Design & Construction Standards:

TECHNICAL GUIDELINES

Division 25

25 00 00 Integrated Automation
25 50 00 Intelligent Building Automation System
25 90 00 Integrated Auto Control Sequences for Facility

FACILITY MANAGEMENT

April 2016

SECTION 25 00 00

INTEGRATED AUTOMATION

PART 1 GENERAL

1.01 SUMMARY

A. Provide all labor, materials, equipment and services necessary for a complete Direct Digital Control (DDC) System comprised of various types of Direct Digital Control (DDC) controllers, conventional electric/electronic controls, and equipment-mounted controls, as indicated. The system shall include all software and hardware for all specified capabilities.

B. All BAS points and data (i.e., setpoints, operating parameters, etc.) shall be enabled for reading and/or writing via BACnet communications to allow for the IBAS monitoring, scheduling, alarming and trending functions

1.02 COORDINATION

A. Electrical power wiring control shall be performed by the Electrical Contractor. Coordinate locations of circuits with the electrical design.

B. The automatic temperature control valves, separable wells for immersion sensors, and taps for flow and pressure instruments shall be provided by the Controls Contractor for installation by the Mechanical Contractor under the Controls Contractor's supervision.

C. All automatic temperature control dampers and airflow stations shall be provided by the Controls Contractor for installation by the Mechanical Contractor under the Control Contractor's supervision, unless they are components of packaged equipment.

D. Adjustments of manual balancing devices, as required to obtain design air and/or water flows, shall be by the Balancing Contractor. The Controls Contractor shall provide assistance to the Balancing Contractor with control adjustments as required to obtain design flows.

E. Controls Contractor shall provide the necessary software for use with the Balancer's personal computer for interfacing with their control equipment. Where proprietary equipment/gateways are required, this equipment shall be provided for the Balancing Contractor's use.

F. The General Contractor shall:

1. Provide on existing work all necessary cutting, patching and painting.

2. Provide access doors or other means of access through ceilings and wall for service to control equipment.

G. Provide necessary housekeeping pads and, where required, concrete inertia bases.

H. Duct smoke detectors shall be provided under the fire alarm system specification.

I. DPS Department of Technology Services will make any and all connections to the DPS intranet. DPS Department of Technology Services will assign an IP address to each IP-communicating controls device.

1.03 SUBMITTAL DATA AND SHOP DRAWINGS

A. Specify that all shop drawings, I/O schedules, point lists, system schematics, and product data shall be submitted for approval per Division 1, Section 01 33 00.

B. Submittal data and shop drawings shall conform to the following requirements:

1. All shop drawings shall be prepared according to the requirements in the most current version of Division 00. Some of the requirements in this document are listed below.

a) Shop drawings shall be developed using the most current version of Auto-CAD (AutoDesk, Inc.) or a version that is 100 percent compatible with the current version. VISIO drawings are not acceptable.

b) Specific information shall be added to the title block of each sheet to aid in the DPS archiving/retrieval process for construction documentation.

2. All final or as-built shop drawings for temperature control will become permanent record documents and shall be prepared on 11"x17".

3. All submittal data shall be bound or in a three-ring binder as appropriate. All the information shall be indexed and tabbed with reference to the specific section of the specifications. All options, ranges, and voltages (which will be provided) shall be clearly indicated on each product data sheet.

4. The format for submittal information shall be as follows:

a) Control drawings and building plans shall be CAD-prepared drawings. Drawings that cannot represent the total information on one drawing (i.e., a building plan) shall be noted with appropriate match lines, cross references, and key plans.

b) The control drawing package shall consist of:

i) A title sheet listing the project title, index of all the control drawings, and a network schematic showing all DDC panels and network connections on the project. The network diagram shall indicate all communication devices. The following information shall be provided for each network device:

- Location (room number).
- Power source (breaker panel I.D. and breaker number).
- Panel software name and serial number.
- Type of controller: the network diagram shall depict the actual connection sequence of the devices, including distances between devices, type of wire used and serial number of controller.

ii) The second drawing in the control package shall consist of typical installation details, a valve schedule, and a damper schedule. The valve schedule shall have entries for: valve tag, system served, quantity type (3w, 2w), GPM, actual CV, actual pressure drop, size, close-off rating, spring range, part number, and manufacturer. The damper schedule shall have entries for: damper tag, system served, quantity, type (PB, OB), CFM, size, actual pressure drop, quantity of actuators, spring range, damper model number, and actuator model number.

iii) Subsequent drawings shall depict complete systems (air handler, chiller, boiler, etc.). The drawing shall show the system schematic, all wiring of the DDC controller, all wiring of field devices, starters, and connections to equipment. Each drawing shall have a bill of materials and a sequence of operation.

iv) Floor plans shall depict equipment location, sensor, and panel locations. The duct and space static pressure monitor points shall be shown.

C. Submittal data and control drawings for all equipment and systems shall be submitted (per Section 01 33 00) to the Architect/Engineer for review prior to ordering or fabrication of the equipment. The following information shall be included in these submittals:

1. Thirty (30) days or less after notice to proceed:

a) Control valve and damper schedules that include:

i) Size.

ii) Cv (valves).

iii) Close off pressure rating (at 0 psi for N.C., two-way valves; at 20 psi for N.O., two-way valves; and at 0 psi between ports A and B for three-way valves).

iv) Gpm or cfm.

v) Spring range of the actuator.

vi) Quantity of actuators (dampers).

vii) Actual pressure drop for each item.

b) Technical specification data sheets of each system component and device, which includes all data needed to show compliance with this document.

2. Sixty (60) days or less after notice to proceed:

a) Control drawings with detailed piping and wiring diagrams; system schematics with controlled/monitored device locations; and connections to all enclosures, panels, and controllers, including a bill of material for all systems.

b) Sequence of operation for all controlled and monitored points for each system. Sequence shall be on same drawing as that for the corresponding system schematic.

c) A complete input/output schedule for each DDC panel and dedicated controller, including point name (the same name to be used in software), functional description of each point, point type, complete wiring diagram for each point from controller to input or output device, field device type, and location, etc.

d) Communications cable schematic showing panel and controller locations, controller power source, and all interconnecting data and communication conductors. Arrange the panels in the order in which they will actually be interconnected in the field.

e) On control drawings show sensor, panel, and equipment locations by referring to room number.

f) DDC network configuration, complete with interconnection diagrams for all peripheral devices, batteries, power supplies, etc.

g) A bill of material shall be shown on each drawing. The bill of material shall include the device code used on the controls drawings, description of the product, name of the manufacturer, complete model number, measurement range (if applicable), and quantity.

h) Identify the electrical power source for each DDC panel by location (room number), panel designation, and breaker number. Include the identification on the drawing and at the DDC panel itself.

i) Submittals shall also include a complete test plan and procedures. Test plan shall be coordinated with the Testing, Adjusting, and Balancing Contractor per Section 23 05 93. The test plan shall delineate the methods of testing and recording the results of the point-by-point verification and calibration of the hardware and the testing and tuning of the software. The test plan shall include a listing of all hardware points with columns for calibration, test and certification. There shall be a similar record for software.

3. Fourteen (14) days prior to system demonstration and acceptance testing:

a) Provide software programs and sequences written in the program language and in English.

1.04 PROJECT RECORD DOCUMENTS

A. Upon completion of the installation, a complete set of record drawings shall be provided. The content and format of the drawings shall be as described previously.

B. Prior to final completion of the installation, prepare complete Operation and Maintenance (O&M) manuals. Refer to Division 1, and Division 23, for requirements. Also provide one set of electronic media containing all CAD-prepared.

1. Temperature control diagrams, including an explanation of the control sequence of each system along with the following instruction wherever applicable.

a) Emergency procedures for fire or failure of major equipment.

b) Normal starting, operating and shutdown procedures.

c) Summer or winter shutdown procedures.

2. The temperature control diagrams are to be wall-mounted in an aluminum frame with plastic laminate glass in a location approved by the DPS Controls Application Engineer, preferably in the main mechanical equipment or fan room where the main control panel is located.

3. A reduced copy of the controller drawing, listing all input and output points with functional descriptions, shall be placed inside the door to each controller enclosure in a plastic pocket attached to the door. The sheet shall be laminated. One sheet is required for each controller housed in the enclosure. Control System Programmer's Manual with complete description of the custom control language and associated editor, including sample-written programs. Provide complete sets of all Programmer's Manuals. All software and firmware algorithms shall be completely described and documented.

4. Provide maintenance, installation, and engineering manual(s) that clearly explain how to debug hardware problems; how to repair or replace hardware; preventive maintenance guidelines and schedules; calibration procedures; and how to engineer and install new points, panels, and operator interfaces.

5. All CAD drawings and controller dumps, generated for operation of the system, shall be included as part of the system documentation. This information shall be submitted in a machine-readable format (i.e., floppy disk).

6. Input/output schedules, data sheets, and all other items required. Describe all regular maintenance that will need to be performed on the DDC hardware. Provide list of recommended spare parts. List all replacement parts with part numbers.

7. Complete original-issue documentation, installation, operation manuals, and supporting software for all third-party hardware and software furnished and installed as part of the system or required for the operation of the system, including remote terminals, user's computer work station, monitors, graphics and memory boards, network servers, printers, and modems.

8. A diagram of the wiring layout for the communication network showing the room number of the location of all junction boxes shall be shown on the diagram. Distances between termination points shall be indicated with a description of routing.

1.05 DEMONSTRATION AND TRAINING

A. The Contractor shall provide a minimum of 16 hours of training in 4-hour blocks one day per week on system operations and provide control demonstration time at the job site for the Owner's personnel.

B. This Contractor shall provide at least 4 hours in one session of classroom training at times and location as directed by the Owner. The training shall focus on design, operation, and maintenance procedures of the products installed and shall cover:

1. Hardware configuration, including PC boards, switches, communication and point wiring, and location of all sensors and control devices.

2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.

3. Operation of central work station, including logging on and off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, changing firmware and software parameters, and generating and linking graphic screens.

4. The operational sequence of each system, including normal and abnormal operating modes, operating control strategies, and operator actions required to reset or monitor the system.

5. Programming using the editor, program design, syntax, and loading of custom control software.

6. Recovery procedures from power failures.

7. Alarm formats.

8. Maintaining software and programming backups.

C. The instructor(s) for the above sessions shall be employee(s) of the Control Contractor whose primary function is customer training and applications support.

D. A minimum of two copies of the most current control drawings shall be provided to the DPS HVAC Shop before the training begins. These shall be in addition to the drawings to be provided under Part 1 Shop Drawing requirements, if the O&M Manuals have not been turned in to the Architect before the time of the training.

E. The training may be phased. The Owner may elect to conduct training and demonstration in two- to four-hour sessions over the life of the warranty period. All instructional material shall be available to each employee at each training session up to a maximum of ten (10) individuals.

F. All demonstration and training sessions shall be coordinated with the DPS Controls Application Engineer.

1.06 WARRANTY

A. The warranty period shall begin as authorized by the DPS Controls Application Engineer in writing. Authorization will not be given before the following conditions are met. Under no conditions will the Controls Warranty begin before the starting date of the General Warranty for the overall project.

1. Completion of the tests and demonstration required in Part 3 and correction of all problems discovered during the testing process.

2. Completion of all punch list items that are the direct responsibility of the Controls Contractor.

3. Conduction of a preliminary training session for personnel of the HVAC Shop of the District. The training shall consist of an orientation session at the job site to familiarize personnel with the location and type of controlled equipment and controls on the project, a discussion of the control sequences, and a review of the control drawings. A copy of the most current control drawings shall be provided to the DPS HVAC Shop at this time as well. Other, more detailed, training sessions (such as for review of the control programs) may be held at a later date during the warranty period

4. Completion and distribution of the as-built control drawings, including correction of all items noted by the Owner and Engineer after review of the documents.

B. The control system shall be guaranteed to be free from original defects in material and workmanship and in software design and operation for a period of 24 months after completion of the contract. The Contractor shall provide the necessary skills, labor, and parts to assure that all system and component failures are promptly repaired.

C. The Contractor shall receive calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist. The response time to critical problems (critical problems are those that may shut down or disrupt the operation of the school or create potential damage to the building or equipment) shall be four (4) hours maximum.

D. During the warranty period, the Contractor shall maintain a backup of all software installed in the system. The backup shall be updated monthly or whenever the Contractor makes a change to the software. A reload of backup software into the system shall be performed by the Contractor immediately upon notification by the Owner. The reload shall be free of charge unless it is due to a power failure of a duration longer than the battery backup.

E. The Contractor shall optimize all control software to assure acceptable operating and space conditions and peak energy efficiency. This shall include changes needed to optimize operation of the systems even if not explicitly described in Control Strategies.

F. The Contractor shall include the extended warranty for upgrades of controllers installed in the building for the warranty period.

G. At the end of the warranty period, the Contractor shall supply updated copies of the latest versions of all project record documentation as described in the Part 1 Project Record Documents requirements. This includes final updated drawings, software documentation, and magnetic media backups that include all changes that have been made to the system during the warranty period.

H. Coordinate with DPS Controls Application Engineer in advance before connecting new DDC system to District network.

I. Once the building DDC system is connected to the network, the Contractor shall notify the DPS Controls Application Engineer before and after performing any work on the DDC components, and report any changes made.

J. During the warranty period, District personnel shall make a reasonable effort to determine if a problem is due to the control system or some other source not the responsibility of the Controls Contractor, before requesting warranty service. However, if the Controls Contractor is called out and determines that the problem is not due to the controls system or other building components, the Contractor shall not charge the District for a service call if it is determined that the source of the problem is not his responsibility.

1.07 OWNERSHIP OF PROPRIETARY MATERIAL

A. All project developed hardware and software shall become the property of the Owner. These include but are not limited to:

1. Project graphic images.
2. Record drawings.
3. Project database.
4. Job-specific application programming code.
5. All other documentation.

PART 2 PRODUCTS

2.01 CONTROL VALVES

A. The automatic control valve shall be sized by the Controls Contractor for the appropriate pressure drop specified by the A/E to ensure proper throttling performance at all system loads.

B. Closeoff (differential) Pressure Rating: valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

1. Water Valves:
   a) Two-way: 150 percent of total system (pump or building domestic water pressure) head.
   b) Three-way: 300 percent of pressure differential between ports A and B at design flow or 100 percent of total system (pump) head.
2. Steam valves: 150 percent of operating (inlet) pressure.

C. Water Valves:

1. Body and trim style and materials shall be per manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service, except where stated otherwise.
2. Sizing criteria:
   a) Two-position service: Line size.
   b) Two-way modulating service: pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to 50 percent of the available pressure differential between the mains, with a minimum of four (4) psi.
   c) Three-way modulating service: pressure drop across the valve in a wide-open position, with full flow through the valve, shall be equal to twice the pressure drop through the heat exchanger (load), with a three (3) psi minimum.
3. Construction:

a) Valves ½" through 2" shall be bronze body or cast brass ANSI Class 250, spring loaded, Teflon or ring packing, and stainless steel stems. Two-way valves to have replaceable composition disc. Johnson VG-7000, Siemens 599 or Belimo globe valves

b) 2-½" valves and larger shall be cast iron ANSI Class 125 with guided plug, stainless steel stems and Teflon or ring packing.

c) Water valves with caged trim are not allowed.

4. Water valves shall fail normally open or closed as scheduled on plans or as follows:

a) HW zone valves - normally open.

b) Heating coils in air handlers - normally open.

c) Chilled water control valves - normally closed.

d) Other applications - as scheduled or as required by sequence of operation.

5. Butterfly valves: modulating, three-way valves or two-position valves 4" and larger may be tight-closing butterfly valves. Full-lug type, 250 psi WOG, extended neck, cast iron body, aluminum/bronze disk, stainless steel shaft, field replaceable cartridge design, EPDM seat and seal with integral actuator. The modulating, three-way valve substitute shall consist of linked butterfly valves with a factory-installed linkage. Modulating valves shall be sized for three (3) psi pressure drop. Johnson Controls VF, Siemens or Belimo

6. Baseboard heating: modulating (not two-position) valves/

7. Evaporative cooler drain and fill valves:

a) Bronze, full-port, two-piece body design; chrome-plated, solid bronze ball with Teflon seats, stem packing shall be adjustable for wear with adjusting screw, 150 WSP, 600 WOG.

b) Bronze valve material composition shall meet ASTM B62.

c) Provide valve complete with actuator, mounting bracket, and all required linkage.

d) Valve normal position shall be as shown on the drawings.

8. For systems with glycol solutions, provide documentation that the valve components in contact with the fluid are compatible with glycol.

D. Steam Valves:

1. Body and trim materials shall be per manufacturer's recommendations for design conditions and service, except stainless steel seats are required for all applications. Equal percentage ports for modulating service.

2. Sizing criteria:

a) Two-position service - pressure drop 10 to 20 percent of inlet psig.

b) Modulating Service - 15 psig or less. Pressure drop 80 percent of inlet psig.

c) Modulating Service - 16 to 50 psig. Pressure drop 50 percent of inlet psig.

d) Modulating Service - over 50 psig. Pressure drop as scheduled on plans.

3. Steam valves shall fail normally open or closed as scheduled on plans or as follows:

a) Low pressure heating - normally open.

b) Heating coils in air handlers - normally open.

c) Steam-to-water converters for heating water - normally open.

d) Steam-to-water converters for domestic hot water - normally closed.

e) High-pressure applications - as scheduled.

2.02 AUTOMATIC DAMPERS

A. All dampers not specified with equipment in other sections of the specifications shall be furnished by the Temperature Control Contractor and shall be single or multiple blade type as required.

B. All damper frames are to be constructed of #13 Gauge G90 galvanized sheet metal, roll formed into channels and welded for maximum strength and shall have flanges for duct mounting.

C. All blades shall be fabricated from single #16 gauge G90 galvanized sheet metal. Blade pins shall be steel, zinc plated, and chromate treated to provide no-slip pivoting when a damper is used as a single module, or is interconnected with others. Blades shall be suitable for high velocity performance.

D. Dampers used for outside, return, or exhaust air, and those used for zone mixing dampers shall be provided with seals to provide tight shut off along all edges of all blades; tight closing and low leakage damper of less than 4.5 cfm/ft. at 1" static pressure. Bearings shall be oil impregnated to provide constant lubrication.

E. Blade edge seals and top and bottom channel seals shall be easily replaced if they are damaged.

F. An internal stop shall be provided on all dampers to prevent over-rotation in the closed position.

G. Ruskin CD-50, Johnson DCO/DCP, NCA SCD-LL-57 or approved equal.

2.03 LOCAL CONTROL PANELS

A. NEMS-1 locking panels shall house DDC controllers transformers, power supplies, communications interfaces, transducers/sensors that do not need to be field mounted, relays, wire termination/junction strips, etc.,.

B. Devices shall be flush-mounted on panel face.

C. Manual timer overrides are not permitted. Manual overrides will be handled through a software function. If any manual override exist they shall be removed as part of this project.

D. Internal components shall be securely mounted on removable sub-panels. Each component shall be individually labeled with function and device identification, as shown on control/interlock shop drawings. Label all components in accordance with Specification Section 26 05 53 Identification for Electrical System.

E. Interconnections between internal and face-mounted devices pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL-listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.

F. Provide on/off power switch with over-current protection and a 1-½" main air gauge for control pressure sources to each local panel. Provide a 120-volt duplex outlet inside each control panel that houses a DDC controller (except VAV controllers) if there is not an outlet within 5' of the enclosure.

G. All control panel locks shall be the same. Contractor shall give the keys to the DPS Controls Application Engineer at completion of training.

H. All field devices shall be mounted in panels. Exceptions include devices with enclosed electrical terminations, and designed to be installed on the controlled/monitored equipment and (e.g., pipe/duct temperature/pressure sensors) or those for space mounting (e.g., space temperature sensors).

I. All advisory controllers shall be provided with battery backup UPS system securely mounted to the wall or inside of the controller cabinet. Basis of design is: CyberPower CP850PFCLCD.

1. Voltage: 120/1/60
2. Voltage Range: 78-142
3. Frequency Range: 57-63
4. Output VA / Watts: 850 VA / 510 W
5. Battery runtime half/full load: 10 min / 2 min
6. Warranty: 3 years limited

2.04 TEMPERATURE SENSORS

A. Temperature sensors shall be thermistor or platinum RTD type.

B. Space (room) sensors shall be surface mounted in standard plastic covers.Sensors shall have a tamper resistant cover with accessible control to permit a +/- 3 deviation from the stored setpoint. Minimum range shall be 50 to 95. Place thermostats or temperature control sensors inside covers that discourage tampering and vandalism in gyms, corridors, art rooms, unsupervised or athletic areas or where shown on drawings. Metal guard and key lock are not required in administration areas or seated classrooms.

C. Immersion-type sensors with matching thermowells shall be used for water/steam applications. Thermowells shall extend beyond to the outside of pipe insulation.

D. Provide averaging elements for all air temperature-measuring applications, except for return air and discharge air applications. Provide sun shields for outdoor sensors.

2.05 SENSOR/TRANSMITTERS

A. Transmitters shall have direct-acting, linear 0-5vdc or 4-20madc output signal compatible with controller, with full-scale accuracy of ±1 percent or better. Zero and span shall be field-adjustable.

B. Pressure

1. Air pressure transmitters shall have a minimum overpressure rating of 10" W.C or up to eight times the rated pressure without damage, whichever is greater.

2. Water differential pressure transmitters shall have stainless steel diaphragm construction, overrange pressure limits selected by the engineer for the appplication, and the accuracy shall be ±0.25 percent of calibrated span.

3. All differential pressure transmitters for water service shall have a differential pressure gauges mounted at the point of application. Provide tees with ½" size, quick-connect fittings (Hanson fittings) on the high- and low-pressure lines.

4. Air differential static pressure transmitters for critical applications (i.e., where the differential pressure can drop below 0.2" W.C. - such as outside-air flowrate monitoring) shall be an Air-Monitor, Veltron II Model, differential-pressure transmitter or Ashcroft only.

5. All differential pressure transmitters for air shall have panel-mounted differential pressure gauges. Provide tees with removable caps on the high- and low-pressure lines.

6. Provide a wind dampening "weatherhead" for each atmospheric pressure sensing point (DWYER A-306). Design to be located,as best as possible,above wind eddies caused by the building structure and roof equipment.

7. Transmitter Span Selection:

a) The span of each transmitter shall be selected by the Contractor. General selection procedures are given below.

b) The selection of the appropriate transmitter span is a crucial step in the design of a functional control system. In general, the span of the transmitter should match the normal ranges of the variable to be controlled. For example, the measurement of system pressure where the normal operating pressure is 20 psi and the peak system pressure is 35 psi, the correct span selection would be 0 to 50 psi. A 0 to 100 psi span, while workable, would be operating in the lower third of the span under normal conditions. This decreases the controller's ability to detect small changes in pressure. Ideally, the control setpoint should be at approximately 75 percent of the transmitter's span. However, expected maximum and minimum values encountered during normal operation of the system must be accounted for.

c) Particular attention to transmitter span must be taken with airflow monitoring stations. The recommendations of the airflow-monitoring station supplier must be followed. Be sure to include an altitude correction factor.

d) Transmitters found operating in the lower 33 percent or upper 20 percent of their span, during normal conditions of system operation, shall be replaced at the Contractor's expense with units having an acceptable span.

C. Water flow sensors should be in-line or insertion turbines, vortex, or magmeter types.

D. Fan and pump status shall be by current switch.

2.06 ELECTRIC AUXILIARY DEVICES

A. Fan and pump status shall be by current switch.

B. Use damper end switches that are integral to the actuator.

C. Control relays shall include d "energized" indication light.

D. Time-delay relays shall be adjustable plus or minus 200 percent (minimum) from the required setpoint.

E. Multi-Level Control Panel for Liquids: the controls shall be conductance-actuated, utilizing electrodes and the conductivity of the liquid itself to sense level. The sensor shall have four (4) level-sensing electrodes and one (1) ground electrode, in lengths suitable for the application. Unit must function on a fiberglass tank.

2.07 ELECTRIC ACTUATORS

A. Damper actuators shall be selected by the Controls Contractor per manufacturer's recommendations to provide sufficient close-off force to effectively seal damper. Furnish a separate actuator for each damper section.

B. All actuators shall provide a means of manually positioning the output coupling in the absence of power.

C. Dual independently adjustable auxiliary switches must be integral to the actuator. The addition of this feature as an accessory kit is not acceptable.

D. All actuators shall provide an easily readable high contrast yellow on black position indicator.

2.08 SAFETY CONTROLS

A. Freezestats: Provide one freezestat for each coil section of each coil bank (e.g., one coil with three sections requires three freezestats). Wire freezestats to protect unit in both hand and automatic operation. Wire one set of contacts directly to the fan starter circuit and the other to an alarm input. The device shall be manually reset unless indicated otherwise.

B. Duct Smoke Detectors: specified to be furnished under Division 26 and mounted by this Contractor.

1. This Contractor shall be responsible for all smoke detector interlock wiring to HVAC equipment.

2. Wire smoke detectors to shut down the equipment in 'hand' and 'automatic' mode.

2.09 OPERATOR INTERFACE

A. Web Server PC (may not be needed) - to be specified by the A/E if needed.

B. Operator Interface Software (A/E may not specify this if previously provided) – The software shall provide the following functions:

1. Graphic Screens - Display of custom graphic screens with dynamic point information and the ability to show animation by shifting image properties based on the status of the point.

a) NOTE - The terms "graphic screens" and "graphic(s)" in this specification refers to graphical images viewed via a PC running Operator Interface Software (a "Thick Client") or a PC viewing graphical images on web pages via a web browser (a "Thin Client").

b) Graphic Generation: Graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall also provide the capability of capturing or converting graphics from other programs such as AutoCAD.

c) Graphics Library: Furnish a library of standard HVAC system/equipment graphics screens such as chillers, boilers, air handlers, terminals, fan coils, unit ventilators, etc.; and standard symbols for HVAC components including fans, pumps, coils, valves, piping, dampers, ductwork, etc.

2. System Applications - Provide the following:

a) System Database Save and Restore: Automatic (when changes occur) or manual backup of the system databases (e.g., a DDC Panel point database and/or control program). The operator shall also be able to manually initiate a download of a specified database to any DDC Device in the BAS.

b) System Configuration: Provide an application for DDC System configuration (DDC Device communications addressing, point definition, etc.).

c) Help: Provide a context sensitive, help system to assist the operator in operation of the DDC System.

d) Security: Each operator shall be required to log on to the DDC System with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator.

e) System Diagnostics: The system shall automatically monitor the operation of all DDC Devices including network communications and provide an alarm when a failure occurs.

f) Standard DDC System Operating Features:

1) Point/Data Overrides/Modifications – Output points and system data (i.e., setpoints) shall be modifiable (i.e., auto vs. manual and overridden value) via a link to each item's graphic screen image.

2) Alarm Processing – An alarm log with acknowledgement and alarm clearing functions; and the ability to configure alarm limits, and system reactions (e.g., an alarm message, communications method, etc.).

3) Trend Logs: The ability to define a custom historical trend log for any data in the system. The data can be displayed tabular or graphical.

4) Scheduling: A graphical method for scheduling equipment operation including normal, holiday and exception scheduling.

3. Control Software Editors: The software shall allow for Operator editing of all control applications including:

a) Application Specific Controller: A full screen graphical editor for each type of application that allows the operator to view and change the configuration, name, control parameters, and set points for all controllers.

b) Custom Control Programming: A graphical editor for creating, modifying, and debugging the custom control programming for all Routers/Panels/Controllers.

4. Web Server: This shall, as a minimum, allow Thin Clients (PC's running web browser software) to perform all the capabilities described above except: Graphic Generation, System Database and Restore, System Configuration, and Control Software Editors.

2.10 DDC CONTROLLER REQUIREMENTS

A. General:

1. A separate DDC controller for each AHU or other HVAC system/equipment shall be supplied.

2. No more than one DDC controller shall be provided for each AHU or other HVAC system. Provide point expansion modules to meet this requirement. Certain systems (e.g., chiller plants) may be best served by multiple controllers – it is the A/E's responsibility to make this determination and to clarify this issue in the design.

3. Equipment Controls and Subsystem Interfaces:

a) Provide interfaces to equipment controls that are to be integrated to the DDC System.

1) No hardware interface is required for equipment controls that communicate via BACnet/IP. However, provide sufficient DDC System capacity for mapping all BACnet/IP points/data into the DDC system.

b) Provide interfaces to Subsystems that do not communicate via BACnet/IP.

c) "Interfaces" shall include standard/optional modules and for DDC Controllers (i.e., an MS/TP interface or Modbus gateway) are provided by separate DDC system devices (i.e., routers/gateways).

d) See the remainder of this design, and equipment controls and Subsystem specifications for more information.

2.11 GENERAL PURPOSE APPLICATION CONTROLLERS

A. General Purpose Multiple Application controllers shall be B-BC or B-AAC BTL-listed for BACnet communications. JCI N1 or N2 protocol communications may be acceptable in certain retrofit situations – consult with DPS about this issue.

B. At least one B-BC controller with BACnet/IP communications shall be provided [Note to Consultant: Consult with the DPS Controls Application Engineer to determine if more than one B-BC controller with BACnet/IP is required for the project]. This controller (a JCI NAE or NCE) need not be provided with integral point termination capabilities. Larger projects (.e.g., High Schools) may benefit from more than one of these controllers – consult with DPS Controls Application Engineer about this issue. Other controllers shall use the MS/TP data link technology.

C. Point Expansion: The General Purpose Multiple Application Controllers shall use point expansion modules to meet the design's point requirements.

D. Point Programming: All point data, algorithms and application software within a controller shall be custom programmable from the operator workstation. Controllers with factory-programmed control sequences (e.g., for a typical AHU or other system) shall not be acceptable.

E. Each output point shall have an integral manual override switch that allows the output to be configured in one of three states: on, off, or automatic operation. An LED shall indicate the state of each output.

2.12 ZONE CONTROLLERS

A. The Zone Controllers shall be B-ASC or B-AAC BTL-listed for BACnet communications using the MS/TP data link technology. JCI N2 protocol communications may be acceptable in certain retrofit situations – consult with DPS about this issue.

B. A Zone Controller shall only be used when the factory programmed sequence meets that required by the sequence of operation.

C. VAV box Zone Controllers controls shall be mounted by the VAV box manufacturer in the factory. The A/E is responsible for coordinating this requirement with the VAV box specifications.

D. Airflow Transducer: Zone controllers for VAV operation shall have a built-in differential pressure transducer for use with the box's integral pitot-type air flow pickup. The A/E shall coordinate this requirement with the VAV box specification to ensure that the boxes are provided with the flow pickup.

E. Integral Actuator: Each Zone Controller for VAV applications shall have an integral direct coupled electronic actuator.

PART 3 EXECUTION

3.01 CONTROL WIRING

A. Provide all control and communication wiring (except CAT 6 for Ethernet/IP) including that for connecting equipment controls and Subsystems to the DDC System.

B. The Cat 6 wiring drops that interconnect the DDC System Controllers, equipment controls, and Subsystems, and the devices to the IBAS shall be installed by the telecom contractor. The installer shall be Panduit certified as outlined in Division 27, Contractor Qualifications. Construction contractor needs to coordinate timing of wiring installation to facilitate the installation and testing of the IBAS system.

1. Final wiring from the DDC System Controllers, equipment controls, and Subsystems to the drops shall be provided by the Controls Contractor.

C. Control wiring shall be concealed except in equipment rooms.

D. Electrical installation will be according to the following requirements:

1. All wire and cable runs will be protected with metallic conduit or cable trays. Exceptions are as follows:

a) NEC Class 2 low voltage wiring where not exposed to view such as above suspended ceilings, in shafts, etc., may be run in cable tray or properly secured to the building (when approved by code authority).

b) Wiring enclosed in temperature control panels.

E. All wire and cable runs will be labeled or otherwise coded at both ends, the labeling or coding scheme should be well-organized, consistent, and documented (submitted).

F. All low voltage instrumentation wiring shall be minimum 18 AWG stranded copperfor sensors and communication.All low voltage cables in ceilings shall be UL listed for air plenum service and suspended neatly from the overhead structure.Do not lay on top of ceiling tiles.

G. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than ½" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

H. Low-voltage (24V or less) AC or DC wiring shall not be run in conduit containing 120 VAC wiring.

I. Label all temperature control wiring junction box covers with an adhesive backed water-proof flexible mylar label with the letters T/C, using an orange background with black letters to differentiate them from junction boxes installed by the electrical and fire alarm contractor. The labels shall be 3" x 3''.

J. Use proper size wire nut type connectors on all sensor wiring with factory recommended twisting. Crimp connectors are not allowed on sensor wiring.

3.02 INSTALLATION AND SETUP REQUIREMENTS

A. Install discharge air temperature sensors in all VAV boxes with reheat coils. Wire each sensor to an AI point termination on the box's associated Zone Controller.

B. Averaging Sensor Elements, Low-Temperature Detection Elements

1. The elements of averaging sensors shall be long enough to serpentine across the area served. The element shall cover the duct area completely and shall be equally spaced. Use copper radius clips at the bends and protect sensor elements at duct penetrations and other points of contact with poly-tubing.

2. Low-temperature detection devices shall fully cover the coil face as described in the Part 2 Safety Controls requirements. Mount and protect elements as described above.

3. Sensing elements shall be located so as not to interfere with filter changing or other maintenance activities. The elements shall be mounted downstream of the coil served.

C. Averaging-type sensing elements shall be firmly supported in ductwork or air-handling units using ½" EMT or other auxiliary support.

D. For all applications utilizing outside air, relief, isolation or exhaust dampers: install an E/P to automatically close the dampers when its associated air-handling unit or fan is turned off. The E/P shall be wired so the damper is closed when the fan or AHU is turned off with the starter switch in the OFF or AUTO position (or in either the BYPASS or VFD modes when a variable-frequency drive is used). The dampers shall open, or return to automatic control, as required, when the fan or AHU is turned on, whether the started switch is in the HAND or AUTO position (or in either the BYPASS or VFD modes when a variable-frequency drive is used).

E. The name of each point shall conform to the District's standard protocol used at DPS. The intent is to utilize standard point names within a project and from one project to another. Consult DPS Controls Application Engineer for current standards.

F. Utilize programming protocol used by JCI at DPS whenever possible.

3.03 CONTROL DEVICE LOCATIONS

A. Outdoor temperature or RH sensors shall be located on the design drawings, and generally on a northern exposure, in a shaded location, preferably in a place where there is a continuous stream of outside air over the sensor, unless shown otherwise. Consult with the DPS Controls Application Engineer to determine the preferred locations.

B. Provide wind-dampening "weatherhead" with insect screen on outdoor atmospheric pressure-sensing point and mount at least 3' above the highest roof structure to minimize false readings due to wind direction and/or eddies.

C. Remote control devices not in local panels shall be accessible for adjustment and service, below 6’ above finished floor whenever possible.

3.04 CONTROL PANELS

A. Electro-pneumatic switches (EPs) and relays shall be grouped together and installed in a single, central panel located next to the enclosure housing the associated controller. At the Contractor's option, the relays and EPs may be installed in the same enclosure as the controller. Remote-mounted relays and EPs are not acceptable. Remote-mounted PE switches are allowed.

B. Electrical power for each panel shall be from a dedicated circuit. Where available in a building, utilize emergency power circuits for all controls. It is the A/E’s responsibility to show a sufficient number of dedicated controls circuits in locations where control power will be needed on the electrical drawings. For retrofit applications, where connecting to existing control-power wiring, it is the Contractor's responsibility to verify that the power source is from a dedicated circuit. **[Note to Consultant: Coordinate power sources with the Electrical Engineer, show all equipment requiring 120V power on the drawings.]**

3.05 IDENTIFICATION

A. All control equipment shall be clearly identified by control shop drawing designation code and a functional description as follows:

1. Control valves: Brass tags.
2. Other remote control devices and sensors (located both within and outside of control panels): metal tags, plastic laminate labels, or (on non-porous surfaces only) adhesive backed labels (i.e., from a laser printer or a dedicated label-making device). Do not attach tag or label to removable covers, adjacent surface etc.,
3. Control panels: Engraved plastic laminate labels. Indicate panel number and systems served.
4. All wiring, including wiring within factory-fabricated panels, shall be labeled within 2" of each termination with DDC point number/controller number or other descriptive information.
5. Plenum-rated cabling shall use different jacket colors to differentiate between the following:
    a) Input point wiring.
    b) Output point wiring.
    c) Communications (i.e., MS/TP).
    d) Low Voltage power.
6. All metal and plastic engraved labels shall be secured with chains, nylon tie-wraps, or rivets. Permanent adhesive is acceptable only when mechanical fasteners would damage the labeled equipment.
7. All switches, relays, and panel components shall be labeled. Relay bases shall be labeled, not the removable relay cube.
8. Labels shall not be mounted on removable surfaces, such as cable tray covers.

3.06 OPERATOR INTERFACE AND OTHER SYSTEM CONFIGURATION

A. General:

1. All DDC System schedules, alarms and trends for this project shall be set up under this section (i.e., for communication to the IBAS).
2. Alarms and trends shall also be communicated to the DDC System's local Operator Interface until the IBAS or warranty period is complete.
3. Schedules shall also be available for modification from the local Operator Interface until the IBAS or warranty period is complete.
4. Consult with the DPS Controls Application Engineer to determine when the local Operator Interface functionality is no longer needed and disable any DDC System communications to the Operator Interface.

B. Graphics – Provide that specified by the A/E for use during system start-up, testing, commissioning and the warranty period (in addition to that provided by the IBAS).

C. Alarms:

1. Size DDC System controllers so that 48 hours of alarm information minimum can be stored at the building (not including any Operator Interface archiving capacity).
2. Set up alarms so that:
   a) They are not issued when the associated system is off (e.g., an alarm for an AHU supply air temperature shall not be issued when the AHU is off).
   b) The alarm limits vary with the associated operating mode (e.g., a space temperature's alarm limits changes between occupied and unoccupied modes).
   c) The alarm limits vary with the associated set-point (e.g., an AHU supply air or space temperature's alarm limits vary with the set-point if reset).
   d) Consult with the DPS Controls Application Engineer to determine the appropriate alarm limits.
3. The following data (and/or BACnet properties or service primitives) shall be associated with each alarm generated/stored by the DDC System:
   a) Time and date of the alarm.
   b) Alarm Priority
   c) Event (alarm) type
   d) The BACnet "From" and "To" states
   e) The BACnet "Event Values" (e.g., alarm limit)
   f) A text description of the alarm condition including:
      1) Location (building, floor, zone, office number, etc.).
      2) Equipment (air handler #, pump, etc.).
   g) Initiating device and object identifier
   h) Acknowledgement time and date
   i) Operator who issued acknowledgement.
4. Alarms shall be generated by the DDC System upon the occurrence of one of the following events (in addition to the specified in the Sequence of Operation):
   a) Failure of a controller or any other DDC System hardware components.
   b) Failure of communications between DDC System components; and between the DDC System and the IBAS, equipment controllers or Subsystems.
   c) A monitored status indicating a discrepancy between the actual and the required value.

d) A monitored value does not meet criteria established by the operator.

e) The deviation of a variable from set-point exceeds operator-established criteria.

f) The output to a final control element is outside operator-established criteria.

g) A digital input is in the state defined by the operator as indicating an alarm condition.

h) Software failures and errors shall be diagnosed and annunciated by the BAS.

D. Trending:

1. Size DDC System controllers so that 72 hours of trend information minimum can be stored at the building (not including any Operator Interface archiving capacity).

2. Set up trends in each associated General Purpose Controller for all points using change-of-value (COV) trending – consult with the DPS Controls Application Engineer to select the appropriate COV thresholds for analog points/data:

a) All Temperature sensors.

b) All Pressure inputs excluding those used to sense flow.

c) All Humidity sensors.

d) All Gas concentration inputs.

e) All Current or Voltage inputs.

f) All Flow inputs.

g) Digital input status points.

h) All Analog outputs.

i) Data (virtual points) used for operator override software switches (e.g., for changing operating status of systems and/or used for switching system modes of operation).

3. Set up trends for each of the following Zone Controller, if applicable, using change-of-value (COV) trending:

a) Space, Supply air and Coil Return Water Temperature.

b) Space/Zone Pressure.

c) Space or Exhaust Humidity.

d) Fan and Heat Pump Status.

e) Air Flow.

f) All Digital input status points.

g) All Occupancy status input points.

h) All Analog output points.

E. Point/Data Naming – Use the convention jointly developed with the DPS Controls Application Engineer and IBAS Contractor. See the Part 1 Submittals requirements in 25 50 00 Integrated Building Automation System.

F. IP Addresses - Addressing shall be set up per the direction of the DPS Controls Application Engineer.

G. BACnet Communications Addressing/Numbering – Consult with the DPS Controls Application Engineer to determine the address/number ranges to be used on this project and the standard for assigning specific addresses/numbers to each of the project's networks and devices.

H. BACnet Broadcast Management Configuration – Only one controller for this project shall be configured as a BBMD (BACnet Broadcast Management Device).

3.07 IBAS COORDINATION

A. The Contractor shall configure the DDC System in preparation for integration with the IBAS as follows:

1. Data Access: The following DDC System data shall be available for communication with the IBAS (e.g., discoverable without need for any configuration or programming efforts of the DDC System by the IBAS contractor):
    a) All input/output points from the DDC System, equipment controllers or
        1) All points from Subsystems that do not communicate via BACnet/IP shall also be available.
    b) Set-points and other sequence of operation parameters as defined in Sequence of Operation and the following:
        1) Lead/lag sequence variables.
        2) Temperature set-points and reset limits.
        3) System switches.
        4) PID tuning parameters.
        5) Alarm limits.
        6) Heating/cooling switchover set-points.
    c) All start/stop schedules within the DDC System (including those associated with an optimum start and/or stop routine).
    d) All alarms set up within the DDC System.
    e) All historical data trended by the DDC System.
2. The DDC System shall accept time synchronization messages from the IBAS and update all controller time clocks in the system accordingly. Coordinate with the IBAS contractor to ensure that the time synchronization message(s) from the Niagara Supervisor works properly to perform this function.
3. The IBAS shall be used to view and modify DDC System schedules using BACnet Schedule/Calendar Objects.
4. Alarms:
    a) The DDC System shall communicate alarms to the IBAS (i.e., using BACnet Alarm and Event Services).
    b) Alarm priority – Coordinate with the IBAS contractor concerning the specific alarm priority values to be used.
    c) Any alarms that cannot be supported by BACnet Intrinsic Reporting (i.e., an alarm determined by the alarmed object's alarm properties) or BACnet Algorithmic Change Reporting (i.e., one of the standard alarm/event algorithms defined in the standard) shall require additional alarm configuration efforts under this section. These efforts include configuring/programming the algorithm, defining a BACnet object which is used to communicate the alarm status and coordination of these alarm objects with the IBAS contractor.
5. Historical Data Trending:
    a) The DDC System controllers shall communicate trend data to the IBAS every 48hrs or when the trend log has reached capacity (whichever is sooner).
    b) Trend data shall be communicated to the IBAS using BACnet Trend Log objects.
6. Point/Data Operator Override - Any manual operator actions described by the sequences shall be available from the IBAS.

7. Point/Data Override Priorities – Coordinate with the IBAS contractor to ensure that commandable points/data (e.g., a BACnet Binary Output object) are written to at the correct priority level by the IBAS.

3.08 TESTING AND DEMONSTRATION

A. Prior to substantial completion, the control system shall undergo a series of tests to verify and demonstrate operation and compliance with this document. These tests and demonstrations shall occur after the Contractor has completed the installation, started up the system, and performed his own performance tests.

B. The tests and demonstrations described in this section are to be performed in addition to the tests that the Contractor performs as a necessary part of the installation, startup, and debugging process. Control system testing and demonstration shall be scheduled with the DPS Controls Application Engineer.

C. The Contractor shall provide at least two men equipped with two-way communication, and shall demonstrate actual field operation of each control and sensing point for all modes of operation, including day, night, summer, winter, occupied, unoccupied, fire/smoke alarm, and power failure modes. The purpose is to test and demonstrate the setup, calibration, response, and action of every point. Any test equipment required to prove the proper operation shall be provided by and operated by the Contractor. The DPS Controls Application Engineer, and District's HVAC representative shall observe and review these tests.

1. The system software shall be complete such that each control loop shall function as specified in the Sequence of Operation. This Subcontractor shall be required to furnish the software program and test the operation of every control loop.

2. After all field connections have been made and control power is available in the control panel, the DPS Controls Application Engineer shall be notified and the control system shall be energized. Any required reloading of the software shall be performed and demonstration of the mechanical system, automatic temperature control system, and other connected systems shall commence.

3. This Subcontractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the specification. Control performance criteria is specified in the sequence of operations shown on the drawings and/or the specifications.

D. Operational logs for each system which indicate all setpoints, operating points, valve/damper positions, mode, and equipment status shall be submitted to the Architect/Engineer. These logs shall cover a 24-hour period and have a sample frequency of not more than 10 minutes. The logs shall be provided in printed and disk formats.

E. Control loops shall maintain setpoint within the following tolerances:

1.	Air pressure	±0.5" w.g.	range 0 to 6" w.g.
		±0.01" w.g.	range -0.1 to 0.1" w.g.
2.	Airflow	±100 cfm.	
3.	Temperature	±1.0°F.	
4.	Humidity	±5 percent relative humidity.	
5.	Fluid pressure	±2.0 psi	range 1 to 150 psi.
		±2.0" w.g.	range 0 to 50" differential pressure.

6. Control loops that do not meet the above tolerances shall be re-tuned.

F. This Contractor shall demonstrate HVAC alarms prior to placing ventilation systems in service.

G. Participate in all tests required between the DDC System and the IBAS. Provide a protcol analyzer (i.e., Wireshark) for use in the testing. See 15975 for more information.

H. The control systems will not be accepted as meeting the Requirements of Completion until all tests and demonstrations described in this section have been performed to the satisfaction of the DPS Controls Application Engineer.

I. After the system has operated properly for 90 days following startup of the final component of the heating and air conditioning systems, as-built copies of the software on electronic media and a printed copy shall be submitted to the Owner for permanent record purposes. Any software upgrading or enhancements to improve the system operation or as required for proper operation of the system during the first 24 months of operation is the responsibility of this

Subcontractor. When changes are made to the software, the Contractor shall immediately provide updated copies of the files on floppy disks.

3.09 CONTROL EXECUTION – GENERAL

A. Provide independently adjustable, minimum ON and OFF timers for each start/stop point. Initially set bvtimes so as not to exceed six (6) starts per hour. On two-speed motors, provide a 20-second adjustable time delay when transferring from high-speed to low-speed, to allow the load to decelerate. This software time delay is in addition to the hardware time delay in the starters.

B. All setpoints, operating points, sequencing ratios, PID tuning parameters, and all other numeric and digital constants shall be adjustable by the user (with a high-level password) from the graphic. To change these values, the user shall not be required to modify program code, recompile, or download.

C. System logs, trend logs, and event-initiated logs shall be set up to provide historical and real-time monitoring of system operation. Logs shall be grouped by equipment.

D. Safety Shutdowns - General: all safety shutdowns of electrical equipment shall be hardwired. All shutdowns shall occur directly through interconnection of contacts on the safety device with the controlling circuit of the electrical equipment. Safety shutdowns through software are not acceptable. Interposing relays may be used only with prior approval of the DPS Controls Application Engineer when no alternative exists.

E. The Contractor shall notify the DPS Controls Application Engineer one month in advance of substantial completion so that the the IBAS (25 50 00) can be scheduled.

3.10 BAS SOFTWARE

A. Provide sufficient internal memory for the specified control sequences and logging. There shall be a minimum of 25 percent of available memory free for future use.

3.11 IBAS REQUIREMENTS

A. See 25 50 00 for Contactor requirements concerning the interface of the BAS system to the IBAS.

B. The point/data list at the end of 25 90 00, the drawings, or other specification sections includes points (and associated field devices) that shall be incorporated into the BAS design as part of this section.

C. Any points and data listed which are not controlled by the 25 00 00 system (e.g., lighting) shall be provided by input/output point interfaces to the 25 00 00 system if this information is not available by digital communications (e.g., BACnet).

D. See 25 90 00 and/or the drawings for the sequences of operation to be implemented by the system.

END OF SECTION 25 00 00

SECTION 25 50 00

INTELLIGENT BUILDING AUTOMATION SYSTEM

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Section 25 00 00 – Controls.

B. Section 25 90 00 – Sequence of Operation and Point/Data List.

C. Other division 21-28 sections that specify the Subsystems to be integrated to the IBAS.

1.02 RELATED WORK

A. This section along with those for the integrated Subsystems are responsible for joint efforts in integrating the Subsystems to the IBAS.

B. The Controls Contractor and Contractor for other integration Division 21-28 Subsystems shall set up the Subsystems to communicate the specified data with the IBAS. Subsystems that are BTL-listed shall be set up to use BACnet Alarm and Event services for alarm reporting and BACnet Schedule/Calendar objects for scheduling.

C. Communications address and device/object instance numbering are the responsibility of each Subsystem's Contractor.

D. All modifications to the IBAS for representing/controlling data from the Subsystems (e.g., graphics, alarm reporting, trend data presentation, schedule viewing/changes, etc.) are the responsibility of this section's Contractor.

E. This sections' Contractor shall revew the sections for all integrated Subsystems to determine the scope of the communicated data and operator interface functions for the IBAS.

F. See Part 3 of this section for more information.

1.03 SUBMITTALS

A. Prior to commencement of the work submit:

1. Graphic Screens and Reports:

a. Meet with the DPS Controls Application Engineer and the Subsystem contractors prior to developing the following submittals to determine the graphic screen design, any communicated point/data list additions/choices, the point/data naming convention, the alarming/trending requirements (including alarm priority levels), the schedules required, and/or any other items listed below regardless of their level of definition in the design.

b. Submit for approval a list of the graphic/report screens to be provided; and, for each screen, provide a conceptual layout of the screen and data, including those linkages to other pages/screens. Details on the required graphics/reports are in Part 3 of the specification.

1) All Subsystem data shall be represented or listed.

2) The point/data naming convention to be used.

3) All operator interface functions required by the specification shall be represented.

4) For Subsystems that are not BTL-listed (and/or do not support BACnet Alarm & Event services, Schedule/Calendar objects, and/or Trend Log objects):

a) Include an alarm list that defines the messages to be used for each class of alarms, and the routing (i.e., to what printers/terminal) of each class of alarms.

b) If applicable, include a start/stop schedule list that defines each unique schedule to be provided, the details of the schedule, and the equipment affected by the schedule.

c) Include a list of all points/data to be trended.

5) For each screen proposed include a list of all setpoints and other operating parameters to be available via the IBAS.

6) The data to be trended.

7) Coordinate the above effort with the Subsystems' contractors to ensure that it properly represents the designs.

2. System Test Plan – Submit the plan and forms to be used in the System Test procedures described in Part 3.

3. Commissioning: Provide for approval all materials as required by the Commissioning Specification.

4. Any product data sheets, if applicable.

B. Upon acceptance of the system installation submit the following Record Drawing documentation:

1. Completed test forms.

1.04 WARRANTY

A. Manufacturer shall guarantee the work to be free from defects in workmanship under normal use for a period of 24 months from date of acceptance of system by Owner.

B. Modify any defective workmanship within guarantee period, immediately, without cost to Owner.

1.05 COMMISSIONING

A. Commissioning shall comply with Sections 23 08 00 Commissioning for HVAC.

B. The Commissioning specifications shall include requirements to test all communications functions between the IBAS and the Subsystems.

C. The IBAS Contractor shall participate in the Commissioing tasks as specified. These tasks shall not be a substiture for proper start-up and testing of the IBAS functions for this project.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The existing IBAS hardware/software system shall be used for execution of the work required herein.

B. Communications wiring, routers, gateways, switches, etc. specified/installed under other section. Unless otherwise determined no hardware or software products/installation, (e.g., routers, gateways, communications wiring/devices) are required in this section for IBAS operation.

C. The IBAS is not capable of executing any control sequences. All building Subsystem sequences shall be executed by the Subsystems' controls.

D. Failure of the IBAS shall not interrupt normal operation of any of the building Subsystems.

2.02 SYSTEM ARCHITECTURE

A. System Level:

1. Each of the following Subsystems, when IBAS integration is included in the project , shall be specified with a separate point of interface to the IBAS.

a. HVAC System:

1) Note – All HVAC equipment controls (including that provided with the equipment) shall be integrated to the DDC System. The DDC System in turn communicates all required IBAS points/data to the IBAS.

b. Plumbing System.

c. Fire Alarm and Notification.

d. Energy and Utility Management.

e. Lighting.

f. Electrical System.

B. Building Level:

1. All Subsystems shall communicate to the IBAS via BACnet/IP.

2. Exceptions/Clarifications:

a. Any Subsystem not available with BACnet/IP (or N1) communications shall be integrated to the DDC System using BACnet MS/TP, Modbus, etc. The Subsystem's points/data shall in turn be routed to the IBAS via the DDC System.

b. HVAC equipment controls provided with the equipment (i.e., chiller controls) shall communicate directly with the IBAS if the equipment is provided with a BACnet/IP interface. However, the DDC System shall still be responsible for simultaneous communications with this equipment for use in meeting the 25 90 00 Integrated Auto Control Sequences for Facility

c. Plumbing system integration functions (typically alarm contact closures) are best accomplished via connection to the DDC System. This includes chilled/hot/steam flow/BTU metering which shall be specified under Section 25 00 00 Integrated Automation.

d. Certain energy metering functions are best accomplished via connection to the DDC System. This includes chilled/hot/steam flow/BTU metering which shall be specified under Section 25 00 00 Integrated Automation.

C. IBAS Enterprise Level:

1. The Subsystems in each DPS building shall communicate with the IBAS via the DPS intranet.

2.03 NETWORK ROUTERS & GATEWAYS

A. All communications hardware/software needed for communicating BACnet/IP data to the IBAS is provided under other sections.

B. All communications hardware/software needed for other interfaces (e.g., BACnet MS/TP, Modbus, etc.) is provided under other sections.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

A. No work shall disturb the operation of the IBAS for use in operating other DPS school's.

B. Work on the IBAS shall be scheduled in advance with the DPS Controls Application Engineer.

C. Time Synchronization – All 25 00 00 Integrated Automation with real-time clocks shall be synchronized from the real-time clock in the IBAS at least once every 24 hours.

D. Develop IBAS graphic screens and other functions in accordance with manufacturer's instructions.

3.02 POINT/DATA INTEGRATION

A. General:

1. Points/data to be mapped are listed in 15985, on the drawings and/or in the Subsystem specifications.

a. The final list of points/data to be integrated shall be defined by the submittal process as defined in Part 1.

2. All DDC System input and output points shall be mapped into the IBAS. .

3. Physical points shall be mapped intothe appropriate BACnet I/O point objects. If possible.

4. Equipment modes (e.g., economizer, warm-up, etc.) and setpoints shall be mapped into BACnet MD, BD or AD objects.

5. Map any other data required for operation of the IBAS functions (i.e., start/stop schedule data).

6. BACnet objects shall use the BACnet standard's object instance numbering scheme.

7. Point/Data Operator Override - Any manual operator actions described by the DDC System or other Subsystem sequences shall be available from the IBAS.

B. Alarms:

1. The following applies to Subsystems that are BTL-listed as B-BC or AAC devices and/or support BACnet Alarm & Event services.

a. Subsystems that are not BTL-listed or support the above services shall be polled by the IBAS for any alarms.

b. Alarms algorithms shall be set up in the IBAS for any Subsystems that do not perform alarm monitoring of its system points (i.e., the target object shall be polled by the IBAS and compared to high/low limits or normal/off-normal states by the IBAS).

2. Alarms (i.e. limits, messages, priorities) shall be set up in each Subsystem by the Subsystem contractor.

3. Alarms shall be automatically communicated from the Subsystem to the IBAS in real-time.

4. When requested by the IBAS, the Subsystem shall provide an alarm summary.

5. Alarm priority – Coordinate with the Subsystem contractor concerning the specific alarm priority values to be used.

A. Historical Data Trending:

1. The following applies to Subsystems that are BTL-listed as a B-BC and/or supports the BACnet Trend Log object.

a. Subsystems that are not BTL-listed or support the Trend object shall be polled by the IBAS for trending requirements.

2. Trends shall be set up in the Subsystem by the Subsystem contractor.

3. The IBAS shall read trend data (i.e., via the BACnet Trend Log object) every 48 hours (or sooner if the trend log has reached capacity), or whenever needed to fulfill an operator display request (i.e., to display a trend report on the IBAS).

3.03 ALARM REPORTING AND MANAGEMENT

A. Set up the IBAS so that the alarms for this project are properly received, processed and routed.

B. Receipt of an alarm shall be indicated on any graphic that includes associated point data. This indication shall be both textual and graphical (i.e., the point name and/or associated device shall change color, flash, and/or etc.).

C. The alarm shall be identified by the IBAS as being received from this building and routed to the alarm summary for this building.

3.04 GRAPHIC SCREENS

A. The system shall be provided with color graphic screens that show all of the controlled systems with all associated points, setpoints and modes of operation. including:

1. Opening screen graphic showing the building, campus, facility, etc.
2. Each HVAC air and water system monitored or controlled.
3. Each floor and zone controlled (floor plan) - both HVAC and smoke detectors where applicable.
4. Each VAV box with DDC controls.
5. Each electrical subsystem monitored or controlled.
6. Each prime mover equipment (boilers, chillers, heat exchangers, pumps, towers, and distribution system).
7. Utility consumption and outdoor condition logs.
8. Fuel oil and generator systems.
9. Each miscellaneous monitored or controlled point.
10. Screens for any Subsystems not listed above with all points/data represented.
11. Menu penetrations: "buttons" shall be provided to allow the user to easily move among the various graphics and menus. At any time, the operator shall be able to return to the main menu with one mouse click and shall switch from graphic to other modes within two mouse clicks.

B. The final selection and design of graphic screens shall be determined as part of the submittal process as defined in Part 1.

3.05 TESTING AND ACCEPTANCE

A. The tests described herein are to be performed after Contractor has performed their own system start-up testing performed as a necessary part of the installation, startup, and debugging process.

B. The testing required below shall be observed by the Owner, and coordinated with the Owner and Subsystem contractors. The Subsystem contractors shall participate in the tests associated with their system.

C. Testing:

1. The IBAS work shall be tested for proper operation.
2. The Contractor shall use a protocol packet analyzer (i.e., Wireshark or any other "sniffer" with a BACnet message decoding capabilities) to:
    a. Verify that the IBAS communications is not generating excessive network traffic (i.e., high packet reject rates), excessive polling by the IBAS, excessive alarm/event messages sent by the Subsystems.
    b. Verify that all messages between the IBAS and the Subsystems are properly formed.
3. Testing shall demonstrate the end-to-end integrity of all data communications and user commands between the Subsystem(s) and the IBAS.
4. Selected time schedules, set point and control mode modifications, and output overrides shall be verified by changing the schedule and observing the correct response of the controlled outputs.
5. Communication with each Subsystem controller with a testing of the operation of sample of messages/services expectedI.
6. Specified IBAS reports and trend logs shall be demonstrated.
7. Alarms shall be demonstrated, along with the output to the alarm GUI.
8. Workstation commands and operating screens shall be explained and demonstrated.

D. Owner and Engineer shall review installation and operation of IBAS, and prepare a list describing any deficiencies (punch list).

E. Upon receipt of list of deficiencies from Owner, Contractor shall prepare written report indicating by Subsystem each outstanding item on list. Contractor shall correct items appearing on installation-inspection report and present written request for re-inspection and approval to Owner.

F. Upon satisfactory completion of punch list and successful demonstration of operation for all components, Owner shall provide acceptance of IBAS. The date of Owner acceptance shall constitute the start of the warranty period.

G. On the date of acceptance, Contractor shall provide the project record documentation.

3.06 INSTRUCTION AND TRAINING

A. Upon completion of work and acceptance by Owner, IBAS representatives shall provide 16 hours of instruction/training to 4 of Owner's operating personnel. This instruction/training shall, at a minimum, consist of a review of the GUI screens created for the project, operator capabilities, Record Drawing documentation, the specific IBAS Interface technology utilized plus a walk through of the Project to identify equipment locations and to answer site questions.

END OF SECTION 25 50 00

SECTION 25 90 00

INTEGRATED AUTO CONTROL SEQUENCES FOR FACILITY

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Sequence Of Operation:
    a) Air Handling Units (VAV).
    b) Makeup Air Unit (gas-fired).
    c) CV AHU.
    d) Chilled Water Cooling.
    e) Air-cooler Chiller.
    f) Chilled Water Pump.
    g) Hot water heating.
    h) Terminal Units.
    i) Exhaust Fans.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.01 SEQUENCE OF OPERATION

A. VAV Air Handler:

1. The occupancy mode (occupied-unoccupied) shall be determined through a user-adjustable, graphical, seven-day schedule with an additional holiday schedule.
    a) Occupied Mode:
        i) All fans shall have a starter with 'hand-off-auto' switch or a Variable Frequency Drive (VFD).
            - When the starter switch is in the 'hand' position, the fan shall run. When the switch is in the 'off' position the fans shall stop. When the switch is in the 'auto' position, the fan shall be under the control of the DDC Controls System.
            - When the fan is controlled by the VFD, the DDC Control System shall interface with the VFD controller and make all monitoring and control points available to the DDC System. The VFD shall have a by-pass switch to allow for manual operation of the fan when the VFD is not operational.
            - The supply fan shall be energized. The supply fan speed shall modulate to maintain duct static pressure setpoint (adjustable). The final setpoint shall be determined in consultation with the balancing contractor. Initial duct static pressure setpoint shall be 1.0' w.g. (adjustable).
            - Provide a high static alarm when the duct static pressure rises above 3.0" w.g. (adjustable).
        ii) Whenever the supply fan is energized, the return/exhaust fan shall be energized. The return fan speed shall modulate to maintain the return Building static pressure setpoint of 0.10" w.g. (adjustable).
        iii) The exhaust air damper shall modulate to maintain the space static pressure setpoint of 0.05" w.g (adjustable).

- Building static pressure sensors shall be located in a space where there will be small changes in the pressure between inside and outside pressure changes. Recommended places: Second floor corridors, common spaces, offices, or library. Do not locate sensor near elevators or exterior doors.

iv) Discharge air temperature setpoint shall be reset based upon return air temperature according to the following reset schedule. All parameters shall be independently adjustable.

- The cooling coil control valve shall modulate to maintain the discharge air temperature setpoint, 55 degrees F (adjustable).
- The heating coil control valve shall modulate to maintain the discharge air temperature as described below.
- Discharge air temperature setpoint is 55 degrees F (adjustable) when outdoor temperature is greater than 70 degrees F.
- Discharge air temperature setpoint is 65 degrees F (adjustable) when outdoor temperature is less than 30 degrees F.

v) Economizer Control: Whenever the outside air temperature is above the space temperature (75 degrees F, cooling; 72 degrees F, heating) the outside air and return air dampers shall positioned for the minimum outside air scheduled. Or the CO2 sensor in the return air duct shall modulate the outside and return air dampers to maintain the minimum outside air required for the occupancy. When the outside air temperature is below 55 degrees F (adjustable), the outside and return air dampers shall be positioned to maintain the mixed air temperature.

vi) Indirect tower cooling (where applicable for evaporative cooling)

- Fill the tower sump if the outside air temperature is above 55 degrees F (adjustable).
- Maintain tower sump water temperature by cycling tower fan's 'off-low-high' using a local temperature controller mounted to the tower sump.
- Provide hardwired time delay internal to the magnetic motor starter when going from fan high-speed to low-speed to allow for fan deceleration.
- The tower sump shall drain to the interior sump whenever the outdoor air temperature is below 35 degrees F (adjustable) for 60 minutes (adjustable).

vii) Filter Status: A differential pressure switch across the filter shall signal an alarm the DDC system when the pressure drop across the filter is above the allowed minimum (adjustable). In addition, provide a magnic-helic gauge to indicate dirty filters.

b) Unoccupied Mode:

i) The supply and return fans shall be de-energized. Both outdoor air dampers and exhaust dampers shall be closed. The return air damper shall be open.

ii) The heating coil valve and pump shall cycle to maintain mixed-air temperature of 45degrees F (adjustable).

iii) The supply fan shall cycle to maintain the unoccupied setpoint temperature (65°F, adjustable).

iv) If the unoccupied space temperature is not maintained the heating control valve shall modulate to maintain the space temperature. And the supply fan shall cycle on.

c) Morning Warm-up:

i) When the outside air temperature is below 55 degrees F, the DDC system shall perform a morning warm-up cycle prior to the occupied mode.

ii) The outside air damper shall be closed and the return air damper shall be open.

iii) The supply fan shall energize and the heating coil control valve shall open.

iv) The Air Handling Unit shall remain in the morning warm-up mode until the return air temperature is 70 degrees F. After the system has achieved 70 degrees F (adjustable) the system shall enter the Occupied Mode.

d) Safety Shutdowns:

i) Duct smoke detection, high-pressure safeties and low-temperature limit trips shall de-energize the air-handling unit supply and return fans and close the outdoor air and exhaust air dampers. Manual reset shall be required to allow the fans to operate.

e) Freeze Protection:

i) When the outdoor air temperature is below 40degrees F (adjustable), the HW and CHW pumps shall be energized continuously for freeze protection. The heating coil valve shall cycle as described elsewhere.

ii) If the unit has shutdown on the low temperature limit switch, energize the return fan until the condition has been resolved.

2. Economizer Fault Detection and Diagnostics (FDD)

a) The following temperature sensors shall be permanently installed to monitor system operation:

i) Outside air.

ii) Supply air.

iii) Return air.

b) Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F.

c) Refrigerant pressure sensors, where used, shall have an accuracy of ±3 percent of full scale.

d) The unit controller shall be capable of providing system status by indicating the following:

i) Free cooling available.

ii) Economizer enabled.

iii) Compressor enabled.

iv) Heating enabled.

v) Mixed air low limit cycle active.

vi) The current value of each sensor.

e) The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.

f) The unit shall be capable of reporting faults to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats.

g) The FDD system shall be capable of detecting the following faults:

i) Air temperature sensor failure/fault.

ii) Not economizing when the unit should be economizing.

iii) Economizing when the unit should not be economizing.

iv) Damper not modulating.

v) Excess outdoor air.

B. Make-Air Unit (Gas-fired):

1. The occupied-unoccupied shall be determined by the kitchen exhaust fan status through a user-adjustable, graphical, seven-day schedule with an additional holiday schedule with the DDC system.

a) Occupied Mode:

i) All fans shall have a starter with ‘hand-off-auto’ switch.

- When the starter switch is in the 'hand' position, the fan shall run. When the switch is in the 'off' position the fans shall stop. When the switch is in the 'auto' position, the fan shall be under the control of the DDC Controls System.
- The fan shall energize and run with the kitchen exhaust fan. When the exhaust fan is on the Make-up Unit shall run.

ii) Discharge air temperature setpoint shall be reset based upon outdoor air temperature according to the following reset schedule. All parameters shall be independently adjustable.

- The cooling coil (if provided) control valve shall modulate to maintain the discharge air temperature setpoint, 55degrees F (adjustable).
- The gas-fired heat exchanger shall have a modulating gas valve that shall modulate to maintain the discharge air temperature as described below:

01) Discharge air temperature setpoint is 55degrees F (adjustable) when outdoor temperature is greater than 70degreesF.

02) Discharge air temperature setpoint is 65degrees F (adjustable) when outdoor temperature is less than 30degrees F.

iii) Indirect tower cooling (where applicable for evaporative cooling)

- Fill the tower sump if the outside air temperature is above 55degrees F (adjustable).
- Maintain tower sump water temperature by cycling tower fan's 'off-low-high' using a local temperature controller mounted to the tower sump.
- Provide hardwired time delay internal to the magnetic motor starter when going from fan high-speed to low-speed to allow for fan deceleration.
- The tower sump shall drain to the interior sump whenever the outdoor air temperature is below 35 degrees F (adjustable) for 60 minutes (adjustable).

iv) Filter Status: A differential pressure switch across the filter shall signal an alarm at the BAS when the pressure drop across the filter is above the allowed minimum (adjustable).

b) Unoccupied Mode:

i) The supply fan shall be de-energized. The outdoor air damper shall close.

ii) The fan coil units or radiant heating control valve shall modulate to maintain the space temperature of 55degrees F (adjustable).

C. Constant Volume Air Handler :

1. The occupancy mode (occupied-unoccupied) shall be determined through a user-adjustable, graphical, seven-day schedule with an additional holiday schedule.

a) Occupied Mode:

i) All fans shall have a starter with 'hand-off-auto' switch.

- When the starter switch is in the 'hand' position, the fan shall run. When the switch is in the 'off' position the fans shall stop. When the switch is in the 'auto' position, the fan shall be under the control of the DDC Controls System.
- The supply fan shall be energized.

ii) Whenever the supply fan is energized, the return/exhaust fan shall be energized.

iii) Discharge air temperature setpoint shall be reset based upon outdoor air temperature according to the following reset schedule. All parameters shall be independently adjustable.

- The cooling coil control valve shall modulate to maintain the discharge air temperature setpoint, 55 degrees F (adjustable).
- The heating coil control valve shall modulate to maintain the discharge air temperature as described below.

01) Discharge air temperature setpoint is 55 degrees F (adjustable) when outdoor temperature is greater than 70 degrees F.

02) Discharge air temperature setpoint is 65 degrees F (adjustable) when outdoor temperature is less than 30 degrees F.

- The local DDC Controller shall modulate the Re-heat coils control valve in the zone duct to maintain the space setpoint, 72 degrees F.

iv) Economizer Control: Whenever the outside air temperature is above the space temperature (75 degrees F, cooling; 72 degrees F, heating) the outside air and return air dampers shall positioned for the minimum outside air scheduled. Or the CO2 sensor in the return air duct shall modulate the outside and return air dampers to maintain the minimum outside air required for the occupancy. When the outside air temperature is below 55 degrees F (adjustable), the outside and return air dampers shall be positioned to maintain the mixed air temperature.

v) Filter Status: A differential pressure switch across the filter shall signal an alarm at the BAS when the pressure drop across the filter is above the allowed minimum (adjustable).

b) Unoccupied Mode:

i) The supply and return fans shall be de-energized. Both outdoor air dampers and exhaust dampers shall be closed. The return air damper shall be open.

ii) The heating coil valve and pump shall cycle to maintain mixed-air temperature of 45 degrees F (adjustable).

iii) The supply fan shall cycle to maintain the unoccupied setpoint temperature (65 degrees F, adjustable).

iv) If the unoccupied space temperature is not maintained the heating control valve shall modulate to maintain the space temperature. And the supply fan shall cycle on.

c) Morning Warm-up:

i) When the outside air temperature is below 55 degrees F, the DDC system shall perform a morning warm-up cycle prior to the occupied mode.

ii) The outside air damper shall be closed and the return air damper shall be open.

iii) The supply fan shall energize and the heating coil control valve shall open.

iv) The Air Handling Unit shall remain in the morning warm-up mode until the return air temperature is 70 degrees F. After the system has achieved 70 degrees F (adjustable) the system shall enter the Occupied Mode.

d) Safety Shutdowns:

i) Duct smoke detection, high-pressure safeties and low-temperature limit trips shall de-energize the air-handling unit supply and return fans and close the outdoor air and exhaust air dampers. Manual reset shall be required to allow the fans to operate.

e) Freeze Protection:

i) When the outdoor air temperature is below 40degrees F (adjustable), the HW and CHW pumps shall be energized continuously for freeze protection. The heating coil valve shall cycle as described elsewhere.

ii) If the unit has shutdown on the low temperature limit switch, energize the return fan until the condition has been resolved.

2. Economizer Fault Detection and Diagnostics (FDD)

a) The following temperature sensors shall be permanently installed to monitor system operation:

i) Outside air.

ii) Supply air.

iii) Return air.

b) Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F.

c) Refrigerant pressure sensors, where used, shall have an accuracy of ±3 percent of full scale.

d) The unit controller shall be capable of providing system status by indicating the following:

i) Free cooling available.

ii) Economizer enabled.

iii) Compressor enabled.

iv) Heating enabled.

v) Mixed air low limit cycle active.

vi) The current value of each sensor.

e) The unit controller shall be capable of manually initiating each operating mode so that the operation of compressors, economizers, fans and the heating system can be independently tested and verified.

f) The unit shall be capable of reporting faults to a fault management application accessible by day-to-day operating or service personnel, or annunciated locally on zone thermostats.

g) The FDD system shall be capable of detecting the following faults:

i) Air temperature sensor failure/fault.

ii) Not economizing when the unit should be economizing.

iii) Economizing when the unit should not be economizing.

iv) Damper not modulating.

v) Excess outdoor air.

D. Chilled Water System

1. The chiller shall be enabled whenever the outside air temperature is above 55degrees F for 30 minutes (both adjustable). The chiller shall be disabled when the outside air temperature drops below 54 degrees F for 30 minutes (both adjustable).

2. Water-Cooled Chiller Control:

a) The chiller shall not be enabled unless the cooling tower sump is filled.

b) The chiller shall start and stop the chilled water and condenser water pumps through its internal controls.

c) The cooling tower fan shall sequence 'off-low-high' to maintain condenser water supply temperature setpoint of 74 degrees F (adjustable). The fan shall be locked out whenever the chiller is de-energized.

d) The cooling tower sump drain and fill lines shall drain whenever the outdoor air temperature is less than 35 degrees F for 30 minutes (both adjustable). The tower sump shall be filled whenever the outside air temperature is greater than 54 degrees F for 30 minutes (both adjustable).

3. The chilled water supply temperature shall be reset from 45 degrees to 52degrees F.

a) The chilled water supply temperature setpoint shall be 52 degrees F when the outdoor air temperature is less than or equal to 55 degrees F.

b) The chilled water supply temperature setpoint shall be 45 degrees F when the outdoor air temperature is greater than or equal to 80 degrees F.

4. Activation of any emergency-stop switches or refrigerant-detection alarms shall de-energize all central plant equipment except makeup-air units and exhaust fans.

E. Air-Cooled Chiller Control:

1. The chiller shall operate with its associated pump in a lead/lag configuration.

2. The chiller controls shall alternate the lead chiller every 336 hours, minimum.

3. The chilled water system shall be enabled by the DDC System when ever the outside air tempeature is above the setpoint listed above.
4. The chiller shall operate by the micro-processor based control system provided by the manufacturer. The chiller controls shall stage the chiller to maintain the discharge water temperatures listed above.
5. Each chiller shall have a flow switch directly connected to the control chiller panel. The chiller shall not operate unless water flow is proven.
6. All points shall be available to the DDC System.

F. Chilled Water Pump Control:

1. The pumps shall be designed for 100% and stand-by operation. The pumps shall be started simultaneously.
2. Each pump shall be provide with a 'hand-off-auto' switch. When the switch is in the 'hand' position the pump shall run. When the switch is in the 'off' position the pump shall be stopped. When the switch is in the 'auto' position, the pump shall be under control of the DDC System.
3. The distribution pumps shall be started and run when the outside air temperature rises 55°F (adjustable).
4. Each Pump status shall be reported through a current sensing relay

G. Cabinet Unit Heater

1. A conventional electric space thermostat shall open/close the control valve and cycle the unit fan to maintain space temperature at setpoint of 68degrees F(adjustable). For hot water heating, when heating water is not available as sensed by the aquastat, the fan shall be de-energized.

H. Unit Heater

1. A conventional electric thermostat shall cycle the unit fan to maintain space temperature at setpoint of 68 degrees F. For hot water heating, when heating water is not available as sensed by the aquastat the fan shall be de-energized.

I. Baseboard Heating

1. Fintube radiation shall be modulated in sequence with the associated VAV box. Heating with Fintube and cooling with the VAV box shall not occur simultaneously. Use non-overlapping spring ranges or sequencing relays on the Fintube control valve and VAV damper actuator.

J. Vav Boxes

1. DDC Control varies the airflow from maximum to minimum and modulates the heating valve in sequence to maintain the space temperature setpoint. The heating valve shall not begin to open until the airflow has reached its minimum setting Set minimum and maximum CFM as shown on the drawings.

K. Face And Bypass Preheat Coil (Make-Up Air Units Only)

A. Two-position preheat coil valve shall open full when outside air temperature is below 35°F. Face and bypass dampers shall modulate to maintain 50°F (adjustable) preheat coil discharge air temperature.

L. Hot Water Heating

1. Heating Water Supply (Steam Heat Exchanger):
    a) Hot water supply temperature shall be reset inversely with changes in outside temperature locate OA sensor on north exposure~~). its setting~~ by modulating in sequence, two normally-closed control valves in parallel in the steam supply to the hot water heat exchanger. Fail-safe operation of steam valve shall be to fail closed.
2. Zone Control:
    a) Building to be zoned as required by floors, orientation and function as determined for specific project.
    b) Provide for each zone a night, weekend and holiday setback.
    c) Provide each zone with an adjustable morning warm-up time period.
3. Temperature reset of a controlled variable is encouraged where overall system energy use will be minimized while still maintaining building temperature control requirements.

M. Boiler Control:

1. The boilers shall be enabled or disabled by the DDC System. Packaged boiler conrollers shall modulate the boilers to maintain the heating water supply temperature scheduled (140°F, adjustable).
2. The following points shall be available to the DDC System:
    a) Enable/Disable the boilers.
    b) High Temperature Limit
    c) Low Water Cut-off
    d) No flow detected
    e) Manual Shut Down
3. Combustion Air Control: Combustion air dampers shall open when the boiler is enabled. The damper end switch shall prove that the damper is open prior to enableing the boiler. If the damper is not proven open, the DDC System shall sen and alarm and the boilers shall be shut down.

N. Heating Water Pumps:

1. Each boiler production (primary) pump shall be provide with a 'hand-off-auto' switch. When the switch is in the 'hand' position the pump shall run. When the switch is in the 'off' position the pump shall be stopped. When the switch is in the 'auto' position, the pump shall be under control of the DDC System.
2. Each production pump shall be started whenever its associated boiler is enabled.
3. Heating water distribution (secondary) pumps shall be provide with a 'hand-off-auto' switch. When the switch is in the 'hand' position the pump shall run. When the switch is in the 'off' position the pump shall be stopped. When the switch is in the 'auto' position, the pump shall be under control of the DDC System.
4. The distribution pumps shall be started and run when the outside air temperature falls below 65°F (adjustable).
5. Each Pump status shall be reported through a current sensing relay.

O. Elevator Shaft Venting:

1. Meet with the Denver Fire Department and Denver Building Department staffs to discuss what they require for control of the elevator hoistway vent.

P. Exhaust Fans:

1. Toilet/Locker Rooms: Toilet room exhaust fans shall be controlled by a time of day clock. During the occupied mode, the fan shall run continuously. During the unoccupied mode the fans shall be off. The DDC system shall associated the exhaust fan with the Air Handling Unit in the vicinity of the exhaust fan. Also allow for manual override of the fan with a 'hand-off-auto' switch.
2. Kitchen Exhaust: Kitchen Hood exhaust fan controls shall be locally controlled by the kitchen staff. The make-up air unit shall be interlocked with the kitchen hood exhaust. The make-up air unit and the hood exhaust shall be monitored by the DDC Control System. The DDC system shall report the following points, minimum.
    a) Exhaust fan status.
    b) Make-up Air Unit fan status.
    c) Make-up Air Unit discharge air temperature.

Q. Laboratory Exhaust/Dust Collection: Lab Exhaust and Dust Collection systems shall be locally controlled. Refer to Special Exhaust Systems Specification Section for additional requirements. The following points shall be reported to the DDC Systems:

1. Fume Hood fan status.
2. Dust Collection fans status.

R. Kiln Hood Exhaust: Kiln exhaust fans shall be locally controlled by a wall mounted switch. The fan status shall be reported thru the DDC Control System.

3.11 COLD WEATHER SEQUENCE

A. A cold weather emergency sequence shall be built in to the BAS that enables DPS to manually control:

1. Mixed Air temperature of RTU and AHU to 45 F.
2. Set OA damper position to minimum or zero.
3. Set the global building night set back temperature to the occupied temperature.

B. The cold weather sequence shall automatically provide the following when outside air temperature is below 10 F (adj):

1. Set the unoccupied temperature equal to the occupied temperature.
2. close Outside air dampers when the average building temperature is more than 5 deg F below setpoint.

C. Controls contractor shall coordinate with DPS Controls Engineer on implementation of this sequence.

3.12 DOMESTIC HW

A. Domestic HW Circ Pump:

1. HWC pump shall operate to maintain the HWC temperature sensor at a point prior to connection to the water heater/CW pipe at a maximum of 104 F. The pump shall shut off when 104 F is reached. The HWC pump shall operate based on a schedule at the BAS and shall be off whener the school is unoccupied.
2. A flow switch shall detect flow at the CW supply going into the HW system. Whenver flow is present, the HWC pump shall run.

PART 4 POINT/DATA LIST

A. General information:

1. These lists include the point/data that should be available for viewing/modification at the IBAS. Other points/data needed by the DDC or other systems to provide their specified functionality are not necessarily listed here. It is the A/E's responsibility to ensure that all points/data required for the DDC of other systems be specified.
2. Under the "Point/Data" column "Occupied Until…" is a time clock value indicating the end of the occupied mode.
3. Under the "Type" column: AO = Analog Output Point, AI = Analog Input Point, BO = Binary Output Point, BI = Binary Input Point, AD = Analog Data, and BD = Binary Data.
4. Under the "R/W" column: R = Read (or monitor) and W = Write (or control)
5. Under the "Notes" column "Emergency" means that an off-normal condition shall generate an emergency-level alarm sent to security or the HVAC Shop (contractor is to consult with owner about where, in each case, the alarm shall be sent and what the alarm message shall state).
6. There may be more than one instance of each point listed. Provide all instances included in the DDC or other system design.
7. Not all points listed are applicable (or applicable as described) for the specific HVAC or other system design. Further some HVAC or other system designs may involve points that could not have been predicted by or included in the below list. The design engineer shall edit the list accordingly.

B. Point/Data Lists (by HVAC or other system type)

1. Constant Volume AHU, RTU or H&V Unit

Point/Data	Type	R/W	Notes
Mixed Air Dampers Actuator(s)	AO	R/W	Provide additional points if the DDC system controls these dampers with multiple points (e.g., a separate AO for the relief or exhaust air damper or a separate BO for a minimum outside air damper).
Mixed Air Temperature	AI	R	
Return Air Temperature	AI	R	
Heating Coil Valve	AO	R/W	Or stages of elec/gas heat controlled by multiple BO's. Provide BI status for gas furnace.
Cooling Coil Valve	AO	R/W	Or stages of DX cooling controlled by multiple BO's
Heating Coil Circulation Pump	BO	R/W	
Cooling Coil Circulation Pump	BO	RW	
Heating Coil Circ. Pump Status	BI	R	
Cooling Coil Circ. Pump Status	BI	R	
Preheat Coil Valve Open/Close	BO	R/W	
Preheat Coil Face and Bypass Dampers	AO	R/W	
Preheat Discharge Air Temperature	AI	R	
Preheat Discharge Air Temperature Setpoint	AD	R/W	
Supply Fan Start/Stop	BO	R/W	
Supply Fan Status	BI	R	
Freezestat	BI	R	
Supply Air Temperature(s)	AI	R	
Supply Air Temperature Setpoint	AD	R/W	If reset off of space temperature.
Space Temperature	AI	R	Emergency
Space Temperature Set Points	AD's	R/W	Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied
Space Temperature Set Point Adjustment(s)	AI or AD	R	At space temperature sensor
Zone Reheat Coil Modulation	AO	R/W	For reheat systems
Filter Status	BI	R	
Smoke Detector	BI	R	
Return Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Return Fan Status	BI	R/W	
Exhaust Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Exhaust Fan Status	BI	R/W	
CO_2 Sensor	AI	R	
CO_2 Set Point	AD	R/W	
Face & Bypass Dampers Actuator	AD	R/W	Emergency
Mixed Air Temperature Low Limit Set Point	AD	R/W	
Occupied Until….	AO	R	
Warm-up Mode	MD	R	
Economizer Mode	BD	R	
Minimum Outside Air Position or Air Flow Set Point	AD	R/W	
Outside Air Flow	AI	R	

2. <u>VAV (Variable Air Volume) AHU or RTU</u>

Points	Type	R/W	Notes
Outside and Return Air Dampers Actuator(s)	AO	R/W	Provide additional points if the DDC system controls these dampers with multiple points (e.g., a separate BO for a minimum outside air damper).
Exhaust/relief Air Damper	AO	R/W	
Mixed Air Temperature	AI	R	
Return Air Temperature	AI	R	
Heating Coil Valve	AO	R/W	Or stages of elec/gas heat controlled by multiple BO's. Provide BI status for gas furnace.
Cooling Coil Valve	AO	R/W	Or stages of DX cooling controlled by multiple BO's
Heating Circulation Pump	BO	R/W	
Cooling Circulation Pump	BO	RW	
Heating Circ. Pump Status	BI	R	
Cooling Circ. Pump Status	BI	R	
Supply Fan Start/Stop	BO	R/W	
Preheat Coil Valve Open/Close	BO	R/W	
Preheat Coil Face and Bypass Dampers	AO	R/W	
Preheat Discharge Air Temperature	AI	R	
Preheat Discharge Air Temperature Setpoint	AD	R/W	
Supply Fan Status	BI	R	
Freezestat	BI	R	
Supply Air Temperature	AI	R	
Filter Status	BI	R	
Smoke Detector	BI	R	
Return Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Return Fan Status	BI	R/W	
Exhaust Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Exhaust Fan Status	BI	R/W	
CO_2 Sensor	AI	R	
CO_2 Set Point	AD	R/W	
Face & Bypass Dampers Actuator	AD	R/W	
Mixed Air Temperature Low Limit Set Point	AD	R/W	
Occupied Until….	AO	R	
Warm-Up Mode	MD	R	
Economizer Mode	BD	R	
Minimum Outside Air Position or Air Flow Set Point	AD	R/W	
Outside Air Flow	AI	R	
Supply Volume Control	AO	R/W	
Supply Air Duct Static Pressure	AI	R	
Return Volume Control	AO	R/W	
Building Static Pressure	AI	R	
Supply Air High Static Alarm	BI	R	
Return Air Low Static Alarm	BI	R	
Supply Air Temperature Set Point	AD	R/W	
Supply Air Duct Static Pressure Set point	AD	R/W	
Building Static Pressure Set point	AD	R/W	
Average or Warmest Space Temperature	AD	R	If used for supply air temperature reset

Evaporative Cooling Sump Fill/Drain	BO	R/W	
Evaporative Cooling Drain/Fill Outside Air Set Point	AD	R/W	
Evaporative Cooling pump start/stop	BO	R/W	
Evaporative Cooling fan status	BI	R	Indirect systems only

3. VAV & Fan Powered VAV Box

Points	**Type**	**R/W**	**Notes**
Heating Coil Valve	AO	R/W	
Damper Actuator	AO or 2 BO's	R/W	
Damper Position Setpoint	AD	R/W	If BO's are used for the damper actuator.
Fan Start/Stop	BO	R/W	
Space Temperature	AI	R	
CFM	AI	R	
CFM Set Point	AD	R	
Maximum CFM Set Point	AD	R/W	
Minimum CFM Set Point	AD	R/W	
Minimum CFM Set Point for Heating	AD	R/W	For VAV box with reheat coil.
Space Temperature Set Points	AD's		Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied.
Space Temperature Set Point Adjustment	AI or AD		At space temperature sensor
Set Point Adjustment	AD	R	At sensor
Occupied/Unoccupied Mode	BD	R/W	
Occupied Until…	AD	R	
Discharge air temperature	AI	R	Not necessary if box is being used for ventilation only
CO_2 Sensor	AI	R	If box is being used for ventilation control
CO_2 Set Point	AD	R/W	If box is being used for ventilation control
Baseboard Heating Valve(s)	AO	R/W	

4. AHU or RTU

Points	Type	R/W	Notes
Mixed Air Dampers Actuator(s)	AO	R/W	Provide additional points if the DDC system controls these dampers with multiple points (e.g., a separate AO for the relief or exhaust air damper or a separate BO for a minimum outside air damper).
Mixed Air Temperature	AI	R	
Return Air Temperature	AI	R	
Heating Coil Valve	AO	R/W	Or stages of elec/gas heat controlled by multiple BO's. Provide BI status for gas furnace.
Cooling Coil Valve	AO	R/W	Or stages of DX cooling controlled by multiple BO's
Heating Circulation Pump	BO	R/Q	
Cooling Circulation Pump	BO	RW	
Heating Circ. Pump Status	BI	R	
Cooling Circ. Pump Status	BI	R	
Preheat Coil Valve Open/Close	BO	R/W	
Preheat Coil Face and Bypass Dampers	AO	R/W	
Preheat Discharge Air Temperature	AI	R	
Preheat Discharge Air Temperature Setpoint	AD	R/W	
Supply Fan Start/Stop	BO	R/W	
Supply Fan Status	BI	R	
Freezestat	BI	R	
Filter Status	BI	R	
Smoke Detector	BI	R	
Return Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Return Fan Status	BI	R/W	
Exhaust Fan Start/Stop	BO	R/W	Only if not hard-wire interlocked to supply fan start/stop.
Exhaust Fan Status	BI	R/W	
CO_2 Sensor	AI	R	
CO_2 Set Point	AD	R/W	
Face & Bypass Dampers Actuator	AD	R/W	
Mixed Air Temperature Low Limit Set Point	AD	R/W	
Occupied Until….	AO	R	
Warm-up Mode	MD	R	
Economizer Mode	BD	R	
Minimum Outside Air Position or Air Flow Set Point	AD	R/W	
Outside Air Flow	AI	R	
Cold Deck Temperature	AI	R	
Cold Deck Temperature Set Point	AD	R/W	
Warmest Space Temperature	AD	R	If used for reset of Cold Deck Temperature
Hot Deck Temperature	AI	R	
Hot Deck Temperature Set Point	AD	R/W	
Coldest Space Temperature	AD	R	If used for reset of Hot Deck Temperature
Zone Damper Actuators	AO's	R/W	One for each zone
Space Temperatures	AI	R	Emergency. One for each zone.
Space Temperature Set Points	AD's		Four AD's per zone – Heating Occupied/Unoccupied and Cooling

			Occupied/Unoccupied.
Space Temperature Set Point Adjustment	AI or AD		At each space temperature sensor

5. Kitchen <u>Makeup Air Unit and Exhaust</u>

Points	Type	R/W	Notes
Kitchen Hood on/off switch	BI	R	
Outside and Exhaust Air Dampers Open/Close	BO	R/W	
Supply Fan Start/Stop	BO	R/W	
Supply Fan Status	BI	R	
Exhaust Fan Status	BI	R	Also provide a BO, R/W if the start/stop of this fan is not interlocked to the supply fan.
Evaporator Cooling Drain/Fill Valves	BO	R/W	
Evaporator Cooling Drain/Fill Outside Air Set Point	AD	R/W	
Evaporator Cooling pump start/stop	BO	R/W	
Evaporative Cooling fan status	BI	R	Indirect systems only
Furnace On/Off	BI	R	
Furnace Modulation	AO	R/W	
Supply Air Temperature	AI	R	
Supply Air Temperature Set Point	AD	R/W	If reset off of space temperature.
Space Temperature	AI	R	
Space Temperature Set Points	AD's		Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied
Space Temperature Set Point Adjustment	AI or AD		At space temperature sensor
Occupied Until…	AD	R	
Occupied/Unoccupied mode	BD	R/W	
Filter Status	BD	R	
Duct Smoke Detector	BD	R	

6. <u>Unit Ventilator, Fan Coil Unit or Water Source Heat Pump</u>

Points	Type	R/W	Notes
Mixed Air Dampers Actuator(s)	AO	R/W	
Heating Coil Valve	AO	R/W	
Cooling Coil Valve	AO	R/W	Or DX cooling BO's.
Fan Start/Stop	BO	R/W	
Fan Status	BI	R	
Freezestat	BI	R	
Reversing Valve	BO	R/W	Heat pump only.
Supply Air Temperature	AI	R	
Supply Air Temperature Low Limit	AD	R/W	
Space Temperature	AI	R	Emergency
Space Temperature Set Points	AD's		Four AD's – Heating Occupied/Unoccupied and Cooling Occupied/Unoccupied
Space Temperature Set Point Adjustment	AI or AD		At space temperature sensor
Occupied/Unoccupied Mode	BD	R/W	
Occupied Until…	AD	R	
Minimum Outside Air set point	AD	R/W	

7. <u>Heating Plant</u>

Points	Type	R/W	Notes
Boiler Start/Stop or Boiler System Enable/Disable	BO	R/W	The latter if there is a boiler management system
Boiler Status	BI	R	
Boiler Alarm – High Temperature	BI	R	
Boiler Hot Water Supply Temperature	AI	R	From boiler(s)
Boiler Alarm – Low Water	BI	R	
Boiler Alarm – No Water Flow	BI	R	
Manual Boiler Shutdown	BI	R	
Combustion Air Damper Position	BI	R	
Building Hot Water Supply Temperature	AI	R	If system is primary/secondary
Boiler Hot Water Return Temperature	AI	R	To boiler(s)
Building Hot Water Return Temperature	AI	R	If system is primary/secondary
Boiler System Hot Water Supply Set Point	AD	R/W	
Building Hot Water Supply or Return Temperature Set Point	AD	R/W	If system is primary/secondary
Steam Pressure	AD	R	Steam boiler(s) only
Steam Converter Valves	1 or 2 AO's	R/W	1/3-2/3 valves
Pump Start/Stop**	BO	R/W	Only those pumps not hard-wire interlocked to a corresponding boiler (e.g., those pumps controlled by the DDC system)
Pump Status**	BI	R	For all hot water pumps included in the heating plant design.
Mixing Valve	AO	R/W	
Boiler Lead/Lag Designation	BD	R/W	
Pumps Lead/Lag Designation	BD	R/W	If more than one boiler pump (and they can feed boiler chiller) or more than one building pump
Boiler System Outside Air Lockout Set Point	AD	R/W	
Lag Boiler/Pump Start/Stop Set Point	AD	R/W	
Glycol low level or Makeup water flow	BD or AD	R	Provide makeup water flow only if there is no glycol feeder
Fuel Flow	AI	R	
System Pressure Alarm	BI	R	Emergency
Carbon Monoxide Alarm	BI	R	Emergency

*On primary/secondary systems there will be boiler and building pump(s).

8. Cooling Plant*

Points	Type	R/W	Notes
Chiller System Outside Air Lockout Set Point	BD	R/W	
Chiller Start/Stop	BO	R/W	
Chiller Status	BD	R	
Chiller Alarm	BD	R	
Chiller Chilled Water Supply Temperature	AI	R	From chiller
Chiller Chilled Water Supply Temperature Set Point Reset	AO	R/W	
Chiller Supply Temperature Set Point	AD	R/W	
Chiller Chilled Water Return Temperature	AI	R	To chiller(s)
Chiller Demand Limiting	AO	R/W	
Chiller Lead/Lag Designation	AD	R/W	
Lag Chiller Start/Stop Set Point	AD	R/W	
Lead/Lag Rotation Run Time Setpoint	AD	R/W	
Chilled Water Pump Start/Stop**	BO	R/W	Only those pumps not hard-wire interlocked to a corresponding chiller (e.g., those pumps controlled by the DDC system)
Chilled Water Pump Status**	BD	R	
Chilled Water Pumps Lead/Lag Designation	BD	R/W	If more than one chiller pump (and they can feed any chiller) or more than one building pump
Building Chilled Water Pump Speed	AO	R/W	
Building Chilled Water Pump VFD Fault	BD	R	
Chilled Water Differential Pressure	AI	R	Variable speed building pump system
Chilled Water Differential Pressure Set Point	AD	R/W	Same as above
Building Chilled Water Flow	AI	R	On variable flow systems
Building Chilled Water Supply Temperature	AI	R	Primary/secondary system
Building Chilled Water Supply or Return Temperature Set Point	AD	R/W	Same as above
Building Chilled Water Return Temperature	AI	R	Same as above
Chilled water glycol low level or Makeup water flow	BD or AD	R	Provide makeup water flow only if there is no glycol feeder
Chilled Water System Pressure Alarm	BI	R	
Flat Plate Heat Exchanger Bypass Valves	BO	R/W	
Condenser Water Pump Start/Stop	BO	R/W	
Condenser Water Pump Status	BI	R	
Condenser Water Pumps Lead/Lag Designation	BO	R/W	
Condenser Water Supply Temperature	AI	R	To chiller(s)
Condenser Water Return Temperature	AI	R	From chiller One for each chiller
Condenser Water Supply Temperature Set Point	AD	R/W	
Cooling Tower Fan Start/Stop	BO	R/W	Provide two points for two-speed fan
Cooling Tower Fan Speed	AO	R/W	
Cooling Tower Fan Status	BI	R	
Cooling Tower Vibration Alarm	BI	R	
Cooling Tower VFD Fault	BI	R	
Cooling Tower Sump Level Alarm	BI	R	May be multiple points (high/low/alarm)
Cooling Tower Sump Temperature	AI	R	
Cooling Tower Sump Drain/Fill	BO	R/W	
Cooling Tower Bypass Valve	AO	R/W	
Condenser Water Makeup Flow	AI	R	
Refrigerant Alarm	BD	R	Emergency
Refrigerant Evacuation Exhaust Fan Start/Stop	BO	R/W	Or high/low for a mechanical room exhaust

			fan

*This "plant" may be that used for a water source heat pump system where there may be no chillers or, possibly in the case of ground-source heat pumps, no cooling towers.
**On primary/secondary systems there will be chiller and building pump(s).

9. Fire Alarm System*

Points	Type	R/W	Notes
System Trouble	BI	R	
System Alarm	BI	R	
Water Flow Alarm	BI	R	
Low Water Pressure	BI	R	May not be available as a separate point.
Disconnect from City	BI	R	May not be available as a separate point.
Zone/Device Status (for each zone/device)	BI's**	R	One BI for each of Alarm, Trouble and Supervisory; or all points can be communicated via one BACnet fire alarm device object for each device.

*Connect to 25 00 00 system if BACnet or other digital communications interface not provided.
**Provide only if connected via a BACnet or other digital communications interface.

10. Fire Suppression*

Points	Type	R/W	Notes
Kitchen Hood Alarm	BI	R	Only if it is not provided by the fire alarm system.
Fire Pump Status	BI	R	Same as above.

*Field devices and points provided under 25 00 00.

11. Lighting Control

Points	Type	R/W	Notes
Lighting Zone Override	BO	R/W	
Lighting Zone Status	BI	R	
Lighting Zone schedule	BACnet Schedule Object	R/W	

12. Plumbing*

Points	Type	R/W	Notes
Basement Water Alarm	BI	R	Contact provided with backflow preventer
Domestic Hot Water Temperature	AI	R	
Kitchen Domestic Hot Water Temperature	AI	R	
Swimming Pool Chemical Treatment System Alarm	BI	R	
Swimming Pool Pump Status	BI	R	
Domestic Water System Pressure alarm (downstream of regulator)	BI	R	Emergency
Natural Gas System pressure alarm (downstream of regulator)	BI	R	Emergency
Domestic Hot Water Recirculation Pump System Start/Stop	BO	R/W	
Domestic Hot Water Recirculation Pump System Status	BI	R	
Domestic Water Booster Pump(s) System Status/Alarm	BI	R	

Domestic Water CW line flow switch	BI	R	

*Field Devices and points provided under 25 00 00.

13. Irrigation*

Points	Type	R/W	Notes
Water Flow	AI	R	Pulse initiator on meter
Booster Pump Start/Stop	BO	R/W	
Booster Pump Status	BI	R	
Isolation Valve	BO	R/W	
Zone Valve On/Off's	BO's	R/W	One for each zone
Moisture sensor	BI	R	

*Field devices and points provided under 25 00 00.

14. Electrical (main switch gear)*

Points	Type	R/W	Notes
Phase Monitor Alarm	BI	R	Emergency
Synchronizing Trip Status	BI	R	Emergency
Phase-to-Phase Voltage or Imbalance	6 AI's or BI's**	R	Between each phase, and between each phase and neutral.
Building Electrical Meter KW	**	R	***
Building Electrical Meter KWH	**	R	***
Standby Generator Status	BI	R	
Standby Generator Exercise	BO	R/W	
Automatic Transfer Switch Position	Multiple BI's	R	Provide points for all ATS positions
Voltage Loss Alarm	AI	R	

*Points connected to 25 00 00systems if a BACnet or other digital interface is not provided.
**Point type depends on electrical monitoring system design.
***Provide pulse initiator on building meter with one BI point (to calculate both KW and KWH) if this information is not available from the electrical monitoring system.

15. Miscellaneous*

Points	Type	R/W	Notes
Exhaust Fan Start/Stop	BO	R/W	Provide point data for each exhaust fan controlled by the DDC system but not associated with an AHU/RTU/MUA
Exhaust Fan Status	BI	R	Same as above
Laboratory Fume Hood Exhaust Fan Status	BI	R	
Laboratory Dust Collection Exhaust Fan Status	BI	R	
Kiln Hood Exhaust Fan Status	BI	R	
Outside Air Temperature	AI	R	
Outside Air Relative Humidity	AI	R	
Walk-in Freezer Temperature	AI	R	
Walk-in Refrigerator Temperature	AI	R	

*Field devices and points provided under 25 00 00.

END OF SECTION 25 90 00