This, along with the Windows user security capabilities, shall enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software, but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shut down the active alarm viewer and/or unable to load software onto the PC.
40. The Server software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.
41. Provide a rack mounted Web Server to automatically convert system displays on the workstation to an Internet page. Internet page shall be readable from standard PC browsers. Acceptable browsers shall be latest version of internet explorer, Chrome, or Firefox. No additional plug-ins, programs, software, hardware, etc. shall be needed to access the Internet page. The server shall be a separate device to provide security protection for the building system from outside hackers.
    1. Coordinate individual system components IP addresses, switch port assignments, security settings such as but not limited to SNMP alarm delivery, HTTPS/SSL settings, VLAN assignment and authorized IP address ranges with the OWNER’s Information Technology Division. Coordination activities with ITD shall be executed through the OAR.
    2. Provide IP address label on the interior of both cabinet door and equipment.
    3. The system shall support the ability to notify school or OWNER designated personnel by SMS or Email messages, utilizing the OWNER’s mail server when problems or situations that require immediate attention arise.
42. Operator Workstation shall display data associated with the project as called out on drawings or object type list supplied. Graphic files shall be created using digital, full color photographs of system installation, AutoCAD or Visio drawing files of field installation drawings and wiring diagrams from as-built drawings. Operator’s workstation shall display data using three-dimensional graphic representations of mechanical equipment. System shall be capable of displaying graphic files, text, trend data and dynamic object data together on each display screen with animation of equipment operation.
43. Controllers shall be programmed using graphical software tools that allow connection of function blocks for visual sequencing of control logic. Function blocks shall display real time data and be animated to show status of data inputs and outputs when in real time operation. Animation shall also show change of status on logic devices and countdown of timer devices in a graphical format.
44. Operator Tracking Log shall record operator changes to the system for future review. This shall include, but not be limited to setpoint changes, time schedule overrides, alarm limits, etc.
45. EMS Workstation: The EMS Workstation shall be an enterprise small form factor with an Intel Core™ i7-10700 or better processor, 16GB of RAM, 512 GB solid state drive, keyboard, mouse, 27-inch LCD color display and the latest version of Microsoft Windows professional operating system software. The workstation shall connect to the network through an internal 1Gbps Ethernet interface card. Workstation shall be equipped with stereo speaker, camera and microphone for virtual meeting and EMS system support.
    1. **GLOBAL CONTROLLER**
46. Building controllers shall incorporate the functions of a 3-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 1GbE ,) master slave token passing (MS/TP) LANs, a point-to-point (PTP/RS-232) connection and telephone modem.
47. Provide global control strategies for the system based on information from any point objects in the system. Programming shall be object-oriented using graphical control function blocks. Global strategies shall include, but not limited to unit scheduling, electrical demand limiting, optimized start-stop of equipment, central plan reset control, etc.
48. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1.5 years (cumulative).
49. Capacitor-backed real-time clock keeps time in the event of power failure or network interruption for up to three days.
50. Each building controller shall support a minimum of 250 BACnet Schedule Objects and 250 BACnet Calendar Objects.
51. Each building controller shall log a minimum 1,000 trend logs. Any point object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator’s workstation. Building controller shall periodically upload trended data to networked operator’s workstation for long term archiving if desired. Archived data shall be available for use in third-party spreadsheet or database programs.
52. Alarms may be generated within the system for any object change of value or state either real or calculated. This includes events such as analog object value changes, binary object state changes and various controller communication failures. Each alarm may be automatically dialed out to a telephone pager or emailed to any Internet PC computer.
53. The global controller shall be equipped with ADR demand limiting capacity interface.
54. The system shall include 5 DI for interfacing to local utility ADR controller. The 5 DI shall be located inside a 24 X 24 X 6 NEMA 4R cabinet with a dual 75VA 24VAC UL listed power supply assemblies RIB model PSH75A75AWB10 mounted in the MDF or IDF room with 2 Ethernet drop for future ADR. Upon closer of each DI the control system shall raise or lower (depend on system mode) global room temperature set point 1 degree (user adjustable).
55. Provide EMS emergency global shut down switch located in the main office.
56. The system shall also include a demand-limiting program that utilizes 3 wire KYZ pulse data from site utility meter. Features indicated below shall be available via a switchable graphical user interface in all operating stations:
    1. Shed/Restore equipment in digital format shall include 5 data input points for interface to future ADR web appliance located in an MDF/IDF room. System server shall accept ADR command from utility service via web interface and shall include at least 5 priority levels of equipment shedding. Load shedding on a given priority level shall include two methods. In one the loads shall be shed and restored in a “first-off/first-on” mode and in the other; the loads shall be shed/restored in a linear fashion.
    2. Adjust operator selected control setpoints in analog format based on energy usage when compared to shed and restore settings.
    3. Shedding may be implemented independently on each zone or piece of equipment connected to the system.
    4. Status of every load shed shall be capable of being displayed on every operator terminal connected to the system. Statuses shall be displayed along with the English description of each load.
    5. **APPLICATION (system and unitary) DDC CONTROLLERS**
57. Application controllers shall include universal inputs that accept 10K thermistors, 0 to 10VDC, 0 to 5 VDC, 2 to 10 VDC and dry contact signals. Any input on a controller may be either analog or digital with a minimum of three inputs that accept pulses. Controller shall include support and modifiable programming for interface to intelligent room sensor with digital display and set point adjustment and override button. Controller shall include binary and analog outputs on board. Analog outputs shall be switch selectable as either 0–10VDC or 0–20mA. Software shall include scaling features for analog outputs. Application controller shall include a supply voltage to power external sensors.
58. Program sequences shall be stored in EEPROM or flash memory. No batteries shall be needed to retain logic program. Controller shall execute program sequences 10 times per second and be capable of multiple PID loops for control of multiple devices. Calculations shall be completed using floating-point math. Programming of application controller shall be completely modifiable in the field over the installed BACnet LANs.
59. Central Plant Controllers shall interface to chiller gateways. Point objects shall reside in the central plant controller. Physical Hand-Off-Auto switches shall be provided for direct wired output control circuits.
60. Controllers for VAV boxes shall use power Over Ethernet (POE) and include one onboard airflow sensor microprocessor driven and pre-calibrated at the factory. Pre-calibration shall be at 16 flow points as a minimum. Factory calibration data shall be stored in EEPROM. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. Calibration parameters shall be adjustable through intelligent room sensor with digital display and set point adjustment and override button. Operator workstation, portable computers and special hand-held field tools shall not be needed for field calibration. Boxes shall be controlled using pressure independent control algorithms and flow readings shall be in CFM
61. Controllers for Dual Duct boxes shall use POE and include two onboard airflow sensors and function like the VAV box controller. Multiple VAV box controllers or controllers with remote airflow sensors are not acceptable.
62. CONTRACTOR shall provide a laminated wiring diagram for each control panel. Locate diagrams on interior side of control panel’s doors.
    1. **TEMPERATURE SENSORS**
63. Temperature sensors shall be 10K ohm thermistor factory-calibrated to within 0.5 degrees F, totally interchangeable with housings appropriate for the application.
64. Top of sensors shall be installed 48 inches above finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells filled with thermal compound. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake and in a location that is in the shade most of the day.
65. Intelligent room sensors shall be equipped with digital display, set point adjustment and override button. Smart room temperature sensor/thermostat shall incorporate PIR motion sensor, temperature display, set point adjustment and override button. Acceptable Manufacturers: Carrier’s I-Vu Energy Management Systems (EMS) and related components.
66. Room thermostat controllers shall be BACnet capable with digital display, set point adjustment and override button. Smart room temperature sensor/thermostat shall incorporate PIR motion sensor, temperature display, set point adjustment and override button. Acceptable manufacturers: Carrier.
    1. **WINDOWS AND DOOR SENSOR**
67. Provide windows and door switches at every operable windows and door in controlled spaces. Each switch shall be connected to a DI point on the DDC controller. Each switch shall be wired independently. Wiring multiple switches in series shall not be acceptable. Acceptable Manufacturers: Illumra E3-MDCCP, Schneider Electric or OWNER approved equal.
    1. **HUMIDITY SENSORS**
68. The humidity sensor shall be a solid-state device that is factory calibrated to provide a linear output with an accuracy of 3.0 percent from 0 to 90 percent RH. A metal fabric filter shall protect the humidity-sensing element.
69. Duct humidity sensors shall have an LCD display and utilize a sampling tube enclosure that is accessible for maintenance personnel.
70. Room and duct sensors shall incorporate a temperature sensor in the same enclosure with LCD display.
    1. **PRESSURE SENSORS**
71. Differential and pressure sensors shall have a tensioned stainless-steel diaphragm to form a variable capacitor that produces a linear output with an accuracy of 1.0 percent of full scale. The unit shall be able to withstand 10 PSIG over pressurization.
72. Steam pressure sensors shall be mounted on a pigtail siphon with manual shutoff ball valve.
73. Air filter differential pressure sensor shall be analog type with output of 0-10 VDC in NEMA 4X enclose with LCD display. Static pressure shall be display with associated mechanical equipment and air filter alarm shall be set at .9” WC (adjustable)
    1. **CARBON DIOXIDE (CO2) SENSORS**
74. Carbon dioxide concentration levels shall be sensed by non-dispersive infrared technology. A corrosion-free sensing chamber shall be used for accurate, stable CO2 sensing. An LCD shall display sensed CO2 concentration.
75. Sensor shall have a range of 0-2000 PPM at +/- 5 percent accuracy with 0 to 10 VDC output and LCD display for long-term calibration stability. Both analog and binary relay output circuits shall be available on the sensor. An automatic background calibration (ABC) algorithm shall be part of factory programing.
76. Acceptable Manufacturers: Carrier.
    1. **ELECTRONIC VALVES**
77. Control Valves ½ inch to 2-inch shall be characterized stainless steel ball valves with actuators sized to close off against twice the maximum fluid pressure. Valve body shall be NPT screwed for 2-way or 3-way application. A push button release shall be provided for manual operation.
78. Control Valves for AHU above 10 ton in capacity shall be Belimo Energy Valve with BACnet MS/TP or BACnet IP connection to EMS, or OWNER approved product.
79. Steam Valves shall be globe valves suitable for 35-PSI inlet steam service. Valve bodies shall be NPT screwed or flanged with spring-return normally closed valve actuators.
80. Valve control shall be accomplished with 2-10 VDC. All valves shall provide feedback 2-10VDC signal to EMS/BMS for monitoring on GUI.
81. Acceptable Manufacturers: Belimo, Honeywell, Johnson Controls, Schneider Electric or OWNER approved equal.
    1. **DAMPER ACTUATORS**
82. Electric damper actuators (including VAV box actuators) shall be direct shaft mounted and use a V-bolt and toothed V-clamp.
83. Actuators shall be sized for 200 percent of the design torque requirements.
84. Damper actuators shall incorporate a release mechanism to manually position the damper for maintenance or emergency override.
85. Damper Actuators located outdoors shall have a clear plastic or metal weather shield approved by manufacturer specifically designed for the application.
86. Damper motor control shall be with 2-10 VDC
87. Acceptable Manufacturers: Belimo, Honeywell, Johnson Controls, Schneider Electric, or OWNER approved equal.
    1. **CURRENT TRANSDUCER**
88. Current transducer shall have solid-state circuitry RIB split core model RIBXGTV10 or OWNER approved equal with 0 to 10 VDC output to EMS control. Alarm trip point or status shall be electronic set via EMS program. FLA + service factor on motor shall be stated on graphic with dynamic live data window.
    1. **CONTROL RELAY**
89. The relay shall be contained in NEMA 4 enclosure with a ¾” NPT conduit fitting. Coil voltage shall be 24 or 120-VAC with a contact rating of 10A. An LED on the enclosure cover shall indicate the relay is energized.
    1. **POWER SUPPLIES**
90. Power supply assemblies shall be UL or NRTL listed as a whole. Primary and secondary of power supply shall be protected by current limiting device.
91. Primary side of power supply shall be provided with a manual disconnect switch.
    1. **ENCLOSURES**
92. Enclosures for indoor and outdoor applications shall be metal NEMA 4, Hoffman A\*\*H\*\*DLP3PT with continuous hinge with 3-point latch or OWNER approved equal and be mounted on the north exposure of the controlled unit when use outdoor.
93. Enclosures shall have common keying (CAT-60) padlock for all control panel on the Project Site.
94. Enclosures shall have permanently affixed to the door an engraved nametag identifying the equipment served. The nametag shall be a minimum 1 inch by 3-inch with ½ inch lettering.
95. Entire control panel assembly shall be UL 508A listed/rated.

**PART 3 – EXECUTION**

* 1. **CONTROLS INSTALLATION**

1. Wiring methods for control system shall be as defined in the Division 26 specifications. Wire types shall conform to manufacturers’ recommendations.
2. All field wiring shall be label on both end with Brady B-427 labels or OWNER approved equal.
3. All panel wiring shall be label with Brady B-342 heat-shrink wire marker or OWNER approved equal.
4. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room. Control panel assemblies must be UL listed as an assembly.
5. Provide software and hardware required to provide controls and monitoring of diagnostic points indicated in specification Section 23 8000.
6. Coordinate with Division 26 electrical installer so that "Hand/Off/Auto" selector switches are installed to override automatic interlock controls when switch is in the "Hand" position. Safety shutdown interlock wiring shall disable the equipment regardless of the position of the H-O-A switch.
   1. **ROOM SENSORS INSTALLATION**
7. Top of room sensors shall be wall mounted at a 48-inch height above finished floor. Room sensors are not permitted on outside walls, at chalkboards, between shelving, in recesses or above heat producing equipment. Coordinate with Division 26 for sensor or thermostat mounting adjacent to light switches.
8. Emergency HVAC shut down switch. Provide STI STOPPER STATION model # SS2249ZA-EN OR OWNER approved equal in main admin office staff area.
   1. **COORDINATION**
9. Coordinate the work with other aspects of mechanical, electrical, fire-life safety and security systems, controls, and photo voltaic systems to obtain a complete and operating system in accordance with the contract documents.
10. Meet with the OAR and school principal and other school staff to determine when each zone or building will be occupied, and to determine programming and scheduling of the heating, ventilating and air conditioning equipment.
11. CONTRACTOR shall contact OAR to coordinate for timely availability of VPN access point(s) form OWNER’s Information Technology Division.
    1. **DDC CONTROL SYSTEM ADJUSTMENTS**
12. Make adjustments under operating conditions to provide sequence of operation for each control system per design intent. If required operating conditions cannot be obtained prior to completion date of the contract due to outdoor seasonal temperatures, return to the job site when requested by the OWNER and re-adjust control system when outdoor temperatures will permit proper operating conditions. Start re-adjustment within seven calendar days after notification.
    1. **PERFORMANCE AND ACCEPTANCE**
13. Test and calibrate each device including but not limited to the following for proper operation, connection, signal value or response.
    1. Building Controllers.
    2. Custom Application Controllers.
    3. Application Specific Controllers.
    4. Input / Output Devices. (Sensors, actuators and monitoring devices)
    5. Operator Interfaces.
14. Verify that systems are standalone and operable upon network failure.
15. Verify that systems return to normal operation automatically upon resumption of network operation or return of power.
16. Test each system for functions of the required control sequence of operation either by normal control operation or forced operation as required. Log and submit results.
17. Test the network for connectivity, data transmission rates, input/output responses, and other appropriate parameters Failure modes, including network failure, individual control system failure, and power outages, shall be simulated and responses logged, with any effects on network operation noted and corrected.
18. Test each preprogrammed time and holiday schedule.
19. Commissioning requirements of Divisions 01, 23, and 26 apply to this Section.
20. Schedule of Responsibilities: Refer to Appendix A. The schedule identifies the responsibilities of the CONTRACTOR for the installation of the environmental controls and energy management system. Deviations and clarifications of this schedule only if allowed by the OAR, provided trade CONTRACTOR coordination and schedule requirements are met. Submit a record copy of the Schedule of Responsibilities to the OAR at the commencement of this Section’s Work.
    1. **WIRING AND INFRASTRUCTURE**
       * 1. Provide necessary wiring, terminations, connections and conduit infrastructure for the complete system as indicated in the construction documents.
         2. All panel wiring shall be label with Brady B-342 heat-shrink wire marker or OWNER approved equal.
         3. All field wiring shall be label on both end with Brady B-427 labels or OWNER approved equal.
         4. Exterior cables whether above or below ground level shall be rated for exterior applications. When entering a building provide a code sized pull box with necessary hardware to transition exterior rated cables to interior applications.
         5. Underground EMS communication cables are permitted to be installed with lighting control communication wiring in underground applications.
         6. Provide both labeling and record documentation for all EMS system cabling. A cable management schedule and diagram shall be provided at each system panel or cabinet, in addition to a complete cabling diagram to be provided at the head end equipment location.
21. The cable management spread file shall include the following:
22. Cable Schedule.
23. Cable Test Forms.
24. Cable Label sequence and nomenclature.
25. Network chart.
26. Cable numbering shall be based on a defined format which readily identifies cable type and allows maintenance technicians to determine originating and terminating locations.
27. Present the data in an Excel spreadsheet that will operate on the latest Windows platform. Information shall be presented in paper and electronic formats.
28. A copy of the plastic laminated cable schedule in a transparent plastic sleeve shall be affixed in the interior side of the front door of each network cabinet or cables convergence hub points.
    1. **DATA LOGGING REQUIREMENTS**

A. The system must be capable of storing the system’s collected and diagnosis data for a minimum of seven days.

B. Program the system for a standard seven-day schedule including holidays.

* 1. **CLEANUP**

A. Remove rubbish, debris and waste materials and legally dispose of off Project Site.

* 1. **PROTECTION**
     1. Protect Work of this Section until Substantial Completion.

END OF SECTION

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **appendix a**  **SCHEDULE OF RESPONSIBILITIES** | | | | | | | | | | | | | | |
|  |  | ITEM |  | Furnish | | |  | Install | | |  | Power |  | Control |
|  |  |  |  | By | | |  | By | | |  | By |  | Wiring By |
| 1 | Magnetic Motor Starters: | |  |  | | |  |  | | |  |  |  |  |
|  | a. Automatic controlled, with or without HOA switches. | |  | E | | |  | E | | |  | E |  | DDC |
|  | b. Manually controlled | |  | E | | |  | E | | |  | E |  | N/A |
|  | c. Manually controlled furnished as factory wired unit equipment | |  | M | | |  | M | | |  | E |  | E |
|  | d. Special duty type (part winding, multi-speed, etc.) | |  | M | | |  | See Note 1 | | |  | E |  | See Note 1 |
|  | e. Adjustable frequency drives with or without manual bypass. | |  | DDC | | |  | E | | |  | E |  | DDC  See Note 2 |
|  | f. Domestic booster pump. Motor Controls | |  | M | | |  | M | | |  | E |  | DDC |
| 2 | Line voltage contactors. | |  | E | | |  | E | | |  | E |  | DDC |
| 3 | Control relay transformers (other than starters). | |  | DDC | | |  | DDC | | |  | E |  | DDC |
| 4 | Control and Instrumentation panels | |  | DDC | | |  | NI | | |  | E |  | DDC |
| 5 | Automatic control valves, automatic dampers and damper operators, solenoid valves, insertion temperature and pressure sensors including wells | |  | DDC | | |  | M | | |  | E |  | DDC |
| 6 | Control interlock wiring between chillers, pumps, cooling towers, fans and air handling units and other miscellaneous mechanical equipment. | |  | DDC | | |  | DDC | | |  | E |  | DDC |
| 7 | Duct Smoke Detectors | |  | E | | |  | M | | |  | E |  | E |
| 8 | Dampers | |  |  | | |  |  | | |  |  |  |  |
|  | a. Control Dampers | |  | M | | |  | M | | |  | N/A |  | DDC |
|  | b. Smoke Dampers and Combination Fire/Smoke Dampers | |  | M | | |  | M | | |  | E |  | E |
| 9 | Airflow Stations with transmitter. | |  | M | | |  | M | | |  | E |  | DDC |
| 10 | Air terminal devices (I.e., VAV and fan powered boxes). | |  | M | | |  | M | | |  | E |  | DDC |
| 11 | Intelligent Devices and Control Units provided with packaged mechanical equipment such as: Large VAV and constant volume package units Boilers and Chillers. | |  | M | | |  | M | | |  | E |  | NI |
| 12 | Intelligent Devices and Control Units not provided by equipment manufacturer such as: Air handling units, Heat pumps, AC units (small < 20 tons), Air terminal units (VAV boxes) | |  | DDC | | |  | DDC | | |  | E |  | DDC |
| 13 | Intelligent Devices and Control Units provided with electrical systems such as: Occupancy / motion sensors, Lighting Control Panels, Switches and dimmers, Switch Multiplexing Control Units, Door Entry Control Units. | |  | E | | |  | E | | |  | E |  | DDC |
| 14 | Gateways for proprietary non-BACnet equipment | |  | M | | |  | M | | |  | E |  | DDC |
| 15 | Communications network devices such as Routers, Bridges and Repeaters. | |  | DDC | | |  | DDC | | |  | DDC |  | DDC |
| Abbreviations | |  |  |  | | |  |  | | |  |  |  |  |
| DDC |  | DDC CONTRACTOR (controls CONTRACTOR) | | | | | | |  |  |  |  |  |  |
| M |  | Mechanical CONTRACTOR | | |  |  | | |  |  |  |  |  |  |
| E |  | Electrical CONTRACTOR | | |  |  | | |  |  |  |  |  |  |
| N/A | | Not Applicable | | |  |  | | |  |  |  |  |  |  |

Notes:

* 1. Magnetic motor starters (special duty type) shall be set in place under electrical division except when part of factory wired equipment, in which case they shall be set in place under mechanical division.
  2. Where a remote motor disconnect is required in addition to the one provided integral to a Variable Frequency Drive (VFD), controls CONTRACTOR shall provide the necessary control interlock between the disconnects.