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UW Project No. 204975
Buffalo Design
13 July 2018

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PART 1 – GENERAL

1.1   RELATED DOCUMENTS

A.   Drawings and Divisions 00 and 01, apply to this Section.

B.   Related Sections:

1.   Division 23.
2.   Division 26.
3.   Division 27.

1.2   SUMMARY

A.   This Section includes control equipment for HVAC systems, including control components, wiring and piping for equipment not directly controlled by the DDC system. Control system consists of DDC controllers, sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories connected to controllers to operate systems according to sequences of operation indicated. The control systems shall be designed such that each mechanical system shall be capable of operating under stand-alone mode. System Software shall be updated to the latest version at project completion.

B.   Electrical equipment, components and accessories shall be U.L. Listed and Labeled.

C.   DDC system and components shall be BACnet Data Communications Protocol compliant. Controllers, devices and components shall be listed by BACnet Testing Laboratories.

D.   DDC system and components shall be Lon Works Data Communications Protocol compliant.

E.   Emergency Power: DDC controller (with Uninterruptible Power Supply) and components shall be furnished with emergency power if equipment controlled is being installed with emergency power.

F.   [Existing][Building][Campus] DDC system [Insert Existing DDC Manufacturer] will be extended and connected to new DDC system.

G.   Existing DDC controller shall be replaced or upgraded if not compatible with new DDC system. Existing controllers, firmware, sensors, actuators and components not compatible with new DDC system shall be replaced. Existing DDC system will be required to operate on operating software specified herein. Gateways will not be allowed to communicate with the existing DDC system.

H.   Unless otherwise indicated, the existing DDC system shall remain operational. Temporary services shall be provided as needed to maintain operations in occupied areas. Disruption in service shall be coordinated and approved by the owner prior to execution of work.

1.3   SUBMITTALS

A.   General: See Division 23 Section "Common Mechanical Materials and Methods" for general requirements of Product Data, Shop Drawings, Reports and Certificates, and Operation and Maintenance data submittals.

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1. Product Data: Include manufacturer's technical Product Data for each control device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions. Hardware: Include technical data for workstations, controllers, transducers/transmitters, sensors, actuators, and components.

2. Software: Include technical data for operating system software, operator interface, graphics, and other third party applications.

B. Shop Drawings (AutoCAD latest version) from manufacturer detailing equipment assemblies, indicating dimensions, weights, loadings, required clearances, and methods of field assembly, components, and location and size of each field connection. Include the following:

1. Schematic flow diagram for each system type showing fans, pumps, boilers, chillers, coils, dampers, valves, and control devices.

2. Each control device labeled with setting or adjustable range of control.

3. Diagrams for all required electrical wiring. Clearly differentiate between factory-installed and field-installed wiring. Label/tag all field installed wiring.

4. Details of control panel faces, including controls, instruments, and labeling.

5. Detailed written description of control sequence of operation.

6. Communication trunk cable schematic showing system architecture, workstations, DDC controller's locations and trunk data conductors.

7. Listing of connected data points, including connected control unit and input device.

8. Sample of color system graphics diagrams indicating monitored systems, data (connected and calculated) point addresses, and operator notations.

9. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.

C. Schedules: Valve schedules identifying valve size, fail-safe position, flow, Cv, actual pressure drop and equipment served. Damper schedules identifying damper size, fail-safe position, pressure drop and equipment served.

D. Field Quality Control and Testing: Test Plans forms which will be used to verify operation of all points and control functions.

E. Certificates: Data Communication Protocol.

1.4 COORDINATION

A. Ensure installation of components is complementary to installation of similar components in other systems.

B. Coordinate installation of DDC system components, control wiring and piping requirements with installation of mechanical systems equipment.

C. Coordinate installation of components (dampers, valves, flow measurement, meters, etc.) provided under this section and to be installed by other sections.

D. Ensure each system is completed calibrated, tested and operational prior to commissioning. Coordinate and provide support for Pre-Functional and Functional Performance Testing.

E. Coordinate and support test/balance contractor for all balancing requirements.

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F.   Coordinate and provide compatible components with proper communication protocol for interface with equipment being furnished.

1.5   OPERATION AND MAINTENANCE DATA

A.   Maintenance data for control systems equipment to include in the operation and maintenance manual specified in Division 23 Section "Common Mechanical Materials and Methods." Include the following:

   1.   Maintenance instructions and spare parts list (including unit cost) for each type of control device.
   2.   Interconnection wiring diagrams with identified and numbered system components and devices.
   3.   Step-by-step procedures indexed for each operator function.
   4.   Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
   5.   Calibration records and list of set points.

B.   Project Record Documents:

   1.   Accurately record actual location of control components, including panels, controllers, thermostats, and sensors.
   2.   Shop drawings reflecting actual installation and operating sequences.
   3.   Include data specified in "Submittals" in final form.
   4.   System software flow chart reflecting operating sequences.
   5.   Documented results of Field Quality Control and Testing Plan.
   6.   Certificate stating that control systems have been tested and adjusted for proper operation.
   7.   Software License Agreements

1.6   QUALITY ASSURANCE

A.   Comply with the latest edition adopted by the Authority Having Jurisdiction of the following codes, regulations and standards:

   1.   City, county, state and federal regulations and codes including amendments
   2.   National Fire Code NFPA 70 "National Electric Code."
   3.   National Fire Code NFPA 90A "Installation of Air-Conditioning and Ventilating Systems."
   4.   Underwriters Laboratories UL 916 "Energy Management Equipment."
   5.   Underwriters Laboratories UL 864 "Smoke Control System Equipment."
   6.   National Fire Code NFPA 92A "Smoke Control Systems."
   7.   National Fire Code NFPA 92B "Smoke Management Systems."
   8.   ANSI/ASHRAE Standard 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
   9.   BACnet Testing Laboratories (BTL): Devices and products utilized in the BACnet interface shall be BTL listed and label.
   10.   [Lon Works Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.]

1.7   SERVICE AND GUARANTEE

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A.   After completion of the system, including software, submit a warranty in accordance with Division 01. Provide all services, materials and equipment necessary for the successful operation of the DDC hardware and controls during the warranty period. Preventive maintenance shall be included. Software and data shall be revised and updated as necessary during warranty period to maintain system performance.

B.   During the warranty period provide a 24-hour emergency service number where a qualified automation service technician familiar with the installed system may be reached. This service technician shall have the capability of remotely communicating with the system for troubleshooting and program alterations.

C.   Provide inspection for opposite season to test, calibrate, and adjust controls. Submit written report for each inspection.

1.8   DELIVERY, STORAGE, AND HANDLING

A.   Store equipment and materials inside and protected from weather.

B.   [Factory Mounted Controls: Where Factory-Mounted Controls are indicated to be factory mounted on equipment, arrange for shipping, packing and labeling of control devices to the equipment manufacturer. Installation requirements, wiring schematics shall be furnished and coordinated directly with respective unit manufacturer. Unless otherwise indicated, all cost associated with factory-mounted controls and wiring shall be included under this section.]

1.9   EXTRA MATERIALS

A.   Furnish spare materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels clearly describing contents. Spare materials used during warranty shall be replaced.

B.   Spare Parts: As a minimum, provide the following spare parts:

1.   Space Temperature Sensors with covers: 5 percent of the installed system or minimum quantity of 3.
2.   Duct and Pipe Temperature Sensors: 5 percent of the installed system or minimum quantity of 2 of each type.
3.   Terminal Unit Actuators (Damper and Valve): 5-percent of the installed system or minimum quantity of 2 of each type.
4.   DDC Controller Power Supplies: Minimum quantity of 1 of each type.
5.   DDC Controller I/O Boards: Minimum quantity of 1 of each type.
6.   Replacement Materials: Provide one replacement diaphragm or relay mechanism for each unique pneumatic damper motor, valve motor, controller, thermostat, and positioning relay.
7.   Binary Water Detector: Minimum quantity of 1 of each type.

PART 2 – PRODUCTS

2.1   MANUFACTURERS

A.   Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1.   Approved Manufacturers:

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        a.   Johnson Controls / Johnson Controls, Inc. (By Manufacturer's Local Branch Office) – Sole Sourced – No Substitutions

    2.   Manufacturers Qualifications: A minimum of 5 (equivalent size and complexity of this project) operational systems within the last 5 years utilizing similar components located in the same State or within 100 miles of project site. Manufacturer or authorized manufacturer's on-site service support shall also be available within the same location parameters indicated.

    3.   Technician Qualifications: Direct employee of manufacturer of primary control system with a minimum of 5 years of experience for systems programming, startup, trouble-shooting and diagnostics.

    4.   Installer Qualifications: By the District Office of the manufacturer as a subcontract, or by a firm regularly engaged in the installation of building direct digital HVAC control systems for a period of not less than 5 years. The entire control system shall be installed by qualified electricians and mechanics, all of which are properly trained and qualified for the work they perform, and directly supervised by the local representative of the component manufacturer.

2.2   BASIC DDC SYSTEM

A.   General: The Direct Digital Control (DDC) System shall be fully integrated and installed as a complete package of controls and instrumentation. The system shall include, but not limited to, all computer software and hardware, operator input/output devices, sensors and controls required for complete operation. Provide all wiring, installation, supervision and labor, including calibration, adjustments, operator training and checkout necessary for a complete and fully operating system.

B.   Integrate this facility with existing Central Operator Workstation(s). Communication network shall be extended connected such that the Operator has access to all facilities via the same log in screen and will utilize the same program commands, control loop software programming languages, and graphics representation as with all other similar systems on the facility wide DDC system. Facility Central Operator Workstation(s) shall be upgraded to the latest software version and any additional software as specified herein will be included. [Hardware shall be upgraded or replaced to support software operations.][Gateways shall not be used to communicate with existing system without prior approval.]

2.3   OPERATOR WORKSTATION

A.   Provide a Personal Computer/Server Workstation at project site for command entry, information management, network alarm management, and database management functions. All real-time control functions shall be resident in the Advanced DDC panels. Workstation shall be general purpose, commercially available, personal computer with sufficient memory and processor capacity to perform all functions described in this specification. Provide sufficient hard drive disk storage to accommodate all fully configured point databases, all application databases, all graphics databases, all user-defined reports, and all historical data archives as described in this specification. Provide the capacity for future point expansion. System shall be able to support five times the initial point installation without system performance degeneration. Point shall be defined as individual line items on DDC point list. A cost allowance shall be allocated for each operator workstation to provide the latest technology available. System shall be provided with or upgraded to the latest and fastest processor, configured with standard peripherals and accessories available prior to commissioning start date. As a minimum, system shall be configured as follows:

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1.   Dual Quad Core Processor 2.93 GHz w/ 12MB L3, 5.86GT/s.6GB, 1333MHz, DDR3 RDIMM Memory. 256GB Solid State Hard Drive. Integrated 16X CD-RW/DVD. (8) external USB 2.0, (1) Parallel, (1) Serial, (2) IEEE 1394a, (2) PS/2and (1) ESATA. Headphone/Speaker, Line-in and Microphone Jacks. Complete with operator workstation software. 19.0" LCD Flat Panel Monitor with adjustable stand. Integrated 2GB Graphics with VGA Out. Keyboard and USB Optical Mouse. V.92 56K Data/Fax Modem. Integrated 10/100/1000 GB Ethernet controller. 1000 VA, 120V power saving UPS System and Surge protection.

2.   Printer: Color laser printer 600x600 dpi optimized color resolution, 250-sheet tray with 256MB memory and printer cable.

B.   Laptop Computer: Provide [one] laptop computer for operator readout of system variables, override control, servicing, trouble-shooting and adjustment of control parameters. Provide all software and hardware necessary for interface at Advanced DDC panels, application Specific digital controllers, variable air volume terminal unit controllers, and at space temperature sensors. As a minimum, system shall be configured as follows:

1.   Quad Core 2.5 GHz, Processor, 8.0GB, DDR3-1333MHz SDRAM Memory. 128GB (SATA3) Solid State Hard Drive. Docking Base with Integrated 8XCD-RW/DVD. VGA on Docking Base: (2) USB 3.0, IEEE 1394a VGA, Parallel, Serial and PS/2. 15.6" HD (1366x768) Anti-Glare LED Backlit LCD Display. 2GB Graphics with VGA Out. Full-Sized backlit Keyboard and EZ Pad Pointing Device. 4Minimum 5 hours Battery with AC Adaptor. Wireless LAN. Integrated 10/100/1000 GB Ethernet. Surge protection and carrying case.

C.   [Manufacturer's Portable Operator Terminal: Provide [one] portable full function operator terminals for operator readout of system variables, override control, servicing, trouble-shooting and adjustment of control parameters. Provide all software and hardware necessary for interface at advanced DDC panels, Application Specific digital controllers, variable air volume terminal unit controllers, and at space temperature sensors. If a DDC panel, controller or sensor requires a different portable operator terminal for interface, provide one of each type. Complete with carrying case.]

D.   Provide Web access to the DDC system to monitor alarms, graphics, override and command set points and control parameters, create and override schedules, and generate reports.

2.4   WEB BROWSER

A.   Provide Web server hardware and software for web based graphical user interface for monitoring and control of the DDC system.

B.   Provide Web based user interface hardware and software to control and display data from all field panels.

2.5   OPERATOR WORKSTATION SOFTWARE

A.   Command Entry/Menu Selection Process: Provide all software for a complete and operational system as described herein. Software shall be multi-tasking, multi-user operating system for operator consoles and controllers, network communication software for dial-up and hard wired trunk applications, operator man-machine interface software, control application software and all other software necessary to provide the functions specified. Operator workstation shall use Microsoft "Windows" operating platform with high speed Internet access. Operator Workstation interface software shall minimize operator training through the use of

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English language prompting, English language point identification, and industry standard PC application software. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change set points from graphical displays through the use of a mouse or similar pointing device.

B.   Password Protection: Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and database manipulation capabilities as he deems appropriate for each user, based upon an assigned password.

1.   Passwords shall be exactly the same for all operator devices, including portable or panel-mounted network terminals. Any additions or changes made to password definition shall automatically cause passwords at all DDC panels on a network to be updated and down loaded to minimize the task of maintaining system security. Users shall not be required to update passwords for DDC panels individually.

2.   A minimum of 10 levels of access with a minimum of 200 user passwords shall be supported.

3.   Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices, and shall be limited to only those items defined for the access level of the password used to log-on.

4.   User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

C.   Operator Commands: The operator interface shall allow the operator to perform commands including, but not limited to, the following:

1.   Start-up or shutdown selected equipment.
2.   Adjust set points.
3.   Add/Modify/Delete time programming.
4.   Enable/Disable process execution.
5.   Lock/Unlock alarm reporting for each point.
6.   Enable/Disable Totalization for each point.
7.   Enable/Disable Trending for each point.
8.   Override PID Loop set points.
9.   Enter temporary override schedules.
10.   Define Holiday Schedules.
11.   Change time/date.
12.   Enter/Modify analog alarm limits.
13.   Enter/Modify analog warning limits.
14.   View limits.
15.   Enable/Disable Demand Limiting for each meter.
16.   Enable/Disable Duty Cycle for each load.

D.   Dynamic Color Graphics Software: System software shall provide user interface through which viewing and commanding may be done using a "mouse" pointing device. The operator shall be able to access to any level of desired system information without being required to enter any commands from the keyboard.

1.   Windowing: Windowing user interface shall be provided to allow operator to simultaneously view several different types of system displays at the same time to analyze system operation (i.e. air handling unit equipment graphic display and several trend graphs of associated space temperatures simultaneously displayed). The system shall be ca

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           pable of a graphic display associated with an alarm to be viewed without interrupting work in progress.

2. Dynamic Data Displays: Dynamic temperature values, humidity values, flow values, and status indication shall be shown in their respective locations, area served, and shall automatically update to represent current conditions without operator interface.

3. System Selection and Penetration: The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, or text based commands. Provide a logical penetration of graphical displays from a site plan on down to each level of digital controllers.

4. Graphics Generation: Graphics generation software shall be provided to allow the user to add, modify, or delete system graphic displays. A minimum of 15 colors shall be available for use. Provide a library of pre-engineered screens and symbols depicting standard HVAC components (e.g. fans, coils, filters, dampers, terminal units, heat pumps, circulation pumps, cooling towers, etc.).

E. Logs and Summaries:

1. Reports shall be generated automatically or manually, and directed to either displays, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

   a. A general listing of all points in the network.
   b. List all points currently in alarm.
   c. List of all off-line points.
   d. List all points currently in override status.
   e. List of all disabled points.
   f. List all points currently locked out.
   g. List of all items defined in a "follow-up" file.
   h. List all Weekly Schedules.
   i. List all Holiday Programming.
   j. List of Limits and Deadbands.

2. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the facility management system. Under no conditions shall the operator need to specify the address of hardware controller to obtain system information.

F. System Configuration and Definition: All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

G. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

1. Add/Delete/Modify Advanced DDC Panels.
2. Add/Delete/Modify Operator Workstations.
3. Add/Delete/Modify Application Specific Controllers.
4. Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants.
5. Add/Delete/Modify alarm reporting definition for each point.
6. Add/Delete/Modify control loops.
7. Add/Delete/Modify energy management applications.
8. Add/Delete/Modify time- and calendar-based programming.

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        9.   Add/Delete/Modify Totalization for every point.

       10.   Add/Delete/Modify Historical Data Trending for every point.

       11.   Add/Delete/Modify custom control processes.

       12.   Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data.

       13.   Add/Delete/Modify dial-up telecommunication definition.

       14.   Add/Delete/Modify all operator passwords.

       15.   Add/Delete/Modify Alarm Messages.

H.   Programming Description: The system shall permit an operator to create, modify and document all process control sequences including all DDC application software, energy management software, and alarm processes. Manufacturer latest technology programming methods shall be provided, i.e. modified basic, graphical or block programming format.

I.   Network-Wide Strategy Development: Inputs and outputs for any process shall not be restricted to a single Advanced DDC panel, but shall be able to include data from any Advanced DDC panel to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of the other processes (cascading).

J.   System Definition/Control Sequence Documentation: All portions of system definition shall be documented to provide hard copy printouts of all configuration and application data. Control process and DDC control loop documentation shall be provided in logical, graphical or block flow diagram format to allow control sequences to be easily interpreted and modified at any time in the future.

K.   Database Save/Restore/Back-Up: Back-up copies of all Advanced DDC panel databases shall be stored in at central operator workstation. Continuous supervision of the integrity of all DDC panel data bases shall be provided. In the event that any DDC panel on the network experiences a loss of its data base for any reason, the user shall have the ability to manually execute to download a new copy or any portions of the respective data base to restore proper operation.

L.   Third Party Software Package: Provide the capability and capacity to run specific third party software packages for word processing, spreadsheets and database management programs and shall provide for on-line data transfer from DDC network or from archived historical data. Use of third party software shall operate concurrently with other tasks such as alarm logging, and report data gathering. Provide software package to analyze trended point in graphic format with measured variable on y-axis and time variable on x-axis.

2.6   LOCAL AREA NETWORK

A.   Operator workstations and Advanced DDC panels shall reside directly on a local area network such that communications may be executed directly between controllers, directly between workstations, and between controllers and workstations on a peer to peer basis. All points connected to network shall be accessible through any operator workstation on the network. Any point on the network shall be available to any controller on the network for control loop processing.

B.   All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment. Access to system data shall not be restricted by the

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hardware configuration of the facility management system. The hardware configuration of the network shall be transparent to the user when accessing data or developing control programs.

C. Manufacturer's highest available speed data transfer rates shall be provided for all communications, alarm reporting, and quick report generation from controllers, and upload/download efficiency between network devices.

D. Provide synchronization of the real-time clocks in all DDC panels.

E. Local Area network communication trunk and software shall be configured to support project system requirements including, but not limited to, Advanced DDC panels, operator workstations, servers, and any other peer-to-peer devices residing on the network. Network shall have a minimum of 25-percent extra capacity of the installed system for future additions.

2.7 ADVANCED DDC PANELS

A. General: Advanced DDC panels shall be microprocessor based, multi-tasking, multi-user, real-time digital control processors. Modular in design and consisting of processor board with programmable memory, power supplies, and input/output (I/O) modules with manual override. Advanced DDC panels shall be provided for each primary air system, primary heating and cooling system to perform independent, stand-alone system operations. Each Advanced DDC panel shall have sufficient memory to support its own operating system and databases including:

1. Control processes.
2. Energy Management Applications.
3. Alarm Management.
4. Historical/Trend Data for all points.
5. Maintenance Support Applications.
6. Custom Processes.
7. Operator I/O.
8. Dial-Up Communications.
9. Manual Override Monitoring.

B. Each Advanced DDC panel shall support the following types of point inputs and outputs (Each Digital and Analog Outputs shall be provided with manual override):

1. Digital Inputs for status/alarm contacts.
2. Digital Outputs for on/off equipment control.
3. Analog Inputs for temperature, pressure, humidity, flow, and position measurements.
4. Analog Outputs for valve and damper position control, and speed capacity control of primary equipment.
5. Pulse Inputs for pulsed contact monitoring.
6. Spare points: Provide a minimum of [insert quantity] spare point for each Input/Output point type (not including pulse inputs).

C. Each Advanced DDC panel communication trunk and software shall be configured to support project requirements, including but not limited to, variable volume terminal unit controllers, and other application specific controllers residing on network. Network shall have a minimum of 25-percent extra capacity of the installed system for future additions. Controllers shall consist of any combination of future application specific controllers and variable air volume terminal unit controllers. Advanced DDC panels shall be provided with at least two serial data

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communication port for operator I/O devices such as industry standard printers, portable operator's terminals or portable lap-top computers. In lieu of above, one serial data communication port and a local operator access and display panel shall be provided.

D.   Each Advanced DDC panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. The DDC panel shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC panel, and shall not require the connection of an operator I/O device.

E.   In the event of the loss of normal power, there shall be an orderly shutdown of all advanced DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back-up shall be provided to support the real-time clock and all RAM memory. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual intervention. Should DDC panel memory be lost for any reason, the user shall have the capability of reloading the DDC panel via the local area network, via the local RS-232C port, or via telephone line dial-in.

F.   Provide NEMA enclosure rated for installed conditions. A local disconnect shall be provided at each controller to individually disconnect control power without interruption to any other controller.

2.8   ADVANCED DDC PANEL SOFTWARE

A.   All necessary software to form a complete operating system as described in this specification shall be provided. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher-level computer for execution. Provide multiple copies and licensing agreements as necessary to support the specified quantity of workstations and portable terminals.

B.   Pre-Tested Control Algorithms: The DDC panels shall have the ability to perform the following pre-tested control algorithms:

1.   Two Position Control.
2.   Proportional Control.
3.   Proportional plus Integral Control.
4.   Proportional, Integral, plus Derivative Control.
5.   Automatic Control Loop Tuning.

C.   Equipment Cycling Protection: Control software shall include a provision for limiting the number of times each piece of equipment may be cycled within any given time period.

D.   Heavy Equipment Delays: The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads.

E.   Power Failure Motor Restart: Upon the resumption of normal power, the DDC panel shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling, and turn equipment on or off as necessary to resume normal operation, including start time delays as described above.

F.   Energy Management and Applications:

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1. DDC Panels shall have the ability to perform any or all of the following energy management and application routines:

   a. Time of Day Scheduling.
   b. Calendar Based Scheduling.
   c. Holiday Scheduling.
   d. Temporary Schedule Overrides.
   e. Optimal Start.
   f. Optimal Stop.
   g. Night Setback Control.
   h. Enthalpy or Dry bulb Switch over (Economizer).
   i. Peak Demand Limiting.
   j. Temperature Compensated Load Rolling.
   k. Fan Speed/CFM Control.
   l. Heating/Cooling Interlock.
   m. Hot Water Reset.
   n. Chilled Water Reset.
   o. Condenser Water Reset.
   p. Air Handling Unit Control and Sequencing.
   q. Chiller Control and Sequencing.
   r. Boiler Control and Sequencing.
   s. Cooling Tower Control and Sequencing.
   t. Fire Alarm, Lighting and Security Controls Interface.
   u. Power, Water and Natural Gas Utilities Monitoring and Recording.

2. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow user customization. Programs shall be applied to building equipment as described in the sequence of operation.

G. Custom Process Programming Capability: DDC panels shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

   1. Process Inputs and Variables: It shall be possible to use any of the following in a custom process:

      a. Any system-measured point data or status.
      b. Any calculated data.
      c. Any results from other processes.
      d. User-Defined Constants.
      e. Arithmetic functions (+, -, *, /, square root, exp., etc.) - Boolean logic operators (and, or, exclusive or, etc.) - On-delay/Off-delay/One-shot timers.

   2. Process Triggers: Custom processes may be triggered based on any combination of the following:

      a. Time interval.
      b. Time of day.
      c. Date.
      d. Other processes.
      e. Time programming.
      f. Events (e.g., point alarms).

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H. Dynamic Data Access: A single process shall be able to incorporate measured or calculated data from any and all other DDC panels on the local area network. In addition, a single process shall be able to issue commands to points in any and all other DDC panels on the local area network.

I. Advisory/Message Generation: Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device, buffer the information in a follow-up file, or cause the execution of a dial-up connection to a remote device such as a printer or pager.

J. Custom Process Documentation: The custom control programming feature shall be self-documenting. All interrelationships defined by this feature shall be documented via graphics flowcharts and English language descriptors.

K. Alarm Management: Alarm management shall be provided to monitor, buffer, and direct alarm reports to operator devices and memory files. Each DDC panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall the DDC panel's ability to report alarms be affected by either operator activity at a PC Workstation or local I/O device, or communications with other panels on the network.

1. Point Change Report Description: All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.
2. Prioritization: The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of three priority levels shall be provided. Each DDC panel shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point. The user shall also be able to define under which conditions point changes need to be acknowledged by an operator, and/or sent to follow-up files for retrieval and analysis at a later date.
3. Report Routing: Alarm reports, messages, and files will be directed to a user-defined list of operator devices, or PC's used for archiving alarm information. Alarms shall also be automatically directed to a default device in the event a primary device is found to be off-line.
4. Alarm Messages: In addition to the point's descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response.
5. Alarms shall be generated for, but not limited to the following:

    a. Motor is commanded on or off but motor status input indicates no change.
    b. Room temperature or static pressure strays outside selectable limits.
    c. An analog input takes a value indicating sensor failure.
    d. A module or node is "dead" to the LAN.
    e. A power outage occurs.

L. Historical Data and Trend Analysis: A variety of Historical data collection utilities shall be provided to automatically sample, store, and display system data in all of the following ways.

1. Point Histories: Advanced DDC panels shall continuously and automatically sample the value of all analog inputs on a user defined time or change of state intervals.
2. Extended Sample Period Trends: Measured and calculated analog and binary data shall also be assign able to user-definable trends for the purpose of collecting operator

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specified performance data over extended periods of time. Sample intervals shall be operator selected change of value based or time based shall be provided. Each advanced DDC panel shall have a dedicated buffer for trend data.

3. Data Storage and Archiving: Trend data shall be stored at the Advanced DDC panels, and uploaded to hard disk storage when archives is desired. Uploads shall occur based upon either user-defined interval, manual command, or when the trend buffers become full.

M. Runtime Totalization: Advanced DDC panels shall have the capability to automatically accumulate and store runtime hours for all binary input and output points.

1. The totalization routine shall have a sampling resolution of one minute or less.
2. The user shall have the ability to define a warning limit for runtime totalization. Unique, user-specified messages shall be generated when the limit is reached.

N. Analog/Pulse Totalization: Standalone DDC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

1. Totalization shall provide calculation and storage of accumulations of up to 99,999.9 units (e.g. KWH, gallons, KBTU, tons. etc.).
2. The totalization routine shall have a sampling resolution of one minute or less.
3. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

O. Event Totalization: Advanced DDC panels shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly, or monthly basis.

1. The event totalization feature shall be able to store the records associated with a user defined minimum before reset.
2. The user shall have the ability to define a warning limit. Unique, user-specified messages shall be generated when the limit is reached.

P. Interlocking:

1. Permit events to occur, based on changing condition of one or more associated master points.
2. Binary contact, high/low limit of analog point or computed point shall be capable of being utilized as master. Same master may monitor or command multiple slaves.
3. Operator Commands:

   a. Define single master/multiple master interlock process.
   b. Define logic interlock process.
   c. Lock/unlock program.
   d. Enable/disable interlock process.
   e. Execute/terminate interlock process.
   f. Request interlock type summary.

2.9 APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controllers shall be fully programmable or pre-programmed to support, but not be limited to, the control of the following configurations of Unitary equipment to ad

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dress current requirements as described in the sequence of operation, and for future expansion. Controllers shall support all the necessary point inputs and outputs to perform the specified control sequences in a totally stand-alone fashion. Application programs and parameter data shall be stored in nonvolatile memory:

1. Unit Ventilators (ASHRAE Cycle I, II, III, or W).
2. Heat Pumps (Air to Air, Air to Water).
3. Packaged Rooftops.
4. Fan Coils and Air Conditioning Units.
5. Cabinet Heaters, Unit Heaters, Convectors, and Radiators.

B. The modes of operation supported by the Controllers shall include, but not be limited to, the following:

1. Day/Weekly Schedule.
2. Comfort/Occupancy Mode.
3. Economy Mode (Standby Mode, Unoccupied, etc.).
4. Temporary Override Mode.

C. The operator interface to any Application Specific controller point data or programs shall be through any network-resident PC workstation, any PC or portable operator's terminal connected to any DDC panel in the network, or through terminal jack at room temperature sensor.

D. Provide NEMA enclosure rated for installed location. A local disconnect shall be provided at each Application Specific controller to individually disconnect control power without interruption to any other digital controller.

2.10 APPLICATION SPECIFIC VARIABLE VOLUME TERMINAL UNIT CONTROLLERS (VAV)

A. VAV Terminal Unit Controllers be fully programmable or pre-programmed to support, but not be limited to, the control of the following configurations of terminal units to address current requirements as described in the sequence of operation, point schedule, and for future expansion. Application programs and parameter data shall be stored in nonvolatile memory.

1. Single Duct Only (Constant Volume, Cooling Only, or Cooling with Reheat).
2. Fan Powered (Parallel or Series).
3. Dual Duct.

B. VAV Terminal Unit Controllers shall support the following types of input and output points:

1. Proportional Cooling Output.
2. Proportional Heating Output.
3. Fan Control Output (On/Off Logic, or Proportional Series Fan Logic).
4. Fan Status Input.
5. Space Temperature Input.
6. Velocity Sensor Input.
7. Auxiliary Temperature Input.
8. Override Push-button.

C. The modes of operation supported by the VAV Terminal Unit Controllers shall include, but not be limited to, the following:

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        1.   Day/Weekly Schedule.
        2.   Comfort/Occupancy Mode.
        3.   Economy Mode (Standby Mode, Unoccupied, etc.).
        4.   Temporary Override Mode.

D.   The operator interface to any VAV controller point data or programs shall be through any network-resident PC workstation, any PC or portable operator's terminal connected to any DDC panel in the network, or through terminal jack at room temperature sensor.

E.   Provide NEMA enclosure rated for plenum use. A local disconnect shall be provided at each VAV controller to individually disconnect control power without interruption to any other digital controller.

2.11   SURGE PROTECTION

A.   Power Line Surge Protection Surge suppressers external to digital controller, shall be installed on all incoming AC power. Surge suppresser shall be rated by UL 1449 (latest edition), and have clamping voltage ratings below the following levels:

        1.   Normal Mode (Line to Neutral): 350 Volts.
        2.   Common Mode (Line to Ground): 350 Volts.

2.12   UNINTERRUPTIBLE POWER SUPPLIES (UPS)

A.   UL Listed, Uninterruptible Power Supplies (UPS) for power interruptions and impulses. UPS shall be rated by UL 1778.

B.   Rechargeable batteries with 15-30 minutes minimum back-up time. Complete with low battery and AC voltage status alarm indication via RS-232 or dry contact relay module.

2.13   WIRING

A.   AC Control Wiring:

        1.   Control wiring for 24 V circuits shall be insulated copper 18 AWG minimum and shall be rated for 300 VAC service.
        2.   Wiring for 120 VAC shall be 14 AWG minimum and shall be rated for 600 VAC service.

B.   DDC Analog Signal Wiring: Analog signal wiring for analog inputs and analog outputs shall be 18 AWG single or multiple twisted pair. Each pair greater than one shall be 100 percent shielded, and have 20 AWG drain wire. Exception is direct connect RTD wiring, which shall be 18 AWG minimum twisted pair, 100 percent shielded, and with 20 AWG drain wire. Each wire shall have insulation rated to 300 VAC. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape, overall 20 AWG tinned copper cable drain wire, and overall cable insulation rated to 300 VAC.

C.   Plenum Cable: Plenum cable shall be UL approved for use only in accessible ceiling spaces. Plenum cable external to electrical raceway is permissible in the following locations:

        1.   DDC communication trunk serving application specific controllers within a building.
        2.   DDC system sensor wire installed above suspended accessible ceilings.

2.14   CONTROL COMPONENTS

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A.   Temperature Sensors:

   1.   Duct or pipe temperature sensors shall be nickel or platinum type RTD's, factory calibrated within plus or minus [0.1] degrees F.
   2.   Use insertion elements in ducts not affected by temperature stratification. Use averaging elements in duct prone to stratification with length at least the widest dimension of the duct cross section.
   3.   Insertion elements for liquids shall be stainless steel encased and matched with the temperature wells installed with a minimum insertion length of 2-1/2 inches.
   4.   Provide outside air temperature sensors with watertight inlet fitting, shielded from direct rays of sun.
   5.   Room Temperature Sensors: Analog or thermistor type complete with mounting bracket and cover. Each room temperature sensor shall be provided with an integral terminal jack for laptop or portable operators terminal interface and with the following:

      a.   [Blank Cover.]
      b.   [LCD Display.]
      c.   [Temperature Set point Adjustment.]
      d.   [Override Timer Pushbutton.]

   6.   Room sensors located in areas subjected to damage shall be provided with protective guard.

B.   Spans and Ranges:

   1.   Temperature:

      a.   50 degrees F span: Room, chilled water, cooling coil discharge air, return air sensors.
      b.   100 degrees F span: Outside air, hot water, heating coil discharge air, mixed air sensors.
      c.   200 degrees F span: High temperature hot water, heating hot water, chilled/hot water system sensors.

   2.   Pressure:

      a.   [-0.25 to .25][-0.5 to 0.5] inches of water differential range: Static pressure of rooms.
      b.   [0 to 4] inches of water differential range: Duct static pressure.
      c.   [0 to 25][0 to 50] psi of water differential range: Heating Water and Chilled Water System differential pressure,

   3.   Humidity:

      a.   0-100 percent relative humidity.

C.   Differential Static Pressure Sensors/Transmitters: Integral pressure transducer and transmitter. Output of pressure instrument shall be 4-20 mA signal proportional to the pressure span. Accuracy shall be 1.0-percent, linearity shall be 0.1-percent. Supply voltage shall be 24 V. Unidirectional with range not exceeding 150-percent of maximum expected input. For Building pressure measurements, provide wall plate (Dwyer A-465 or equal) for indoor building pressure sensor and equalizing plate (Dwyer) for atmospheric reference.

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D.   Dynamic Pressure Sensors/Transmitters:

1.   UL Listed, microprocessor based with flash memory, bidirectional or unidirectional dynamic pressure and airflow measurement assembly. Complete with sensor, transmitter, enclosure, mounting kit and UL plenum rated cabling. Installed accuracy shall be 2-percent airflow (0-3000 cfm FPM), 4-percent dynamic pressure (+0.5 in w.g.) and repeatability shall be +0.25-percent of reading. Sensor assembly shall consist of hermetically sealed thermistors in weather-proof housing. Transmitter output shall be fused, isolated and linear (4-20 mA or 0-10 VDC). 12-bit A/D converter with 0.1-percent output resolution.

2.   [Coordinate with Division 23 Section "Air Duct Accessories" for installation provisions.]

3.   Manufacturer: Ebtron, Inc.

E.   Relative Humidity Transmitters: Integral humidity transducer and transmitter. Output of relative humidity instrument shall be a 4 to 20 milliampere signal proportional to 0 to 100 percent relative humidity input. Accuracy shall be 2 percent of full scale within the range 20 to 80 percent relative humidity. Sensing element shall be chilled mirror type, polymer, or thin film polymer type. Supply voltage shall be 24 V DC.

F.   Binary Water Leak Detectors: When water is present at sensor probes, the relay releases and returns to a non-powered state. During a powered steady state condition, the contacts will change states and signal an alarm condition if:

1.   A leak is detected.

2.   An internal malfunction occurs.

3.   Power is lost to the sensor.

4.   Three types of sensors are common and used depending on locations:

a.   Wet floor and secondary pans, remote spot sensor probe typical in overflow pipes or at drains.

b.   Wide area protection such as Data Room ceilings and crawlspaces, water sensing cable (Basis of Design: Dorlen Products).

5.   Manufacturers:

a.   Darwell Technology Systems.

b.   Honeywell.

c.   Siemens.

d.   Dorlen Products Inc.

e.   Building Automation Products Inc.

G.   Binary Fuel/Oil Leak Detectors: When oil is present at sensor probes, the relay releases and returns to a non-powered state. During a powered steady state condition, the contacts will change states and signal an alarm condition if:

1.   A leak is detected.

2.   An internal malfunction occurs.

3.   Power is lost to the sensor.

H.   VAV Terminal Box Control Components:

1.   Actuator: DDC manufacturer's standard DDC system compatible VAV terminal unit damper actuator for each terminal unit. VAV terminal unit actuator shall be [field in

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stalled][provided to the terminal box manufacturer for factory installation. Coordinate with Division 23 Section "Air Terminal Units"].

2. Air Flow Sensor: Sensor shall be provided by VAV terminal unit manufacturer.

3. Differential Pressure Transducer: DDC manufacturer's standard DDC system compatible VAV terminal unit differential pressure transducer for each VAV terminal unit. VAV terminal unit pressure transducer shall be [field installed][provided to the terminal box manufacturer for factory installation. Coordinate with Division 23 Section "Air Terminal Units"]. The differential pressure transducer shall accept air flow measurement signal from the terminal box air flow sensor.

I. Actuators: Actuators shall have ISO 9001 quality certification and shall be UL Listed. Provide for all motor-operated dampers, valves, and AHU fan flow control device of sufficient size and type, matched to application and rated for maximum operating temperature/pressures conditions.

1. Electric or Electronic Actuators: Solid state positioner to stop automatically at end of travel. Complete with permanently lubricated gear train. Provide proportional, or 2-position (with adjustable SPDT auxiliary end-switch) actuators. Provide with spring return to normally-open or normally-closed on loss of control power. Power return type actuators shall not be acceptable. Modulating actuators shall be provided with position feedback signal corresponding to the actual valve position. All actuators shall be provided with visual position indicator. Substitution for 3-point floating type actuators suitable for pulse width modulation control in lieu of analog type actuators shall be permitted only for terminal units, [Unit Heaters][,][Fan Coil Units][,][Cabinet Heaters], [Finned Tube Radiation][,][and][Convectors]. Use of non-analog type actuators for any other applications shall not be allowed without prior approval. [Provide position feedback for actuators as indicated in "DDC Point List".]

2. [Pneumatic Actuators: Proportional or two position actuators with spring return to normal position on loss of control air. Pilot positioning devices shall be provided for modulating applications.]

J. Control Dampers: Low leakage control dampers where not furnished with package units. Extruded aluminum airfoil shape automatic control dampers with interlocking metal edge blades. Maximum blade width is 6-inches. Leakage rate, according to AMCA 500, "Test Methods for Louvers, Dampers and Shutters," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch w.g. pressure differential. Blade linkage shall be out of the airstream. Where possible use damper shafts that extend 6-inches past damper frame. [Coordinate with Division 23 Section "Air Duct Accessories" for installation provisions.]

1. Manufacturers:

   a. TAMCO.
   b. Ruskin CD-50.
   c. [Approved equal].

K. Control Damper Blade Position Indicator: Switch kit to sense open and closed position of damper blade.

L. Control Valves: Valves shall have stainless steel stems and stuffing boxes with extended necks to clear the piping insulation. Valve bodies shall be designed for not less than 125 psig working pressure or 150 percent of the system operating pressure, whichever is greater. Valve leakage rating shall be 0.01 percent of rated Cv. Unless otherwise specified, bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends;

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bodies for 2 inch valves shall have threaded ends; and bodies for 2 inches to 3 inches shall be of brass, bronze or iron. Bodies for valves 2-1/2 inches and larger shall be provided with flanged-end connections. Valve Cv shall be within 100 to 125 percent of the calculated Cv. Valves shall provide effective control within pumping system total head pressure with a minimum of 100:1 turndown. Pressure drop not to exceed [5] psig at maximum flow rate for hydronic systems. [Coordinate with Division 23 Section "Hydronic Piping" for installation provisions.]

1. Two-Way Valves: Two-way modulating valves shall have equal-percentage characteristics.
2. Three-Way Valves: Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.
3. Valves for Chilled-Water and Condenser-Water: Internal valve trim shall be bronze except that valve stems may be type 316 stainless steel. Valves larger than 4 inches shall be butterfly.
4. Valves for Hot-Water Service Below 250 degrees F: Internal trim (including seats, seat rings, modulating plugs, and springs) of valves controlling water hotter than 210 degrees F shall be Type 316 stainless steel. Internal trim for valves controlling water 210 degrees F or less shall be brass or bronze. Nonmetallic parts of hot-water control valves shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.
5. Valves for Steam Service: Bodies for valves 4 inches and larger shall be iron. Internal valve trim shall be Type 316 stainless steel. Steam valves shall have linear characteristics.

M. Characterized Control Ball Valves (1/2" – 2"): Valves 1/2 inch through 2 inches shall be nickel plated forged brass body. NPT screw type with stainless steel ball, stem and fiberglass reinforced Telfon seats and seals. The valves shall have an ISO type 4 bolt flange with non-metallic thermal isolation adapter to provide stable mechanical connection. Flow type for modulating two-way valves shall be equal percentage. Three-way valves shall have equal percentage control port. The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service requiring no maintenance.

N. Pressure Independent Flow Control Valves: Control valve shall be pressure independent modulating type configured to maintain a constant differential pressure across the control surfaces. Cast iron, steel or bronze rated for 150-psig minimum working pressures. Valve internal components shall be stainless steel, steel, Teflon, brass, or bronze. 0 to100-percent design flow modulation with no more than +5-percent variation. Range-ability shall be 100:1 minimum. Valve flow characteristics shall be able to be changed without removing valve from piping system. Complete with Pressure/temperature ports to measure inlet/outlet/internal pressures and calibrated performance tag. [Coordinate with Division 23 Section "Hydronic Piping" for installation provisions.]

1. Manufacturers:

   a. Flow Controls Industries
   b. [Approved equal]

O. Control Panels: Panels shall be UL listed, NEMA type rated for application and location, surface or flush mounted panel as indicated with key locked door with continuous hinge and standard baked enamel finish.

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P.   Differential Pressure Switches:

    1.   Filter Status: Diaphragm operated which actuate a SPDT snap action switch. A field adjustable pressure set point with a range suitable for air flow status applications. The switch voltage and current rating shall be double the load requirements. Provide sensing tubes connected to tips with multiple holes and bulkhead fittings specifically designed for air flow sensing. Manufacturer: Dwyer or approved equal.

    2.   Air System - Limit Differential Pressure Switch: Pressure switches shall incorporate gauge and switch point indicator(s) for continuous indication of applied pressure and switch settings. Diaphragm operated with switching accomplished by photocell controlled relays. Set point adjustment controlled by knobs. Complete with set point latching circuit and external push-button switch for manual reset. Range [0-8] inches water gauge. Manufacturer: Dwyer or approved equal.

    3.   Water System Differential Pressure Switch: Form-C contacts, automatic reset, screw-adjustable trip point, all components non-corrosive; wetted parts shall consist of a Buna-N diaphragm with O-ring seal; complete with NEMA rated enclosure suitable for application. Select operating range to match function. Provide instrument gage valve for each input.

Q.   Current Transmitters (split-core): Designed for three phase or single phase installations to convert monitored AC current to a proportional DC voltage of 0-10 VDC,4-20 mA output or connected to DDC Network. Transmitter shall be selected based on maximum primary current, voltage and size of conductor. Minimum 2,000 VAC internal isolation and 600 VAC case insulation. Accuracy +/-1-percent of full scale. Complete with LED indicator for normal and fault status. Repeatability plus or minus 2-percent of full scale. Response time 100 milliseconds. Each phase shall be monitored for Equipment Energy consumption (kWh) or demand (kW) metering.

R.   Current Sensing Relay: 100-percent solid state with adjustable range (+/- 1-percent of range) trip set point to monitor AC current. Provide with contact transfer with no calibration drift, complete with LED status indicator. Limit off-state leakage to 2 mA or less. Rating (200 ampere minimum) shall exceed equipment being monitored.

S.   Carbon Dioxide (Air Quality) Sensors: 0-2,000ppm, Carbon Dioxide CO2 sensors (duct or wall mounted) with integral transducers and LCD display. Output signal shall be 4 to 20 mA or 0-10 VDC. Accuracy shall be <+50ppm, + 2- percent of measured value. Calibration shall not be required for a minimum of 5-years.

T.   Control Relays: Relays shall be rated for the application, with a minimum of two sets of Form C contacts, enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays should be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage.

U.   Low Limit Thermostats: DPDT, incremental bulb type; actuates if any 12-inch maximum increment is below its setting; adjustable setting, manual reset. Provide capillary element length of 2.14 equaling 2.14 square feet of coil area per foot capillary element. One DPDT contact shall shut down equipment and the second contact shall signal the DDC system.

V.   Contactors: Single coil electrically operated. Contacts shall be double break silver to silver. Number of contacts and rating shall be selected for the application intended. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices to limit transients to 150 percent of rated coil voltage.

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W. Transformers: Transformers shall conformance to UL 506. Class 2 current limiting type or over-current protection. Connected load shall be limited to 80-percent of transformer rated capacity.

X. Nameplates: [Nameplates shall be in accordance with Division 23 Section "Identification for Mechanical Piping and Equipment."][Laminated plastic 1/16-inch thick with neatly beveled edges and screwed to panel. Color shall be black with 0.375-inch white engraved block lettering.]

2.15 FLOW MEASUREMENT

A. Air Measuring Unit (AMU):

1. Air measuring unit (AMU) assembly shall be UL Listed, true averaging, independent multi-point sensing type, and microprocessor-based transmitter with 16-character LCD display. Sensors shall be factory calibrated to standards that are traceable to the National Institute of Standards and Technology (NIST). Probes shall be configured to suit installed locations (duct and/or fan inlet). Vortex shedding arrays, pitot tubes, RTD, differential pressure sensing arrays and auto-zeroing sensors are not acceptable.

2. Airflow and Temperature Measurement: Hermetically sealed thermistors mounted in the assembly with marine grade waterproof epoxy. Wiring shall be UL plenum rated, Kynar coated and installed within probe with no exposed wiring to environment. Airflow rate and temperature data of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.

3. Airflow accuracy shall be +0.2% over entire operating airflow range. Temperature accuracy shall be +0.15 F over operating temperature range of –20 F to 160 F. Operating humidity range shall be 0-99% RH (non-condensing)

4. Probes: Gold anodized or stainless steel tube suitable for operating environment complete with mounting brackets and installation hardware.

5. Transmitter/DDC Communications Interface: DDC manufacturer shall coordinate proper communications interface requirements for compatibility with DDC system. DDC Communications Interface shall be capable of communicating with DDC system specified in this section with following interface options:

    a. Linear Analog Output Signal: Field selectable, fuse protected, and isolated, 0-5Vdc, 0–10Vdc and 4–20mA and field selectable BACnet-MS/TP Master, ModBus-RTU and Johnson Controls N2 Bus.

    b. 10 Base-T Ethernet: Field selectable BACnet-Ethernet, BACnet-I/P, ModBus TCP and TCP/IP.

    c. LonWorks Free Topology.

6. [Infra-red Interface Card: Provide interface card complete with upload/download software at each transmitter suitable for downloading airflow, temperature data or uploading transmitter configuration data utilizing a handheld Palm or Microsoft windows operating system.]

7. [Coordinate with Division 23 Section "Air Duct Accessories" for installation provisions.]

8. Manufacturers:

    a. Ebtron, Inc.
    b. [Approved equal.]

B. Water Flow Meter:

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1. Insertion Turbine type meter complete with all installation hardware (branch outlet, close nipple, and full port ball valve) necessary to enable insertion and removal of the meter without shutdown. Accuracy: +/-2.0% over a 50:1 turndown. 4-20mA, 0-10V, or 0-5V, scalable pulse output. Remote visual instantaneous rate of flow and totalized flow display. Ratings: 150 psig minimum pressure and 200 F minimum temperature. Complete with certificate of calibration [Provide hot tap hardware necessary to enable hot tap installation into a live system.] Manufacturer: Onicon, EMCO Turbo-bar.

2. In-Line Electromagnetic Flow Meters: ANSI B 16.5 [Class 150][Class 300] electromagnetic flow meter with integral sensor, counter and transmitter. Output of flow shall be 4-20 mA signal proportional to the span, complete with remote wall mounted keypad and LCD display with backlight. NEMA 4X Enclosure. Accuracy plus/minus 0.25% of reading form 3.3-33 ft./s, +/- 0.0075 ft./s at flows less than 1 ft./s. 0-300F temperature range. Complete with certificate of calibration. Manufacturer: Onicon, EMCO sensor and MAG Signal Converter or approved equal.

3. Insertion Electromagnetic Flow Meter: Complete with all installation hardware (branch outlet, close nipple, and full port ball valve) necessary to enable insertion and removal of the meter without shutdown. Accuracy +/- 1% of reading from 2-20 ft./sec and +/- 0.02 ft./sec below 2 ft./sec. Ratings: 400 psig pressure and 250 F temperature. 4-20mA, 0-10V, or 0-5V, scalable pulse output. Remote visual instantaneous rate of flow and totalized flow display. Complete with certificate of calibration. [Provide hot tap hardware necessary to enable hot tap installation into a live system.] Manufacturer: Onicon.

4. [Coordinate with Division 23 Section "Hydronic Piping" for installation provisions.]

C. Water Metering:

1. Water metering is per Division 22 Section "Water Distribution Piping Specialties."
2. Water meters are used for leak detection on systems where flow below the threshold of a flow meter is possible.
3. Water meters are used on cold water domestic and irrigation systems.
4. Water meters are used where the data desired is in the form of a volume (gallons or cubic feet) and not expressed as a flow rate.

D. BTU Meters:

1. BTU meters shall consist of a flow meter, two temperature sensors with thermowells, BTU meter and all installation hardware. A certificate of NIST traceable calibration shall be provided with each installed system.
2. BTU Meter:

   a. Output Points: Integral LCD display and outputs for Energy total, energy rate, flow rate, supply and return temperatures.
   b. Output Signals: BACnet, MS/TP, BACnet/IP, Lonworks, JCI-N2, MODBUS RTU, MODBUS TCP, or Siemens P-1) or via individual analog and pulse outputs.
   c. Factory programmed for specific application and shall be re-programmable using front panel keyboard.

3. Temperature Sensors:

   a. Temperature sensors shall be bath-calibrated and matched (NIST traceable) for specific temperature range for each application.

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        b.   The calculated differential temperature used in the energy calculation shall be accurate to within +/- 0.15 F (including the error from individual temperature sensors, sensor matching, input offsets and calculations).

    4.   BTU Flow Meter:

        a.   Refer to Water Flow Meter paragraph for flow meter type.

        b.   Flow meter shall be installed in accordance with manufacturer's instruction for upstream and downstream straight pipe runs

    5.   Manufacturers:

        a.   Onicon System 10.

        b.   [Approved equal].

E.   Steam Flow Meter:

    1.   Insertion turbine flow meter with isolation valve to permit installation and removal without process shutdown, suitable for service pressure and temperature. Complete with 2 spare rotors. Output flow shall be 4-20 mA signal proportional to flow. Accuracy: +/- 1%. Manufacturer: EMCO Turbo-bar [TMP-60S (125 psig, 400 F)] [TMP-910 ANSI B 16.5 [Class 150][Class 300][Class 600], 400 F] [TMP-960 ANSI B 16.5 [Class 150][Class 300][Class 600], 750 F] or approved equal.

    2.   Vortex Flow Meters (Flanged): ANSI B 16.5 [Class 150] [Class 300][Class 600] In-line Vortex Mass flow meter complete with integral density compensation to provide direct mass steam output flow. Output of flow shall be 4-20 mA signal proportional to the span with scaled pulse totalization. Accuracy: +/- 1%, Repeatability: +/- 1%. NEMA 6 enclosure and remote mounted LCD display, complete with certification of calibration. [Provide flow straightener.] Manufacturer: Onicon F-2500 or approved equal.

    3.   Insertion turbine flow meter with isolation valve (full port ball valve) to permit installation and removal without process shutdown. Output of flow shall be 4-20 mA signal proportional to the span. Complete with pressure and temperature transmitters. Manufacturer: EMCO Turbo-bar, rotor (plus 2 spare rotors), with temperature transmitter (range: 212-400 F), pressure transmitter (range: 0-150 psig), complete with full port 150 LB gate valve.

    4.   [Coordinate with Division 23 Section "Steam and Condensate Heating Piping" for installation provisions.]

F.   Condensate Flow Meter:

    1.   Hot tap insertion flow meter with isolation valve, momentary DPDT relay output with frequency proportional to the flow rate. Paddle wheel type sensing mechanism suitable for minimum temperatures of 225 deg F. Complete with waterproof enclosure, counter and power converter. Manufacturer: Onicon.

    2.   ANSI B 16.5 Class 300 electromagnetic flow meter with integral sensor, counter and transmitter. Output of flow shall be 4-20 mA signal proportional to the span, complete with NEMA 4X enclosure. Accuracy plus/minus 0.25% of rate. Manufacturer: EMCO sensor suitable for 390 deg F minimum fluid temperature, remote wall mounted Signal Converter or approved equal.

    3.   Coordinate with Division 23 Section "Steam and Condensate Heating Piping" for installation provisions.

2.16   ROOM PRESSURE MONITORING

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A.   Through the wall room pressure transmitters and monitors. Monitor shall be capable of interfacing with the Building DDC system, communicating alarms, differential pressure, and status point information. Monitor shall include LCD display of pressure monitoring mode, high or low pressure alarm, general failure, status of door switch, audible horn, and status lights. Monitor shall also include 2-position keyed switch to disable alarms for space cleaning and maintenance. Monitor shall be capable of positive or negative pressure indication. Positive pressure monitoring shall be provided for [C-Section Room, IV Room, and Pharmacy Anteroom]. Negative pressure monitoring shall be provided for [Patient Isolation rooms, Isolation Nursery Room, and Chemo Room].

2.17   ROOM TEMPERATURE AND HUMIDITY MONITORING

A.   Room temperature and humidity transmitters with LCD display for monitoring. Continuous LCD displays for Temp F and Relative Humidity RH on stainless steel panel, installed in [C-Section Rooms].

2.18   VARIABLE FREQUENCY DRIVE INTERFACE

A.   Variable Frequency Drives (VFD) shall be provided under Division 23 Section "Variable Frequency Drives." DDC manufacturer shall coordinate proper communications (BACnet, RS-485, Ethernet, ModBus, or LonWorks) interface requirements for compatibility with DDC system. Provide all hardware, software and wiring required for DDC system interface.

2.19   REFRIGERANT MONITORING AND SYSTEM INTERFACE

A.   Description: UL Listed, Photo Acoustic Infrared sensor shall continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, and shutting down equipment, and automatically activating ventilation system.

B.   Performance Requirements:

1.   Refrigerant to Be Monitored: [HCFC-123][HFC-134a] [R-11] [R-22] [R-12] [Ammonia] [R-12] [R-13] [R-113] [R-114] [R-401a][R-402a][R-404a][R-407a][R-500][R-502][R-507][r-509b].
2.   Range: 20-1,000ppm.
3.   Sensitivity: 20ppm detection limit.
4.   Linearity: Plus/minus 5% of a linear response in the 20-1,000ppm range and plus/minus 5% of full scale in the 100-1,000ppm range.
5.   Range: 0-1,000 ppm.
6.   Sensitivity: 1ppm in the 0-100ppm range and plus/minus 10% of reading in the 100-1,000ppm range.
7.   Linearity: 1ppm in the 0-100ppm range and plus/minus 10% of reading in the 100-1,000ppm range.

C.   Operating Requirements:

1.   Operating Temperature: 32 to 104 deg F.

2.   Relative Humidity: 0-95%, non-condensing over the operating range.
3.   Power Input: 24VAC/DC or 120VAC
4.   Alarm Relays: 4 relays at 8A resistive load.
5.   Alarm Set Points: Displayed on front of meter.
6.   Audible Output: Sonic alert at 75 to 80 dB at 60 inches.

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    7.   Analog Output: 0- to 10-V dc or 4- to 20-mA current sourcing.

    8.   Serial Output Type: RS 232.

D.   Sensor Configuration: Photoabsorptive IR sensor.

    1.   Single-sensing channel.

    2.   Expandable to four channels.

E.   Operating Requirements:

    1.   Operating Temperature: 32 to 122 deg F.

    2.   Relative Humidity: 0-95%, non-condensing over the operating range.

    3.   Power Input: 120VAC

    4.   Alarm Relays: 3 relays at 8A resistive load.

    5.   Alarm Set Points: Displayed on front of meter.

    6.   Audible Output: Sonic alert at 75 to 80 dB at 60 inches.

    7.   Analog Output: 0- to 10-V dc or 4- to 20-mA current sourcing.

    8.   Serial Output Type: RS 232.

F.   Sensor Configuration: Photo absorptive IR sensor.

    1.   Single-sensing channel.

    2.   Expandable to [four][eight] channels.

G.   Display: 10-character, alphanumeric, vacuum-fluorescent indicating lights for each alarm set point; standard alarm; acknowledge switch and test switch mounted on front panel; and alarm status LEDs and service fault LEDs.

    1.   Enclosure: NEMA 4X, type as required for ambient condition.

H.   Alarm Output: Indicating light flashes and horn sounds.

    1.   Unit-mounting device with single-light beacon.

    2.   Remote unit for mounting outside machinery room with single-light beacon.

I.   Calibration Kit:

    1.   Include zero and span gasses with appropriate regulator(s).

J.   Control Tubing:

    1.   Sample Tubing Material: Install 1/4-inch O.D. tubing to each monitored zone. The tubing shall be refrigerant-grade copper, 1/4-inch O.D. seamless Type ACR (hard or annealed) complying with ASTM B280 or seamless Type L (drawn or annealed in accordance with ASTM B88.

    2.   Polytubing and other gas absorbing/leaching types are not acceptable due to sample corruption. Nylon non-plasticized 1/4-inch O.D. tubing, similar to Parker Hannifin, may be used if pre-approved, installed or bundled in 1/2-inch or 3/4-inch EMT conduit, or larger, 80% free area.

K.   Agency Approvals:

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      1.   UL 091217.

  L.   Manufacturers:

      1.   Mine Safety Appliances Chillgard.
      2.   OI Analytical.
      3.   General Analysis Corp.
      4.   [Approved equal]

  M.   Switches and Labels:

      1.   Ventilation System Emergency Control Break Glass Switch: On-only, manual reset. Upon activation, ventilation system shall operate under the Purge Mode. Locate adjacent to and outside of each Refrigeration Machinery Room exit.
      2.   Emergency Control Break Glass Switch: Off-only, manual reset. Upon activation, electrically energized equipment (except for emergency ventilation system) and devices within the refrigeration room shall be de-energized. Locate adjacent to and outside of each Refrigeration Machinery Room exit.
      3.   Ventilation System Central Control Station: 3-position switch (automatic-off-on type), located outside the main entrance of the Refrigeration Machinery Room. Switch shall be NEMA Type 4/13, oil tight selector switch. Provide with colored indicator lamps, one to indicate flow with the other to indicate no flow. Pilot light shall be NEMA Type 4/13 Pilot light, push-to-test transformer. Switch and indicator lamps shall be provided within enclosure. Enclosure shall be NEMA Type 4 enclosure, keyed lock with glass panel face. 2 spare enclosure keys and 10 spare lamps shall be provided.
      4.   Labels: Permanent identification labels for each switch, panel and indicator lamp.

2.20 OXYGEN O2 MONITORING AND SYSTEM INTERFACE

  A.   Self-contained oxygen and alarm detection system capable of detecting hazardous oxygen levels with meter display with oxygen sensor, sensor cable, RF shielded IC chip and NEMA 4X enclosure. Complete with the following:

      1.   Auxiliary Relays: One latching and one non-latching SPDT dry contact relay per channel.
      2.   Audible and visual LED alarms indications on preset alarm levels.
      3.   Calibration Kit(s) for installed units. Include zero and span gases with appropriate regulators.
      4.   [Extra Materials (Oxygen Sensor): Provide 20-percent of the installed system or minimum quantity of 2.]
      5.   [Battery Backup.]
      6.   [Remote Horn.]

  B.   Manufacturers:

      1.   ENMET Corporation.
      2.   Mine Safety Appliances Company.
      3.   [Approved equal.]

2.21 CARBON MONOXIDE CO MONITORING AND SYSTEM INTERFACE

  A.   Self-contained carbon monoxide detection system.

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B. Single or multi-channel, dual level detectors, using solid state sensors with 3-year minimum life, suitable over temperature range of 23 to 130 deg F, calibrated for 35 ppm and 100 ppm with maximum 2-minute response time.

C. Calibration Kit: Include zero and span gases with appropriate regulators.

D. Manufacturers:

1. Quatrosense Environmental Limited (QEL).
2. Mine Safety Appliances Company.
3. [Approved equal.]

2.22 BOILER EMERGENCY REMOTE SHUTDOWN SWITCH

A. Manually operated remote shutdown switches, palm-type, switch buttons that will shut down the boiler systems. The emergency shutdown switches shall be clearly identified with signage. Emergency shutdown switches shall have a manual reset and shall be in accordance with ASME CSD-1, Direct Ignition System and Factory Mutual requirements.

2.23 FIRE ALARM SYSTEM INTERFACE

A. Fire Alarm System Interface: Fire alarm system and air handling equipment smoke detectors shall be provided under Division 26. Provide all hardware, software and wiring required for DDC system interface. Coordinate DDC requirements with Fire Alarm System Contractor.

2.24 LIGHTING SYSTEM INTERFACE

A. Lighting Control System Interface: Occupancy sensors shall be provided under Division 26. Provide all hardware, software and wiring required for DDC system interface. Coordinate DDC requirements with Electrical Contractor.

2.25 SECURITY SYSTEM INTERFACE

A. Security System Interface: Security system shall be provided under Division 26. Provide all hardware, software and wiring required for DDC system interface. Coordinate DDC requirements with Security System Contractor.

2.26 IRRIGATION SYSTEM INTERFACE

A. Irrigation System Interface: Irrigation system and shall be provided under Division 02. Provide all hardware, software and wiring required for DDC system interface. Coordinate DDC requirements with Irrigation System Contractor.

B. Water metering shall be by pulse type water meter per Division 22 Section "Water Distribution Piping Specialties."

2.27 UTILITY METERING

A. Electrical Meter: Building Electric Pulse Initiator shall be provided under Division 26. Provide all hardware, software and wiring required for DDC interface. Coordinate DDC requirements with Electrical contractor.

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B.   Water metering shall be by pulse type water meter per Division 22 Section "Water Distribution Piping Specialties."

C.   Natural Gas Meter: Natural Gas Meter shall be provided under Division 23 Section "Meters and Gages for Mechanical Piping."   Provide all hardware, software and wiring required for DDC interface. Coordinate DDC requirements with meter manufacturer. [Provide to utility company a magnetic volume pulser for installation in the Gas Company's meter. Meter and installation cost shall be incurred by the DDC contractor.]

D.   Water Metering: Building water pulse generator shall be provided under Division 23 Section "Meters and Gages for Mechanical Piping." Provide all hardware, software and wiring required for DDC interface. Coordinate DDC requirements with water meter manufacturer.

2.28   PNEUMATIC CONTROL COMPONENTS

A.   I/P Transducer: Digital to pneumatic transducer to convert plus or minus VDC pulse width modulation outputs or continuous proportional current or voltage to 0-20 psi.

B.   Control Air Piping:

1.   General: Existing control air shall be extended with pressure regulators provided as needed.
2.   Copper Tubing: ASTM B75 or ASTM B88. Tubing 0.375-inch outside diameter and larger shall have a minimum wall thickness equal to ASTM B88, Type M. Tubing less than 0.375-inch outside diameter shall have a minimum wall thickness of 0.025-inch.

   a.   Concealed tubing shall be hard or soft copper: Multiple tubing shall be racked or bundled.
   b.   Exposed tubing shall be hard copper; rack multiple tubing.
   c.   Fittings shall be solder type ANSI B16.18 or ANSI B16.22, using ASTM B32, 50-50 lead-tin solder, or compression type ANSI B16.26.

3.   Polyethylene Tubing:

   a.   UL Listed, Flame-resistant, single or multiple polyethylene.
   b.   Fittings shall be compression or barbed push-on type.

4.   Air Pressure Gauges: 1-1/2-inch minimum diameter, 0-30 psi scale; Provide on control signal tubing and main control air.

C.   Control Air Supply:

1.   Air Compressor: [Single][Duplex] tank mounted air compressor complete with integral motor starters, [alternator, lead-lag controls,] and belt guard. Size compressor to run not more than 33-percent of the time with full system load. Tank shall be ASME constructed for 150 psig.
2.   Refrigerated Air Dryer: Packaged unit complete with 3-micron filter/separator, pressure reducing station, gauges, hot gas bypass valve, automatic condensate drain (pipe to nearest floor drain), non-cycling compressor, and two by-pass valves to facilitate removal of heat exchanger and/or oil filter. Size dryer for continuous operation to reduce the compressed air dew point temperature at 20 psig output pressure to 20 degrees F with average tank pressure of 80 psig and ambient temperature between 50 and 95 degrees F.

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3. Air Pressure Reducing Valve Station: Air pressure reducing valve station(s) complete with filter, pressure relief valve, pressure gauges, mounting bracket and shut-off valves shall be provided as required for control air main requirements.

4. Air Pressure Gauges: 1-1/2-inch minimum diameter, 0-30 psi scale; install on all control signal tubing and control air mains.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owner Representative in writing of conditions detrimental to the proper and timely completion of the work.

3.2 INSTALLATION (GENERAL)

A. Install in accordance with manufacturer's instructions.

B. Provide all miscellaneous devices, hardware, software, interconnections installation and programming required to insure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install components for easy accessibility; in general, mount 60-inches (panels measured from top edge) above floor with minimum 3'-0" clear access space in front of units.

B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration and high temperature.

C. Identification: Provide permanently mounted tags to all instruments with point address designation, system reference and description. Label all wiring, tubing at each end to match control diagrams.

D. Control Panels:

1. Provide for controls and instruments at equipment and in mechanical room.
2. Install temperature gages and pilot lights flush on the cabinet door. Install controllers, switches, timers, transformers, and relays in the interior of the cabinet; mount on a steel or aluminum subpanel or on the back panel of the cabinet. Provide and label control parameters and test points within the panel for total evaluation of system operation. Electrical controls shall be wired to numbered screw type terminal strips.

E. Digital Controllers:

1. Provide DDC controllers configured to control a single mechanical system such as an air handling unit, terminal unit, chilled water system, heating water system, etc., to operate a system in a complete standalone mode. DDC controllers shall be able to operate and control respective system upon loss of DDC system network communication.
2. Provide digital control cabinets that protect digital controller electronics from dust, at locations shown on the drawings.

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3.   Provide a disconnect power switch and surge protector for each digital controller.

F.   Temperature Sensors: Provide temperature sensors in locations to sense the appropriate condition.   Provide sensor where they are easy to access and service without special tools.   Calibrate sensors to accuracy specified.   In no case, will sensors designed for one application be installed for another application.

1.   Room Temperature Sensors: Provide on interior walls to sense average room temperature conditions. Avoid locations which may be covered by office furniture or subjected to sunlight. Room temperature sensors should not be mounted on exterior walls when other locations are available.   Unless otherwise indicated, sensors intended for control by occupant, or areas served by displacement systems, center-line mounting height shall be 4 feet above finished floor to allow ADA accessibility.   Sensors intended for use by service or maintenance personnel, center-line mounting height shall be at 5 feet above finished floor. Coordination with Architect and Architectural elevations supersedes this guidance.

2.   Duct Temperature Sensors:

a.   Select specific sensor location within duct to accurately sense appropriate air temperatures. Do not locate sensors in dead air spaces or positions obstructed by ducts or equipment. Install gaskets between the sensor housing and duct wall. Seal duct and insulation penetrations.

b.   Install duct averaging sensors, freeze protection sensors, between two rigid supports in a serpentine position to sense average conditions. Thermally isolate temperature-sensing elements from supports. Provide duct access doors to averaging sensors.

3.   Immersion Temperature Sensors: Provide thermowells for sensors measuring temperatures in liquid applications or pressure vessels. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to effect proper flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of the pipe area. Increase piping size as required to avoid restriction. Provide thermowells with thermal transmission material within the well to speed the response of temperature measurement. Provide wells with sealing nuts to contain the thermal transmission material.

4.   Outside Air Temperature Sensors: Provide outside air temperature sensor on north side of the building, away from exhaust hoods, air intakes and other areas that may affect temperature readings. Provide sunshields to protect outside air sensor from direct sunlight.

G.   Damper Actuators: Actuators shall not be mounted in the air stream.

H.   Pressure Sensors:

1.   General: Install pressure sensing tips in locations to sense appropriate pressure conditions.

2.   Duct Static Pressure Sensing: Unless otherwise indicated, locate duct static pressure tip approximately two-thirds of distance from supply fan to end of duct with the greatest pressure drop.

3.   Differential Pressure Sensing for Hot Water and Chilled Water Systems: Install with input isolation valves, zero differential calibration valve and pressure gages.

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4.   Pumping Proof with Differential Pressure Switches: Install high pressure side between pump discharge and check valve.

5.   Steam Pressure Sensing: Install snubbers and isolation valves on steam pressure sensing applications.

I.   Flow Measurement: Install and locate per manufacturer's instructions.

J.   Water Metering: Install and locate per manufacturer's instructions.

K.   Variable Pumping Application: Differential pressure sensor/transmitter shall be hard-wired directly to respective pumping system DDC controller. Utilization of network for data transfer will not be allowed. Unless otherwise indicated, locate hydronic differential pressure sensor/transmitter at the furthest distance from pumping discharge.

3.4   REFRIGERANT MONITORING

A.   Install per manufacturer's instructions. Examine machinery layout for proper location of monitoring device. Verify refrigerant contained in machinery(s) to ensure compatibility of refrigerant monitor.

B.   Sample Tubing: The tubing should be shipped sealed to the site, installed in good workmanship manner, field-assembled with compression fittings. Soldered or brazed connections are not acceptable due to foreign gases and contaminants. Tubing shall be field-assembled with compression fittings, with filters furnished by the monitor manufacturer. Locate the sensing terminations in areas not subject to damage and downwind in the direction of convection airflow of the device to be monitored and where shown on the drawings. Identify each sample tube, both ends, with stamped (nonferrous) metal tags labeling zone/chiller monitored.

C.   Sample exhaust tubing should be routed to a safe area (i.e. outside building or into building exhaust).

D.   Engage a factory-authorized service representative to inspect, test and adjust components, equipment installation, and electrical connections for compliance with requirements.

3.5   OXYGEN O2 MONITORING

A.   Install per manufacturer's instructions. Refer to Project Drawings for mounting heights and locations. Engage a factory-authorized service representative to inspect, test and adjust components, equipment installation, and electrical connections for compliance with requirements.]

3.6   POWER, CONTROL WIRING, AND CONDUIT

A.   All control wiring, all conduit for control wiring, and all miscellaneous accessory equipment for control wiring systems shall be provided by the Control Subcontractor as part of the control system. Conform to Division 26, 27 requirements, NFPA 70, and all local code requirements.

B.   All wiring in or through mechanical, electrical rooms, finished spaces, on roofs, in walls, below grade and inside equipment (except within control wiring compartments or control panels) shall be installed in conduit and properly supported. Label wire groups to match corresponding wiring diagrams.

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C.   DDC System Power: 120 VAC power provisions for the DDC system shall be provided by Division 26 to the locations indicated. If additional locations for 120 VAC power are required, either extend power from indicated locations, or provide power from nearest electrical panel with available capacity. Provide additional circuit breakers (20-amp maximum) same as installed breakers and label for service. Spare circuit breakers shall not be used unless approved by the Electrical Engineer. Power source shall be same as power source (normal or emergency power) serving equipment being controlled. Power provisions (wiring, installation, and materials) for all components furnished under this section shall be included. Coordinate all work with Electrical Contractor.

D.   Plenum Cable: Plenum cable type, installation methods and use shall be subject to City and State Codes and Regulations. Within ceiling space, attach directly to wall or slab on 4-foot centers, or support from ceiling suspension wires on 4-foot centers. Do not attach cables to pipes or ducts, or lay on ceilings. Cables shall be routed as high as possible without interference to equipment, ceiling, lighting access and removal.

E.   Instrumentation and communication cable shall not be run together in the same conduit or raceway as power wiring.

F.   Provide Surge and transient protection consisting of devices installed externally to digital controllers and operator workstations.

G.   Communication Cable: Provide all communication wiring between operator workstation and Advanced DDC panels, between Advanced DDC panels and application specific controllers and VAV digital controllers. All communication cable shall be checked for continuity, grounding, and shielding. [Local area network communication wiring between operator workstations and Advanced DDC panels shall be in conduit.]

H.   Network Communications: Coordinate with Owner for Internet, Ethernet availability, connection regulations and restrictions.

I.   Grounding: Ground controllers and cabinets to a good earth ground. Grounding of the green AC ground wire, at the breaker panel, alone is not adequate. Run metal conduit from controller panels to adequate building grounds. Ground sensor drain wire shields at controller end. All associated ground loop problems shall be corrected.

J.   Provide interface control wiring for equipment with remote sensors, panels, limits, and components, etc., furnished (shipped loose) by the manufacturer and to be field installed. Materials, wiring and termination shall be provided and installed in accordance with manufacturer's instruction, including, but not limited to the following:

1.   Chillers: Flow switches, differential pressure and temperature sensors.
2.   Humidifiers: Remote and High limit sensors.
3.   Boilers: Temperature and pressure sensors, remote control panel, control valves and pump interlock.
4.   Kitchen Hood: Temperature sensors, filter switches, remote control panel.
5.   Cooling Towers: Sump heater temperature sensor, level and vibration switches, and controls.
6.   Pumping Package: Flow sensors, temperature and differential pressure sensors.
7.   Indoor/Outdoor Split Unit: Temperature, humidity controllers and Evaporation/condenser sections.
8.   AC Unit: Temperature, humidity controllers and control panels.

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3.7   AIR PIPING

A.   Use copper tubing where subject to damage or temperatures in excess of 200 degrees F, where adjacent to heating pipes passing through common sleeve, and where not readily accessible.

B.   Exposed or Inaccessible Areas: Copper or single/bundled plastic tubing shall be provided with a tray, conduit or raceway with suitable junction boxes. Attached directly to wall or ceiling, 4 feet on centers, using pipe clamps; or install in metal trays supported by steel rod hangers, installed within 6 inches of slabs. Do not attach any tubing to pipes and ducts.

C.   Concealed Accessible Areas: Flame resistant polyethylene tubing may be used when concealed in walls or above ceilings and within control panels. Attach directly to wall or slab on 4-foot centers, or support from ceiling suspension wires on 4-foot centers using bridle rings and Erico "Caddy" Cat. No. 2-1-2-4 spring clips. Do not install any tubing attached to pipes or ducts, or laid on ceilings.

D.   Tubing Identification: Tubing shall be provided with identification tags.

E.   Test Compressed air piping at 30% over operating pressure. Blow out clean before attachment of any control instrumentation.

3.8   DDC POINT SUMMARY

A.   Provide all Database generation.

B.   Dynamic Color Display: Provide all dynamic graphic displays at each operator workstation System graphical displays shall be color-coded. Include outside air temperature indication on each primary air and water systems displays. As a minimum, the following shall be provided:

1.   Site Plan: Overall site plan, including all associated buildings.
2.   Building Floor Plan: Each floor plan graphic shall contain all graphical displays, equipment with area served, and locations associated with that building floor plan.
3.   Detailed Dynamic Color and data system graphics shall be provided for each piece of mechanical equipment including, but not limited to, [air][and][water] systems. Provide equipment run status, alarms, and analog variables for each system.
4.   Details, colors, and graphics shall be approved by the Owner prior to generation.

C.   Runtime Totalization: At a minimum, runtime totalization shall be incorporated, but not limited to, each monitored equipment, fans, and pumps. Warning limits for each point shall be entered with owner defined messages.

D.   Trend Log: Each input/output points shall be trended. Historical archiving of owner-selected points shall be provided at the operator workstation with the capability of transfer to graphic format representation.

E.   Alarm Points: All analog inputs (High/Warning/Low Limits) and selected digital inputs alarm points shall be prioritized, printed, routed, with alarm message per owner's requirements. Loss of communication network shall also initiate an alarm. Provide all software timers necessary to prevent false alarms. Unless indicated otherwise, for non-critical applications, initial alarm setup parameters shall be +/- 5% deviation from set point for a time duration exceeding 5 minutes. For critical application such as life safety monitoring or equipment failure, initial alarm setup parameters shall be zero deviation without any time delay.

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F.   Heavy Equipment Delays and Power Fail Restart Software: Each advanced DDC panel shall be provided with heavy equipment and power fail restart application software. Each advanced DDC panel shall start respective equipment in sequence and shall be time based and not dependent on prior system start-up.

G.   Database Save: Provide back-up database for all advanced DDC panels at the operator workstation computer hard disk. Provide additional back-up database for each Advanced DDC panel on Compact Disc (CD).

3.9   FIELD QUALITY CONTROL AND TESTING

A.   Demonstrate compliance of the HVAC control system with the contract documents. Calibrate instrumentation and controls and verify the specified accuracy using calibrated test equipment. Adjust controls and equipment to maintain conditions indicated, to perform functions indicated, and to operate in the sequence specified. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Ensure that tests are performed by competent employees of the DDC system installer or the DDC system manufacturer regularly employed in the testing and calibration of DDC systems. Calibrate field equipment and verify equipment and system operation before placing the system on-line. Field-testing will be witnessed by the Owner, Owner's representative or Commissioning Agent and shall include the following:

1.   System Inspection: Observe the HVAC system in its shutdown condition. Provide end-to-end wiring checkout. Check dampers and valves for proper normal positions. Document each position for the test report.

2.   Calibration Accuracy and Operation of Inputs Test: Check for proper calibration and operation of each input instrument. For each sensor (temperature), record the reading at the sensor, and using traceable test equipment, and record the reading at the digital controller. Document each reading for the test report.

3.   Operation of Outputs Test: Check the operation of each output to verify correct operation. Command analog outputs to minimum range, such as 4 mA, and maximum range, such as 20 mA, measure and record commanded and actual output values. Document each command and result for the test report.

4.   Actuator Range Adjustment Test: With the digital controller, apply a control signal to each actuator and verify that the actuator operates properly from its normal position to full range of stroke position. Record actual spring ranges and normal positions for all modulating control valves and dampers. Include documentation in the test report.

5.   Digital Controller Start-up and Memory Test: Demonstrate that programming is not lost after a power failure, and digital controllers automatically resume proper control after a power failure.

6.   Surge Protection: Show that surge protection, meeting the requirements of this specification, has been installed on incoming power to the digital controllers and on communication lines.

7.   Application Software Operation Test: Test compliance of the application for:

a.   Ability to communicate with the digital controllers, uploading and downloading of programs
b.   Text editing program: Demonstrate the ability to edit the control program off line
c.   Reporting of alarm conditions: Cause alarm conditions for each alarm, and ensure that workstation receives alarms
d.   Reporting trend and status reports: Demonstrate ability of software to receive and save trend and status reports

e. Execution of Sequence of Operation: Furnish graphic trends to show the sequence of operation is executed in correct order. Demonstrate the HVAC system operates properly through the complete sequence of operation, for example seasonal, optimal start/warm-up, and occupied/unoccupied modes of operation. Demonstrate proper control system response for abnormal conditions for which there is a specified response by simulating these conditions. Demonstrate hardware interlocks and safeties work. Demonstrate the control system performs the correct sequence of control after a loss of power

f. Control Loop Stability and Accuracy: Furnish graphic trends of control loops to demonstrate the control loop is stable and that set point is maintained. Control loop response shall respond to set point changes and stabilize within 1 minute

g. Opposite Season Test: Testing shall be repeated for opposite season.

B. Document all tests with detailed results. Provide statement that all corrective action taken. Include test report in Operation and Maintenance Manuals.

3.10 TRAINING

A. Upon substantial completion of the mechanical system work, furnish the services of a competent technician regularly employed by the DDC manufacturer for the instruction of facility personnel in the operation and maintenance of each DDC system at project site. Provide a minimum of [40] hours for training. Coordinate with Owner for number of personnel, date, time, and location. Multiple training times may be necessary to accommodate different working shifts.

B. Furnish a written test plan and training schedule for approval 15 days prior to instructing operating personnel including the following:

1. Recommended training schedule for operator's workstation, standalone DDC controllers, Application specific digital controllers and field components.
2. List of all training materials, aids, etc.
3. List of customer training schools offered by the DDC manufacturer.

C. Provide all training and materials necessary for each facility personnel, including:

1. Operations and Maintenance Manual
2. As-Built control diagrams
3. Detailed description of the system
4. Complete listing, graphical logic diagrams of all software programs required to perform the sequence of operation
5. Commands, operating and troubleshooting instruction and routine maintenance procedures.
6. Theory of operations
7. Hardware architecture
8. Operation of system
9. Operator Commands
10. Control sequence programming
11. Data base entry
12. Reports and logs
13. Alarm reports
14. Diagnostics.
15. Physical layout of each piece of hardware
16. Troubleshooting and diagnostics procedures

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      17.   Repair instructions
      18.   Preventive maintenance procedures and schedules
      19.   Calibration procedures.

D.   Provide [8] hours of additional training 3 and 6 months after project completion. Training to address specific topics that the facility personnel need to discuss and to answer questions concerning operation of the system.

PART 4 – SEQUENCE OF OPERATION AND DDC POINT LIST

A.   Sequence of operations and point list are indicated on drawings.

B.   Controls shall be by the DDC system unless indicated to be by local controls.

C.   DDC system shall schedule each system or zone independently per owner's operating schedule. Operating schedules shall be confirmed with Owner and adjusted as necessary

D.   Additional points shall be provided to execute the sequence of operations.

END OF SECTION