

SECTION 25 51 00-INTEGRATED AUTOMATION FACILITY CONTROLS**PART 1: GENERAL****1.01 SCOPE OF WORK**

- A. General Contractor shall furnish and commission a fully integrated building automation system (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems as herein specified.
- B. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems components shall have been thoroughly tested and proven in actual use for at least two years.
- C. General Contractor and the Installing Contractors shall furnish and/or install all equipment and systems specified herein.
- D. Authorized Vendors:
 - 1. Siemens Building Industries – APOGEE/Desigo System (BACnet)

1.02 DESCRIPTION

- A. The control system will consist of a BACnet high-speed, peer-to-peer network of BTL certified controllers and a front end that operates on a BACnet IP (Internet Protocol) Network.
- B. An operator workstation shall be available that allows user access. The user shall interface with the network via multi-tasking dynamic color graphics. Each mechanical system, building floor plan, and control device will be depicted by a point-and-click graphic.
- C. For Local Area Network installations provide access to the control system via the Texas State University Wide Area intranet. Texas State University shall provide a connection to the Internet via high-speed cable modem, ADSL, ISDN, T1 or through the facility ISP. Texas State University shall pay for all monthly Internet access fees and connection charges.
- D. The system shall support remote access, setpoint adjustment, schedule changes, calendar changes, point overrides, and graphics screens over the Texas State University WAN and the Internet.
- E. The System will provide for future expansion to include monitoring of the card access, fire alarm, and lighting control systems.

SECTION 25 51 00-INTEGRATED AUTOMATION FACILITY CONTROLS**1.03 RELATED SECTIONS**

- A. Division 1 General and Special Conditions
- B. Division 23 Mechanical
- C. Division 26 Electrical
- D. Drawings and general provisions of the contract, including general and Supplementary Conditions and Division 1 specification sections, apply to this section.

1.04 QUALITY ASSURANCE

- A. The BAS system shall be designed, commissioned and serviced by manufacturer employed, factory trained personnel. Manufacturer shall have an in-place support facility within 100 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. Provide 800 number accesses to 24-hour support center, staffed with factory-trained personnel to assist in trouble shooting and problem resolution. Distributors or licensed installing contractors are not acceptable.
- B. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.
- C. BAS shall comply with UL 916 PAZX and 864 UDTZ, European Community, and other subsystem listings as applicable, and herein specified, and be so listed at the time of bid.
- D. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.
- E. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.
- F. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels and extend new field panels on a previously installed network.

SECTION 25 51 00-INTEGRATED AUTOMATION FACILITY CONTROLS**G. Contractor/Manufacturer Qualifications:**

1. Reference Section **1.04.A** as well as the following.
2. Contractor shall have an established working relationship with the Control System Manufacturer for a minimum of 10 years.
3. All products used in this installation shall be new, currently under manufacture, and shall be applied in standard off the shelf products. This installation shall not be used as a test site for new products unless explicitly approved by Texas State University in writing.
4. Spare parts will be available for at least 5 years after completion of the contract.

1.05 SUBMITTALS**A. Pre-Construction Submittals:**

1. Contractor shall provide control drawings and other submittals on all hardware, software, and installation to be provided under this scope. No work may begin on any segment of this project until submittals have been reviewed and approved for conformity with the design intent.
2. Physical copies and Electronic Submittals are to be provided to Planning, Construction and Design as well as to Technical Services for review and approval.
3. Provide a “Comply/Non-Comply” statement for each section or subsection of this specification with transmittal of the 25.51.00, 1.7 SUBMITTALS.
4. Refer to A-1 in the Appendix at the end of this document.

B. Post-Construction As-Builts:

1. All As-Builts will be provided on Magnetic/Optical Disk to Planning, Construction, and Design, where they will be required to transmit to Archive.
2. Terminal Equipment Network/Power Trunk Connection Layouts will be provided for all Networked devices. This will be provided as a floor layout with the *actual* Terminal Equipment locations and how the Floor Level Network is run to each unit, labeling what Controller/Floor Level

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Network or MSTP Trunk it belongs to as well as power trunk if applicable.

1.06 WARRANTY

- A. Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of one year after system acceptance. Any equipment shown to be defective during the warranty period shall be adjusted, repaired or replaced at no additional charge to the owner.
- B. The adjustments, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.

1.07 CODES AND STANDARDS

- A. National Electric Code (NEC)
- B. Uniform Building Code (UBC)
 - 1. Section 608, Shutoff for Smoke Control
 - 2. Section 403.3, Smoke Detection Group B Office Buildings and Group R, Division 1 Occupancies
 - 3. Section 710.5, Wiring in Plenums
 - 4. Section 713.10, Smoke Dampers
 - 5. Section 1106 Refrigeration Machinery Rooms
 - 6. Section 1107, Refrigeration Machinery Room Ventilation
 - 7. Section 1108, Refrigeration Machinery Room Equipment and Controls
 - 8. Section 1120, Detection and Alarm Systems
- C. Uniform Mechanical Code (UMC)
- D. ASHRAE 135-2001
- E. FCC Regulation, Part 15- Governing Frequency Electromagnetic Interference
- F. Underwriters Laboratories UL916

1.08 SYSTEM PERFORMANCE

- A. The system will conform to the following standards:
 - 1. Graphic Display. The system shall display a graphic with 20 dynamic points/objects with all current data within 10 seconds.
 - 2. Graphic Refresh. The system shall update a graphic with 20 dynamic points/objects with all current data within 8 seconds
 - 3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 2 seconds. Analog objects should start to adjust within 2 seconds

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4. Object Scan. All changes of state and change of analog values will be transmitted over the high-speed Ethernet network such that any data used or displayed at a controller or workstation will have been current within the previous 8 seconds
5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 1 second. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control
7. Performance. Programmable controllers shall be able to execute DDC PID control loops at a frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency
8. Multiple Alarm Annunciation. All workstations on the network must receive alarms within 5 seconds of each other
9. Reporting Accuracy. The system shall report all values with an end-to-end accuracy as listed or better than those listed in Table 1.
10. Stability of Control. Control loops shall maintain measured variable at setpoint within the tolerances listed in Table 2.

a. Table 1: Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5°C [±1°F]
Ducted Air	±0.5°C [±1°F]
Outside Air	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water Temperature	±0.5°C [±1°F]
Delta-T	±0.15°C [±0.25°F]
Relative Humidity	±5% RH
Water Flow	±5% of full scale
Airflow (terminal)	±10% of full scale <i>(see Note 1)</i>
Airflow (measuring stations)	±5% of full scale
Air Pressure (ducts)	±25 Pa [±0.1 "W.G.]
Air Pressure (space)	±3 Pa [±0.01 "W.G.]
Water Pressure	±2% of full scale <i>(see Note 2)</i>
Electrical (A, V, W, Power factor)	5% of reading <i>(see Note 3)</i>
Carbon Monoxide (CO)	±5% of reading

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Carbon Dioxide (CO ₂)	±50 ppm
Note 1: 10%-100% of scale. Note 2: For both absolute and differential pressure.	Note 3: Not including utility-supplied meters.

B. Table 2: Control Stability and Accuracy

<i>Controlled Variable</i>	<i>Control Accuracy</i>	<i>Range of Medium</i>
<i>Air Pressure</i>	± 50 Pa [± 0.2 " w.g.] ± 3 Pa [± 0.01 " w.g.]	0-1.5 kPa [0-6" w.g.] -25 to 25 Pa [-0.1 to 0.1" w.g.]
<i>Airflow</i>	$\pm 10\%$ of full scale	
<i>Temperature</i>	$\pm 0.5^{\circ}\text{C}$ [$\pm 1.0^{\circ}\text{F}$]	
<i>Humidity</i>	$\pm 5\%$ RH	
<i>Fluid Pressure</i>	± 10 kPa [± 1.5 psi]	0-1 kPa [1-150 psi]
<i>" " differential</i>	± 250 Pa [± 20 " w.g.]	0-12.5 kPa [0-50" w.g.]

PART 2: PRODUCTS**2.01 ACCEPTABLE MANUFACTURERS**

- A. Siemens Building Technologies - Apogee System

2.02 MATERIAL

- A. All products used in this project installation shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by a Texas State University Representative in writing. Spare parts shall be available for at least five years after completion of this contract.
- B. All DDC Controllers shall be BACnet Test Laboratory (BTL) listed.

2.03 NETWORKING COMMUNICATIONS/OPERATOR WORKSTATION INTERFACE

- A. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of three levels; a campus-wide Ethernet based management level network on TCP/IP protocol, a high performance peer-to-peer building level network and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or developing control programs.

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- B. The design of BAS shall allow the co-existence of new DDC Controllers with existing DDC Controllers in the same network without the use of gateways or protocol converters.
- C. All control products provided for this project shall comprise a BACnet internetwork. Communication involving control components (i.e. all types of controllers and Operator Workstations) shall conform to ANSI/ASHRAE Standard 135-2001, BACnet.
- D. Each BACnet device shall operate on the BACnet Data Link/Physical layer protocol specified for that device.
- E. The time clocks in all controllers shall be automatically synchronized daily.
- F. Peer-to-Peer Building Level Network:
 - 1. All operator devices shall have the ability to access all point status and application report data or execute control functions for any and all other devices via the peer-to-peer network. No hardware or software limits shall be imposed on the number of devices with global access to the network data at any time. Network shall support a minimum communications speed of 115.2 Kbps.
 - 2. The network shall support a minimum of 100 DDC controllers and PC workstations.
 - 3. The system shall support integration of third party systems (fire alarm, security, lighting, PLCs, chiller, boiler) using integration with standard protocols including Modbus, and BACnet, as well as third party devices via existing vendor proprietary protocols. This DDC Controller shall exchange data between the two systems for inter-process control. All exchange points shall have full system functionality as specified herein for hardwired points. *DDC Controllers shall be manufactured and supported by this vendor and not supplied by a third party.* Provide examples of 5 reference projects utilizing gateways required for this project.
- G. Management Level Network
 - 1. The Building Automation System Front End shall simultaneously connect to the Ethernet and Building Level Network without the use of an interposing device (i.e. no AEM Devices or Area Routers are to be used, causing a single point of failure for the entire building)

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2. Operator Workstation shall be capable of simultaneous connection and communication with BACnet, OPC, and Apogee networks without the use of interposing devices.
3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
4. Any PC on the Ethernet Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet. Any Workstation shall be able to interrogate any controller on the building level network.
5. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in an alarm notification at the Work Station.
6. The Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3
7. Access to the system database shall be available from any client workstation on the Management Level Network.

H. DDC Controller Floor Level Network/MSTP Trunk

1. This level communication shall support a family of application specific controllers and shall communicate with the peer-to-peer network through DDC Controllers for transmission of global data. A minimum speed of 4800 Kbps shall be supported.
2. The network shall have the following minimum capacity for future expansion:
 - a. Each Building Level Network will have capacity for 99 controllers.
 - b. The Building Controller shall have capacity for 1000 Terminal Equipment Controllers.
 - c. Each Building will have an overall capacity for 12,500 devices.

I. Building Automation System Front End

1. Building Automation System Interface
 - a. The BAS shall provide a graphical interface that allows users to access the BAS data via the Internet, extranet, or Intranet.
 - b. A Virtual Server, or Web Based Building Automation Interface will be supplied.

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2. Web Server:
 - a. Shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Chrome or Firefox.
 - b. The Web browser software shall run on any operating system running Windows 7 and higher.
 - c. The Web Browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface.
 - d. The Web Browser Client shall support at a minimum, the following functions:
 1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java Authentication and encryption techniques to prevent unauthorized access shall be implemented.
 2. Alarm Management: Provide alarm notification “pop-ups” that show how many active alarms are in the system. Provide a means to display a summary of all active alarms, when they occurred and a means to filter alarms by alarm classification (critical, maintenance, network, HVAC, etc). Provide an historical alarm and event log and timeline to support analysis of alarm activity, operator activity (like log-ins and commands) and changes to the system.
 - e. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - f. Storage of the graphical screens shall be in the Server, without requiring any graphics to be stored on the client machine.
 - g. Real-time values displayed on a Web Page shall update automatically without requiring a manual “refresh” of the Web Page.
 - h. Users shall have administrator defined access privileges. Depending on the access privileges assigned, the user shall be able

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to modify common application objects, such as schedules, calendars, and set points in a graphical manner.

- i. Graphic screens on the Web Browser Client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.
- j. Operator Workstation located at Texas State University designated location will communicate with the entire control system using the Texas State University existing Wide Area Network. Texas State University shall furnish appropriate static IP addresses for the new system’s BACnet Broadcast Management Device.
- k. Workstation information access shall use the BACnet Protocol. Communication shall use the ISO 8802-3 (Ethernet) Data Link/Physical Layer Protocol.
- l. Server Hardware will be a Virtual Server provided by Texas State University.
- m. The Workstation shall support the following BACnet Interoperability Building Blocks (BIBBs).

Data Sharing	Alarm & Event	Scheduling	Trending	Device & Network Mgmt.
DS-RP-A,B	AE-N-A	SCHED-A	T-VMT-A	DM-DDB-A,B
DS-RPM-A	AE-ACK-A		T-ATR-A	DM-DOB-A,B
DS-WP-A	AE-ASUM-A			DM-DCC-A
DS-WPM-A	AE-ESUM-A			DM-TS-A
				DM-UTC-A
				DM-RD-A
				DM-BR-A
				NM-CE-A

n. **SYSTEM SOFTWARE**

- 1. Operating System. Furnish a concurrent multitasking operating system. The operating system also shall support the use of other common software applications that operate under Microsoft Windows. Acceptable operating systems are Windows 7 or newer.
- 2. System Graphics. The operator workstation software shall be a graphical user interface (GUI). The system shall allow display of up to 10 dynamic and animated graphic screens

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at once for comparison and monitoring of system status.

Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.

3. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Visio or AutoCAD.
 4. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program. Graphics shall be created by drag-and-drop selection of graphic symbols and drag-and-link with BACnet objects with dynamic and interactive display fields.
 5. Multilingual. Software shall be supported in the following languages English, Spanish, French, German, and Chinese.
 6. Dynamic Data Exchange (DDE). Software shall support dynamic data sharing with other Windows-based programs for third party add-on functionality e.g. preventative maintenance, tenant billing, etc.
- o. *System Applications. Each workstation shall provide operator interface and off-line storage of system information. Provide the following applications at each workstation:*
1. System Database Save and Restore. Each workstation shall store on the hard disk a copy of the current database of each

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Building Controller. This database shall be updated whenever an operator initiates a save command.

2. Manual Database Save and Restore. A system operator with the proper password clearance shall be able to save the database from any system panel. The operator shall be able to clear a panel database via the network and may initiate a download of a specified database to any panel in the system from the network.
3. System Configuration. The workstation software shall provide a method of configuring the system. This shall allow for future system changes or additions by users under proper password protection.
4. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
5. Security. Each operator shall be required to log on to the system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the functions accessible to viewing and/or changing each system application.
6. System Diagnostics. The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers.
7. Alarm Processing. Any object in the system shall be configurable to alarm in and out of normal state. The operator shall be able to configure the alarm limits, alarm limit differentials, states, and reactions for each object in the system.
8. Alarm Messages. Alarm messages shall use the English language descriptor for the object in alarm, in such a way that the operator will be able to recognize the source, location, and nature of the alarm without relying upon

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acronyms or other mnemonics.

9. Alarm Reactions. The operator shall be able to determine (by object) what if any actions are to be taken during an alarm. Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation.
 10. Trend Logs. The operator shall be able to define a custom trend log for any data object in the system. This definition shall include change-of-value digital, change-of-value analog, time interval, start time, and stop time. Trend data shall be sampled and stored on the Building Controller panel, and be archivable on the hard disk and be retrievable for use in spreadsheets and standard database programs.
 11. Alarm and Event Log. The operator shall be able to view all system alarms and change of states from any location in the system. Events shall be listed chronologically. An operator with the proper security level may acknowledge and clear alarms.
 12. Object and Property Status and Control. Provide a method for the operator to view, and edit if applicable, the status of any object and property in the system. The status shall be available by menu, on graphics, or through custom programs.
 13. Clock Synchronization. The real-time clocks in all building control panels and workstations shall be using the BACnet Time Synchronization service. The system also shall be able to automatically synchronize all system clocks daily from any operator-designated device in the system. The system shall automatically adjust for daylight savings and standard time, if applicable.
- p. Workstation Applications Editors. Each PC workstation shall support editing of all system applications. Provide editors for each application at the PC workstation. The applications shall be downloaded and executed at one or more of the controller panels.
1. Controller. Provide a full-screen editor for each type of application that shall allow the operator to view and change the configuration, name, control parameters, and set points for all controllers.

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2. Scheduling. An editor for the scheduling application shall be provided at each workstation. Provide a method of selecting the desired schedule and month. This shall consist of a monthly calendar for each schedule. Exception schedules and holidays shall be shown clearly on the calendar. Provide a method for allowing several related objects to follow a schedule. The start and stop times for each object shall be adjustable from this master schedule.
- q. Custom Application Programming. Provide the tools to create, modify, and debug custom application programming. The operator shall be able to create, edit, and download custom programs at the same time that all other system applications are operating. *The system shall be fully operable while custom routines are edited, compiled, and downloaded.*
- r. REPORT MANAGEMENT
 1. The following reporting capability shall be provided at the operator workstation.
 2. Reporting:
 - a. Internal reports built into operator workstation software
 - b. External reporting via ODBC
 3. Internal Reports
 - a. User definable query reports (support advanced multiple property, multiple object).
 - b. Reports shall be scheduled for automatic generation by schedule or event.
 - c. Manual execution to printing/file.
 - d. Ability to save report in system report folder.
 - e. Query controller hierarchy.
 - f. Report to multiple destinations
 - i. Email
 - ii. Print
 - iii. File (text, csv, xml)
 - iv. Terminal
 4. Enterprise Interface
 - a. ODBC driver supporting common SQL statements

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- (select, update, insert, where, order by, group by, etc.)
- b. Allow integration to Enterprise software
 - c. Shall be capable of being used with third party software that supports ODBC connection such as: Microsoft Access, Excel, Crystal Reports, etc.
 - d. All queries shall be real time into live controller network.
 - e. Shall be able to both read and write using SQL.
- c. All information exchanged over Internet shall be optionally encrypted and secure via SSH (provided by Owner).

2.04 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLER

- A. The DDC & HVAC Mechanical Equipment Controllers shall reside on a Building Network.
- B. DDC & HVAC Mechanical Equipment Controllers that do not meet the functions specified in Section 2.4.1 and Section 2.5 for DDC Controllers or Section 2.4.2 and Section 2.5 for HVAC Mechanical Equipment Controllers are not acceptable.

2.4.1 DDC CONTROLLERS

- A. DDC Controllers shall be multi-tasking, multi-user, real-time digital control processors consisting of enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point I/O schedule. Each controller shall support a minimum of three (3) Floor Level Application Specific Controller Device Networks.
- B. Each DDC Controller shall have sufficient memory to support its own operating system and databases, including:
 - b. Control processes
 - c. Energy management applications
 - d. Alarm management applications including custom alarm messages for each level alarm for each point in the system.
 - e. Historical/trend data for points specified

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- f. Maintenance support applications
 - g. Custom processes
 - h. Operator I/O
 - i. Manual override monitoring
- C. Each DDC Controller shall support firmware upgrades without the need to replace hardware.
- D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- E. As indicated in the point I/O schedule, the operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board hand/off/auto operator override switches for digital control type points and gradual switches for analog control type points.
- 1. Switches shall be mounted either within the DDC Controllers key-accessed enclosure, or externally mounted with each switch keyed to prevent unauthorized overrides.
 - 2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.
- F. DDC Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output.
- G. Each DDC Controller shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.

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- H. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
1. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V
 2. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
 3. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
 4. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)
 5. Isolation shall be provided at all peer-to-peer panel's AC input terminals to suppress induced voltage transients consistent with:
 6. IEEE Standard 587-1980
 7. UL 864 Supply Line Transients
 8. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)
- I. In the event of the loss of normal power, non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 60 days.
1. Upon restoration of normal power, the DDC Controller shall automatically resume full operation without manual intervention.
 2. Should DDC Controller memory be lost for any reason, the user shall have the capability of reloading the DDC Controller via the local RS-232C port, or from a network workstation PC.
- J. Provide a separate DDC Controller for each AHU or other HVAC system as indicated in Section 3.02. It is intended that each unique system be provided with its own point resident DDC Controller.

2.05 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

- A. General:

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1. The software programs specified in this Section shall be provided as an integral part of DDC Controllers and shall not be dependent upon any higher-level computer for execution.
 2. All points shall be identified by up to 30 character point name and 16 character point descriptor. The same names shall be used at the PC workstation.
 3. All digital points shall have user defined two-state status indication (descriptors with minimum of 8 characters allowed per state (i.e. summer/winter)).
- B. Control Software Description:
1. The DDC Controllers shall have the ability to perform the following pre-tested control algorithms:
 - a. Two-position control
 - b. Proportional control
 - c. Proportional plus integral control
 - d. Proportional, integral, plus derivative control
- C. DDC Controllers shall provide the following energy management routines for the purpose of optimizing energy consumption while maintaining occupant comfort.
1. Start-Stop Time Optimization (SSTO) shall automatically be coordinated with event scheduling. The SSTO program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by time of occupancy.
 - a. The SSTO program shall operate in both the heating and cooling seasons.
 - 1.) It shall be possible to apply the SSTO program to individual fan systems.
 - 2.) The SSTO program shall operate on both outside weather conditions as well as inside zone conditions and empirical factors.
 - b. The SSTO program shall meet the local code requirements for minimum outside air while the building is occupied.

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2. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or groups of points according to a stored time.
 - a. It shall be possible to individually command a point or group of points.
 - b. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start or stop within that group.
 - c. The operator shall be able to define the following information:
 - 1.) Time, day
 - 2.) Commands such as on, off, auto, and so forth.
 - 3.) Time delays between successive commands.
 - 4.) There shall be provisions for manual overriding of each schedule by an appropriate operator.
 - d. It shall be possible to schedule events up to one year in advance.
 - 1.) Scheduling shall be calendar based.
 - 2.) Holidays shall allow for different schedules.
3. Enthalpy switchover (economizer) .The Energy Management Control Software (EMCS) will control the position of the air handler relief, return, and outside air dampers. If the outside air dry bulb temperature falls below changeover set point the EMCS will modulate the dampers to provide 100 percent outside air. The user will be able to quickly changeover to an economizer system based on dry bulb temperature and will be able to override the economizer cycle and return to minimum outside air operation at any time.
5. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.
6. Night setback control: The system shall provide the ability to automatically adjust setpoints for night control.
7. The Peak Demand Limiting (PDL) program shall limit the consumption of electricity to prevent electrical peak demand charges.

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- a. PDL shall continuously track the amount of electricity being consumed, by monitoring one or more electrical kilowatt-hour/demand meters. These meters may measure the electrical consumption (kWh), electrical demand (kW), or both.
 - b. PDL shall sample the meter data to continuously forecast the demand likely to be used during successive time intervals.
 - c. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
 - d. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.
- D. DDC Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.
1. A single process shall be able to incorporate measured or calculated data from any and all other DDC within the building (i.e. Outside Air Temperature and Humidity) and if necessary on the network (i.e. Plant conditions). In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network if absolutely necessary.
 2. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message (via pop-up dialog box, text message or e-mail) to a workstation or specified device.
 3. DDC Controllers shall provide a HELP function key, providing enhanced context sensitive on-line help with task orientated information from the user manual which will be integrated into the Building Automation System.
 4. DDC Controllers shall be capable of providing and displaying comment lines for sequence of operation explanation when looking at the program locally.
- E. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other

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panels on the network. In compliance with this standard, there will not be a single point of failure for an entire building, and all the panels that reside within.

1. All alarm or point change reports shall include the point's English language description and the time and date of occurrence.
 2. The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. A minimum of six priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, DDC Controller, etc.) to provide full flexibility in defining the handling of system alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 3. Alarm reports and messages will be directed to a user-defined list of operator devices or PCs based on time (after-hours destinations) or based on priority.
 4. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.
 5. In critical applications, operator-selected alarms shall be capable of remote notification via text message or e-mail to a remote operator device.
- F. A variety of historical data collection utilities shall be provided, to manually or automatically sample, store and display system data for points as specified in the I/O summary.
1. Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of 1 minute to 7 days shall be provided. Each DDC Controller shall have a dedicated RAM-based buffer for trend data and shall be capable of storing data samples. All trend data shall be available for transfer to a Workstation without manual intervention.
 2. DDC Controllers shall also provide high-resolution sampling capability for verification of control loop performance. Operator-initiated automatic and manual loop tuning algorithms shall be provided for operator-selected PID control loops as identified in the point I/O summary.

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- a. Loop tuning shall be capable of being initiated either locally at the DDC Controller, from a network workstation. For all loop-tuning functions, access shall be limited to authorized personnel through password protection.
- G. DDC Controllers shall be capable of automatically accumulating and storing run-time hours for digital input and output points and automatically sample, calculate and store consumption totals for analog and digital pulse input type points, as specified in the point I/O schedule.
- H. The peer-to-peer network shall allow the DDC and Controllers to access any data from or send control commands and alarm reports directly to any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall send alarm reports to multiple workstations without dependence upon a central or intermediate processing device. The peer-to-peer network shall also allow any DDC Controller to access, edit, modify, add, delete, back up, and restore all system point database and all programs.

2.06 FLOOR LEVEL NETWORK APPLICATION SPECIFIC CONTROLLERS (ASC)

- A. Each DDC Controller shall be able to extend its performance and capacity through the use of remote application specific controllers (ASCs) or MSTP Network Device through Floor Level Networks/MSTP Network.
- B. Each ASC or MSTP Network Device shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC or MSTP Network Device shall be a microprocessor-based, multi-tasking, and real-time digital control processor.
- C. Terminal Equipment Controllers/MSTP Network Devices:
 1. Provide for control of each piece of equipment, including, but not limited to, the following:
 - a. Variable Air Volume (VAV) boxes
 - b. Constant Air Volume (CAV) boxes
 - c. Exhaust Fans
 - d. Series/Parallel Fan Coil Units
 2. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators. Terminal controllers utilizing proprietary control signals and actuators shall not be acceptable. As an alternative, provide DDC Controllers or other ASCs/MSTP Network Devices with industry

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standard outputs for control of all terminal equipment including pneumatic actuation.

3. Room temperature sensors shall be provided as indicated on the drawings. Provide device as described in the Field Devices section of this specification.

2.07 FIELD DEVICES

A. Provide instrumentation as required for monitoring, control or optimization functions. All devices and equipment shall be approved for installation in the City of Temple.

B. Room Temperature Sensors

1. Digital room sensors shall have LCD display, day / night override button, and setpoint slide adjustment override options. The setpoint slide adjustment can be software limited by the automation system to limit the amount of room adjustment.

Temperature monitoring range	+20/120°F -13° to 49°C)
Output signal	Changing resistance
Accuracy at Calibration point	$\pm 0.5^\circ\text{F}$ (+/- 0.3°C)
Set Point and Display Range	55° to 95° F (13° to 35°C)

2. Liquid immersion temperature:

Temperature monitoring range	+30/250°F (-1°/121°C)
Output signal	Changing resistance
Accuracy at Calibration point	$\pm 0.5^\circ\text{F}$ (+/-0.3°C)

3. Duct (single point) temperature:

Temperature monitoring range	+20/120°F (-7°/49°C)
Output signal	Changing resistance
Accuracy at Calibration point	$\pm 0.5^\circ\text{F}$ (+/-0.3°C)

4. Duct Average temperature:

Temperature monitoring range	+20° $\pm 120^\circ\text{F}$ (-7°/+49°C)
Output signal	4 – 20 mA DC
Accuracy at Calibration point	$\pm 0.5^\circ\text{F}$ ($\pm 0.3^\circ\text{C}$)
Sensor Probe Length	25' L (7.3m)

5. Outside air temperature:

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Temperature monitoring range	-58°±122° F (-50°C to +50°C)
Output signal	4 – 20 mA DC
Accuracy at Calibration point	±0.5°F (+/-0.3°C)

C. Liquid Differential Pressure Transmitter

Ranges	0-5/30 inches H2O 0-25/150 inches H2O 0-125/750 inches H2O
Output	4 – 20 mA DC
Calibration Adjustments	Zero and span
Accuracy	+/-0.2% of span
Linearity	+/-0.1% of span
Hysteresis	±0.05% of span

D. Differential pressure:**1. Unit for fluid flow proof shall be Penn P74.**

Range	8 to 70 psi
Differential	3 psi
Maximum differential pressure	200 psi
Maximum pressure	325 psi

2. Unit for air flow shall be Siemens Building Technologies SW141.

Set point ranges: 0.5” WG to 1.0” WG (124.4 to 248.8 Pa)
1.0” WG to 12.0” WG (248.8 to 497.6 Pa)

E. Static pressure sensor:

Range	0 to .5” WG (0 to 124.4 Pa) 0 to 1” WG (0 to 248.8 Pa) 0 to 2” WG (0 to 497.7 Pa) 0 to 5” WG (0 to 1.2 kPa) 0 to 10” WG (0 to 2.5 kPa)
Output Signal	4 – 20 mA VDC
Combined static error	0.5% full range
Operating Temperature	-40° to 175° F (-40C to 79.5°C)

F. Air Pressure Sensor:

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Range:	0 to 0.1 in. water (0 to 24.9 Pa)
	0 to 0.25 in. water (0 to 63.2 Pa)
	0 to 0.5 in. water (0 to 124.5 Pa)
	0 to 1.0 in. water (0 to 249 Pa)
	0 to 2.0 in water 90 to 498 Pa)
	0 to 5.0 in. water (0 to 1.25 kPa)
	0 to 10.0 in. water (0 to 2.49 kPa)

Output signal	4 to 20 mA
Accuracy	±1.0% of full scale

G. Humidity Sensors:

Range	0 to 100% RH
Sensing Element	Bulk Polymer
Output Signal	4 – 20 mA DC
Accuracy	At 77°F (25°C) ± 2% RH

H. Insertion Flow Meters (Equal to Onicon Series F-1200)

Sensing Method	Impedance Sensing
Accuracy	+ 2% of Actual Reading
Maximum Operating Pressure	400 PSI
Output Signal	4 – 20 mA

Bi-directional where required.

I. Pressure to Current Transducer

Range	3 to 15 psig (21 to 103 kPa) or 3 to 30 psig (21 to 207 kPa)
Output signal	4 – 20 mA
Accuracy	± 1% of full scale (± 0.3 psig)

J. Control Valves (all control valves shall have electric actuators).**1. Electric Control**

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage
Control Action	Normal open or closed as selected
Medium	Steam, water, glycol
Body Type	Screwed ends 2" and smaller, flanged

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	Valves 2½” and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4-20 MA or 2 position 24 VAC/120VAC

2. All automatic temperature control valves in water lines shall be provided with characterized throttling plugs and shall be sized for minimum 25% of the system pressure drop or 5 psi, whichever is less.

a. Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.

b. Two position valves shall be line size.

Maximum differential pressure 200 psi

Maximum pressure 325 psi

3. Unit for air flow shall be Siemens Building Technologies SW141.

Set point ranges: 0.5” WG to 1.0” WG (124.4 to 248.8 Pa)
1.0” WG to 12.0” WG (248.8 to 497.6 Pa)

K. Static pressure sensor:

Range	0 to .5” WG (0 to 124.4 Pa) 0 to 1” WG (0 to 248.8 Pa) 0 to 2” WG (0 to 497.7 Pa) 0 to 5” WG (0 to 1.2 kPa) 0 to 10” WG (0 to 2.5 kPa)
Output Signal	4 – 20 mA VDC
Combined static error	0.5% full range
Operating Temperature	-40° to 175° F (-40C to 79.5°C)

L. Air Pressure Sensor:

Range:	0 to 0.1 in. water (0 to 24.9 Pa) 0 to 0.25 in. water (0 to 63.2 Pa) 0 to 0.5 in. water (0 to 124.5 Pa) 0 to 1.0 in. water (o to 249 Pa) 0 to 2.0 in water 90 to 498 Pa
	0 to 5.0 in. water (0 to 1.25 kPa) 0 to 10.0 in. water (0 to 2.49 kPa)

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Output signal	4 to 20 mA
Accuracy	$\pm 1.0\%$ of full scale

M. Humidity Sensors:

Range	0 to 100% RH
Sensing Element	Bulk Polymer
Output Signal	4 – 20 mA DC
Accuracy	At 77°F (25°C) $\pm 2\%$ RH

N. Insertion Flow Meters (Equal to Onicon Series F-1200)

Sensing Method	Impedance Sensing
Accuracy	+ 2% of Actual Reading
Maximum Operating Pressure	400 PSI
Output Signal	4 – 20 mA

Bi-directional where required.

O. Pressure to Current Transducer

Range	3 to 15 psig (21 to 103 kPa) or 3 to 30 psig (21 to 207 kPa)
Output signal	4 – 20 mA
Accuracy	$\pm 1\%$ of full scale (± 0.3 psig)

P. Control Valves (all control valves shall have electric actuators).**1. Electric Control**

Rangeability	40:1
Flow Characteristics	Modified. Equal percentage
Control Action	Normal open or closed as selected
Medium	Steam, water, glycol
Body Type	Screwed ends 2" and smaller, flanged Valves 2½" and larger
Body Material	Bronze
Body Trim	Bronze
Stem	Stainless Steel
Actuator	0-10 VDC, 4-20 MA or 2 position 24 VAC/120VAC

2. All automatic temperature control valves in water lines shall be provided with characterized throttling plugs and shall be sized for minimum 25% of the system pressure drop or 5 psi, whichever is less.

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- a. Positive positioning relays shall be provided on pneumatic control when required to provide sufficient power for sequencing.
- b. Two position valves shall be line size.

Q. Damper Actuators

1. Electric control shall be Siemens Building Technologies OpenAir™ direct coupled actuators.
2. Damper actuators shall be brush less DC Motor Technology with stall protection, bi-directional, fail safe spring return, all metal housing, manual override, independently adjustable dual auxiliary switch.
 - a. The actuator assembly shall include the necessary hardware and proper mounting and connection to a standard ½” diameter shaft or damper blade.
3. Actuators shall be designed for mounting directly to the damper shaft without the need for connecting linkages.
4. All actuators having more than 100 lb-in torque output shall have a self-centering damper shaft clamp that guarantees concentric alignment of the actuator’s output coupling with the damper shaft. The self-centering clamp shall have a pair of opposed “v” shaped toothed cradles; each having two rows of teeth to maximize holding strength. A single clamping bolt shall simultaneously drive both cradles into contact with the damper shaft.
5. All actuators having more than a 100 lb-in torque output shall accept a 1” diameter shaft directly, without the need for auxiliary adapters.
6. All actuators shall be designed and manufactured using ISO900registered procedures, and shall be Listed under Standards UL873 and CSA22.2 No. 24-931.

2.08 MISCELLANEOUS DEVICES**A. Thermostats**

1. Room thermostats shall be of the gradual acting type with adjustable sensitivity.

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2. They shall have a bi-metal sensing element capable of responding to a temperature change of one-tenth of one degree. (Provide all thermostats with limit stops to limit adjustments as required.)
 3. Thermostats shall be arranged for either horizontal or vertical mounting.
 4. In the vertical position thermostat shall fit on a mullion of movable partitions without overlap.
 5. Mount the thermostat covers with tamper-proof socket head screws.
- B. Freezestats:
1. Install freezestats as indicated on the plans and provide protection for every square foot of coil surface area with one linear foot of element per square foot of coil.
 - a. Upon detection of low temperature, the freezestats shall stop the associated supply fans and return the automatic dampers to their normal position. Provide manual reset.
- C. Firestats:
1. Provide manual reset, fixed temperature line voltage type with a bi-metal actuated switch.
 - a. Switch shall have adequate rating for required load.
- D. Electronic Airflow Measurement Stations and Transmitters (At Duct Locations).
1. Stations – each insertion station shall contain an array of velocity sensing elements and straightening vanes. The velocity sensing elements shall be of the RTD or thermistor type. The sensing elements shall be distributed across the duct cross section in a quality to provide accurate readings. The resistance to airflow through the airflow measurement station shall not exceed 0.08 inches water gage at an airflow of 2,000 fpm. Station construction shall be suitable for operation at airflow of up to 5,000 fpm over a temperature range of 40 to 120 degrees F, and accuracy shall be plus or minus 3 percent over a range of 125 to 2,500 fpm scaled to air volume. Each transmitter shall produce a linear, temperature compensated 4 to 40 mA DC, output corresponding to the required velocity pressure measurement.
- E. Fan Inlet Airflow Measuring Station

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1. Each station shall contain parallel air straightener, total and static pressure sensing manifolds, internal piping and external pressure transmission ports with flexible tubing and quick-connect fittings. Fabricate of galvanized steel, size for fan inlet in which mounted. Maximum pressure loss through station of 0.08 inches water gage at 1500 fpm. Station shall have accuracy of 2%. Identify by model number, size, area, and specified airflow capacity.
- F. Current Sensing Relay:
1. Provide solid-state, adjustable, current operated relay. Provide a relay which changes switch contact state in response to an adjustable set point value of current in the monitored A/C circuit.
 2. Adjust the relay switch point so that the relay responds to motor operation under load as an “on” state and so that the relay responds to an unloaded running motor as an “off” state. A motor with a broken belt is considered an unloaded motor.
 3. Provide for status device for all fans and pumps.

PART 3: EXECUTION**3.01 PROJECT MANAGEMENT**

- A. Provide a designated project manager who will be responsible for the following:
1. Construct and maintain project schedule
 2. On-site coordination with all applicable trades and subcontractors
 3. Authorized to accept and execute orders or instructions from owner/architect
 4. Attend project meetings as necessary to avoid conflicts and delays
 5. Make necessary field decisions relating to this scope of work
 6. Coordination/Single point of contact

3.02 SEQUENCE OF OPERATION

- A. Philosophy of Sequences:

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1. All control sequences shall include equipment-operating strategy, required graphics, required alarm messages, required logging, and required reporting and point list requirements.
 2. The purpose of the control system is to provide a management tool for operating the complex in an efficient manner. Therefore, as much practical operating information is to be programmed into the control system as part of the base package, as possible.
- B. Prior to application programming, the Controls Contractor shall meet with the Owner and Engineer to determine point name formats, Alarm Message Formats, Graphic Formats, Report Formats, Data Logging formats and final sequences of operation.
- C. Specific Sequences of Operation
- D. Reference Section 17250

3.03 INSTALLATION

- A. Wiring.
1. All wire and cable used in the installation of the system shall be marked to identify it as part of the BAS. Cable shall be shaded blue throughout the installation.
 2. Cable for building level network shall have low capacitance characteristics to support specified baud rate of 115K.
 3. Cable shall be marked to indicate the name of the BAS manufacturer, the application for the cable, gauge and UL listing. Application marking shall state “PMD/LAN” for building level network; “POWER” for all 120V and 24V power runs; “TEMP CONTROL” for all point wire connections. Markings shall occur at a minimum of every 10 feet, and at each junction box and field/panel termination point.

3.04 START-UP AND COMMISSIONING

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The Installing Contractor shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. These procedures apply to the BAS and all gateways to other systems, including fire alarm/life safety.

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- B. Provide any recommendation for system modification in writing to owner. Do not make any system modification, including operating parameters and control settings, without prior approval of owner.

- C. Prior to commissioning proceeding, the following prerequisites shall be met and confirmed in writing:
 - 1. All control hardware is installed.
 - 2. Wiring installation is complete.
 - 3. All terminations for power and control wiring are complete.
 - 4. Power is from final, permanent sources.
 - 5. Mechanical/electrical systems are substantially complete.
 - a. Duct caps are removed, ductwork completed.
 - b. Air and water systems are balanced.
 - 6. Database is complete
 - a. Points, including alarms
 - b. Programming, including real-time control software and time-of-day scheduling
 - c. Graphics, if workstation is present.
 - 7. Coordination is completed to allow full access to systems
 - a. Shutdowns, if required, are scheduled and agreed upon
 - b. Coordination with other contractors who impact the startup/checkout schedule

- D. The Controls Contractor shall prepare a commissioning process book with all procedures, forms and submittal information. Plan shall include the following information:
 - 1. Track that prerequisites for checkout have been completed, with dates.
 - 2. List of parties to be involved in checkout and required for signoff.
 - a. Owner's rep

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- b. Engineer
- c. Other as required
- 3. List of procedures and tasks to be completed.
- 4. Collection of forms to capture tasks, results, dates, and signoffs for each category of task.
- 5. Warranty letters
- 6. Acceptance letter indicating executive turnover with signatures
- E. Commissioning plan tasks and procedures will be included as per the following:
 - 1. Field panel checkout
 - a. Verify enclosure is not mounted on vibrating surface
 - b. Verify class I and class II wiring is separated within enclosure
 - c. Check for shorts/grounds/induced voltages/proper voltages
 - d. Verify proper point terminations in accordance with as-builts
 - e. Verify that all modules are in proper place and addressed
 - f. Verify proper power voltage
 - g. Load database and programming
 - h. Startup the panel
 - i. Point and device checkout
 - j. FLN/MSTP Network and Power Trunk Diagrams are available for reference.
 - 2. Analog input point checkout
 - a. Verify the correct wiring terminations per the design documentation package, at the field panel. Verify that all wiring and terminations are neat and dressed.
 - b. Verify the point address by checking that the analog input instrument is wired to the correct piece of field equipment. Do this by altering the environment at the sensing element or by

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disconnecting one of the wires at the sensor, and verifying that the reading at the field panel has reacted to this change.

- c. Verify the point database to be correct, (i.e., alarm ability, alarm limits, slope/intercept, engineering units, etc.). Verify that the correct change of value (COV) limit has been defined.
 - d. Verify the sensor has the correct range and input signal. (i.e., 20-120 DEG F, 4 - 20 ma). Verify that the device is mounted in the correct location and is wired and installed correctly per the design documentation package.
 - e. Set-up and/or calibrate any associated equipment (i.e., panel LCD meters, loop isolators, etc.). Verify that these auxiliary devices are mounted in the correct location and are wired and installed correctly per the design documentation package.
 - f. Verify the correct reading at the field panel using appropriate ~~MMH~~ devices. Verify that any associated LCD panel meters indicate the correct measured value.
3. Digital input point checkout
- a. Verify the device is correctly wired and terminated as shown in the design documentation package. Verify that all wiring and terminations are neat and properly secured.
 - b. Verify the point address by verifying that the digital input is correctly terminated at the controlled piece of equipment.
 - c. Verify the point database is correct (i.e., point name, address, alarm ability, etc.).
 - d. Set-up and/or calibrate the associated equipment, i.e. smoke detector, high/low temp detector, high/low static switch, flow switch, end switch, current relay, pressure switch, etc. is mounted in the correct location, and is wired and installed correctly per the control system installation drawings.
 - e. With the controlled equipment running or energized as described in the digital output checkout procedures, verify the correct operation of the digital input point and associated equipment by putting the digital input monitored equipment into its two states. Verify that the proof or status point indicates the correct value at the operator's terminal and that the status led is giving the proper indication in each mode of operation (on/off).

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4. Digital output point checkout
 - a. Verify that device is correctly wired and terminated as shown in the design documentation package.
 - b. Verify that the correct voltage is utilized in the circuit.
 - c. Verify the point database to be correct (i.e. point name, address, etc.).
 - d. Check and verify that the end device responds appropriately to the digital output(s).
 - e. After verifying the set-up and operation of any associated digital input/proof points, check and verify correct operation of the logical point and associated equipment by commanding the point to all possible states (i.e. off, on, fast, slow, auto, etc.). Verify that the defined proof delay is adequate for all modes of operation.
 - f. If any interlocked equipment exists that has independent hand-off-auto or auxiliary control wiring, verify correct operation of it. Also check that any interlocked equipment such as EP switches for damper operation or exhaust and return fans are wired correctly and operate correctly.
 - g. Verify that the controlled piece or pieces of equipment can not be cause to change state via the digital output if an associated hand-off-auto switch is in the hand /on or hand/off mode of operation, unless specified as a fireman's override point etc.

5. Analog output point checkout
 - a. Verify the correct wiring or piping terminations per the design documentation package, at the field panel. Verify that all wiring and piping terminations are neat and dressed.
 - b. Insure that the correct output device(s) are installed per the Control System Installation Drawings. (i.e., I/P or P/I transducers, transformers, power supply, etc.). Verify that these devices are installed, wired and piped correctly. Verify that any configuration jumpers are in the proper settings for the required application. Verify related transformers are fused in accordance with installation drawings.

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- c. Verify the point database to be correct. Verify that the correct COV limit has been defined.
 - d. Verify the point address by checking that the analog output is wired and/or piped to the correct output transducer and/or equipment.
 - e. Verify that the controlled device is calibrated (i.e., 3-8PSI valve, 8-13 PSI damper motor, 4-20 ma variable frequency drive, etc.) and is in the correct location, and is wired or piped and installed correctly per the design documentation package. If the controlled device is not calibrated, then a three point (high, low and mid-point) calibration procedure shall take place. Verify proper operation of the end device. When calibration has been verified, ensure that installation drawings, point database, and PPCL have been updated.
 - f. Set-up and or calibrate any associated equipment, (i.e., panel LCD meters, loop isolators, pneumatic gauges, etc.). Also verify that these auxiliary devices are mounted in the correct location, and are wired or piped and installed correctly per the design documentation package.
 - g. After verifying the set-up and operation of any associated equipment check for the correct operation of the logical point and associated equipment by commanding the analog output to the top and bottom of its range. Verify that the control device(s) responded appropriately as indicated by the design documentation package. Check to insure that all network terminals; host console devices, etc. can also command these outputs.
 - h. Check that all-pneumatic gauges, pilot positioners and LCD panel meters indicate the correct values.
6. Terminal equipment controller checkout
 - a. Load program database
 - b. Enable programs
 - c. Verify sequence of operations
 7. Programming checkout
 - a. Provide checkout for each system and sequence of operation.

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- b. The following are sample sequence of operations tests. The intent of these procedures is to provide a plan of action to verify system operations via block checks of the project specific sequence of operations. The procedures may be used in this format, or one procedure to a page should more detail be required. The procedures outlined below should be verified for accuracy, and may be modified to meet your specific requirements.
 - c. **DESCRIPTION OF TEST:** AHU Alarm Checkout. Verify AHU-1 discharge air temperature alarming is operational and is received at the designated terminal.
 - d. **INPUT TO TRIGGER TEST:** Change discharge temperature high alarm limit through software to a value below the current discharge temperature (discharge temperature - 10 Deg F).
 - e. **EXPECTED OUTCOME:** A high temperature alarm will be received per the Alarm Definition Report at its designated terminal.
 - f. Provide signoff sheet with indication for test Pass, Fail, Date of test and Initials for signoff.
8. Customer acceptance
- a. Provide customer system acceptance sign-off sheet listing job name, project number, and the following statement: “THIS SYSTEM HAS BEEN FULLY DEMONSTRATED AND EXPLAINED IN ACCORDANCE WITH THE CONTRACT AND IS APPROVED FOR ACCEPTANCE BY THE OWNERS REPRESENTATIVE ON (date) BY (name). THIS SYSTEM IS ACCEPTED WITH THE FULL KNOWLEDGE THAT THE INSTALLATION MUST UNDERGO A TOKEN DEBUGGING PERIOD AND THE UNDERSTANDING THAT ALL ITEMS ON THE ATTACHED LIST WILL BE CORRECTED IN A TIMELY MANNER FROM THE ABOVE DATE. I ACCEPT THIS SYSTEM WITH EXCEPTIONS AS NOTED BY THE ATTACHED DETAILED LIST.”
 - b. Provide the following spaces for signoff:
 - 1.) Customer signatures title and date
 - 2.) DDC contractor signatures title and date

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- 3.) Contract number
- c. The Controls Contractor shall provide written notification at key turnover points:
 - 1.) Warranty period partial turnover (if required)
 - 2.) Warranty period final turnover
 - 3.) Customer acceptance letter
- d. Acceptance shall not occur until owner verifies that training has been delivered, warranty has been signed off, and operating and maintenance manuals have been delivered.

3.05 TRAINING

- A. The Controls Contractor shall provide comprehensive training to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal working hours of 8:00 AM to 4:00 PM weekdays.
- B. Provide up to 40 hours of on-site training for Owner's designated operating personnel as needed. Training shall include:
 1. Explanation of drawings, operations and maintenance manuals
 2. Walk-through of the job to locate control components
 3. Operator workstation and peripherals
 4. DDC controller and ASC/MSTP Network Device operation/function
 5. Operator control functions including graphic generation and field panel programming
 6. Operation of portable operator's terminal
 7. Explanation of adjustment, calibration and replacement procedures
- C. Provide tuition for University Facilities personnel for classroom training for Controls Equipment Training.

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D. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training shall be available from the Controls Contractor. If the Owner requires such training, it will be contracted at a later date.

Submittals Completion Checklist				
	Description	Yes	No	Comments
Controls Drawings				
Table of Contents	List of Contents within the submittals.			
Abbreviation Table	All Abbreviations used need to be listed here for easy reference			
Control Symbols Legend	List of all symbols used within the document and what they reference			
Master Bill of Materials	List of all parts used in project, to include at a minimum the Part Numbers, Manufacturer, Model Number, Device Tag, Device Range/Control as well as Control Type, General Description of items, and quantities used. Exclusions are Schedules (i.e. Valve/Damper etc.)			
Riser Diagrams	Provide detailed riser diagram of the complete system or building systems indicating all wiring types and protocols			
System Flow Diagrams	Provide schematic flow diagrams for each system being controlled. Illustrate all control points/objects labeled with point/object names shown on the controller termination drawing. The schematics will graphically show the location of all control devices in each system. Each System will also contain it's specific BOM with same specifications as the MBOM. Each system will also contain a Sequence of Operations for that specific system.			
System Wiring Diagrams	Provide a schematic ladder wiring diagram for each controlled system and control panel. Each schematic shall have all elements labeled. Illustrate specific termination details for all field equipment such as communication interfaces, VFD Interface I/O, Chiller Interface I/O, VRF Systems, RTU's FAS Systems, Generator Systems, Switch Gear Interfaces, Valves, Actuators and all end device terminations.			

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Submittals Completion Checklist				
	Description	Yes	No	Comments
Controls Drawings				
Transformer Loading	Provide a transformer loading calculation chart for all control transformers. Identify each load and it's power consumption in this chart. This should be included on each control panel ladder diagram			
Panel Pictorial	Provide scaled panel pictorial drawings indicating all components being installed in each control panel. Terminals, power outlets, power supplies, relays, switches, interface boards, terminators, controllers, any panel mounted components.			
Schedules				
Valve Schedule	Provide valve schedules indicating Valve Number, System/Function, Tag, Quantity, Flow Rate, Media Type, Body Type, Design Pressure Drop, Calculated CV, Actual CV, Pipe Size, Valve Body Size, Flow Characteristic, Close Off Pressure, Coil Pressure Drop, Fail Safe Mode, Control Signal, Model Number, Actuator Model Number, Power Requirements, Nema Rating. All Valves installed on campus will be spring return to the appropriate position for the system unless approved in writing by Texas State University.			
Damper Schedule	Provide Damper Schedule indicating Dampuer Number, System/Function, Tag Quantity, Duct Dimensions, SQ/FT Area, Required Torque per SQ/FT, Actual Actuator Torque, Fail Safe Mode, Control Signal, Model Number, Actuator Model Number and Power Requirements.			
Air Flow Station Schedule	Provide Air Flow Station schedule indicating Flow Station Number, System/Function, Tag, Quantity, Duct Dimensions/Area, Control Signal, Model Number, Interface Protocol, and Power Requirements.			

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	Description	Yes	No	Comments
Controls Drawings				
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Damper Schedule	Provide Damper Schedule indicating Dampuer Number, System/Function, Tag Quantity, Duct Dimensions, SQ/FT Area, Required Torque per SQ/FT, Actual Actuator Torque, Fail Safe Mode, Control Signal, Model Number, Actuator Model Number and Power Requirements.			
Air Flow Station Schedule	Provide Air Flow Station schedule indicating Flow Station Number, System/Function, Tag, Quantity, Duct Dimensions/Area, Control Signal, Model Number, Interface Protocol, and Power Requirements.			

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Submittals Completion Checklist				
	Description	Yes	No	Comments
Schedule				
Water Flow Meter Schedule	Provide water flow meter schedules indicating Flow Meter Number, System/Function, Tag, Quantity, Pipe Size, Pipe Schedule, Flow Rate, Control Signal, Model Number, Interface Protocol, Any pertinent setup information required for maintenance, Power Requirements.			
Utility Metering Schedule	Provide utility metering schedule indicating (As Applicable) Meter Number, System/Function, Tag, Quantity, Pipe Size Pipe Schedule, Flow Rate, KW Rates, CT Sizes, Panel Locations, Circuit Numbers, or Metering Areas for GAS/City Water. For all utility metering provide Interface Control Signal, Model Number, Interface Protocol, and Power Requirements. Indicate who is providing the meter if it is provided by others.			
Terminal Box Schedule	Provide Terminal Box Schedule indicating Box Number, System/Function, Tag, Duct Inlet Dimensions, Minimum CFM, Maximum CFM, Fan Operation, Reheat Operation, Space Sensor Type, Controller Model Number, Interface Protocol, and Power Requirements.			
Product Data	Provide Product Data Sheets/Cut Sheets for all products on the MBOM. When manufacturer’s cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements.			

SECTION 25 51 00-INTEGRATED AUTOMATION FACILITY CONTROLS

Submittals Completion Checklist				
	Description	Yes	No	Comments
Integrations	Products requiring integration to the controls system will supply, as part of their packages, catalog data sheets, wiring diagrams, and points lists to the Division 23 Contractor (when integrating with an Integrated Automation Facility Controls and Control System) for proper coordination of work. EACIS Contractor shall also include a complete points list/registry list of all points available to be integrated into the Automation Facility Controls. This contractor shall be responsible for As-Built drawings pertaining to overall Integrated Automation Facility Controls architecture and network diagrams. All As-Built drawings shall also be submitted to Planning, Construction, and Design as well as Technical Services.			
Training	The Contractor shall provide a course outline and training manuals for all training classes at least three weeks prior to the first training class. Review and approval by Texas State University shall be completed at least one week prior to the first class. Contractor shall provide a qualified/competent trainer in the training course provided to Texas State University.			

END OF SECTION 25 51 00