

SECTION 23 09 23

DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

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PART 1: GENERAL

1.01 DEFINITIONS

1. UW: University of Washington, Seattle
2. Owner: The University of Washington Project Delivery Group
3. Owner Agent: Employee of the UW
4. Controls Engineer: Employee of CEUO Shop 69 HVAC responsible for BAS and DDC systems operations
5. UW-IT: UW group responsible for campus-wide IT operation
6. UW-BIT/OT: A specialized team within UW Facilities BIT group responsible for BAS/DDC configuration and data quality
7. DDC: Direct or Distributed Digital Controls.
8. BAS / EMS / BMS: Equivalents to DDC above
9. Component: Devices such as actuators, sensors, limit switches, wall modules, and similar items.
10. Controller: Electronic device including logical programming for execution of the SOO. May or may not include communications features. May or may not include on board I/O.
11. I/O: non-logical I/O devices used when addition inputs and outputs are required by SOO
12. SOO: Sequence of Operation as defined by MEOR
13. MEOR: Mechanical Engineer of Record
14. Milbank Box: Locking metal enclosure from Milbank Corp.

1.02 RELATED STANDARDS REQUIREMENTS

1. University of Washington Facilities Design Specification (FDS)
2. UW DDC point naming standards

3. UW DDC graphics standards
4. UW DDC alarm and trend configuration standards
5. UW metering and monitoring standards
6. Section 23 09 13 - Instrumentation and Control Devices for HVAC
7. Section 26 05 83 - Wiring Connections: Electrical characteristics and wiring connections.
8. Section 28 46 00 - Fire Detection and Alarm

1.03 REFERENCE STANDARDS

Work under this Section is subject to requirements of Contract Documents including but not limited to General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements. If conflicts do arise, the most stringent applies.

The latest edition of the following standards and codes in effect and amended as of the supplier's proposal date, and any applicable subsections thereof, shall govern the design and selection of equipment and material supplied:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
2. ANSI/ASHRAE Standard 135, BACnet - A Data Communication Protocol for Building Automation and Control Networks.
3. ASHRAE Standard 147 - Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.
4. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests.
5. Uniform Building Code (UBC), including Local amendments.
6. International Building Code (IBC), including local State and Local amendments.
7. UL-916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
8. UL-873 – Temperature Indication and Regulating Equipment.
9. UL-864 – Fire and Smoke Control.
10. National Electrical Code (NEC) and as applicable local electrical code.
11. FCC Part 15, Subpart J, Class A.
12. EMC Directive 89/336/EEC (European CE Mark).
13. National Fire Protection Association (NFPA) Standards, as specified.
14. 70, 92A, 92B, 101, 204
15. UL (DIR) - Online Certifications Directory.
16. ASHRAE 90.1: Specifies energy efficiency control requirements (scheduling, setpoint control, demand response)
17. (NEC) - NFPA 70:
 - a) Wiring methods, grounding, and overcurrent protection of control systems.
 - b) DDC panels
18. City, county, state, and federal regulations and codes in effect as of contract date.
19. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for

necessary approvals by any outside governing authorities. Refer to the general conditions of the contract.

1.04 STANDARDS COMPLIANCE

1. All equipment and materials are to be from the manufacturer's regular production, UL and/or ULC or CSA certified, manufactured to the standard quoted plus additional specified requirements.
2. Where UL and/or ULC or CSA-certified equipment is not available submit such equipment to inspection authorities for special inspection and approval before delivery to the site.
3. Submit proof of compliance with specified standards with shop drawings and product data. Label or listing of specified organization is acceptable evidence.
4. In lieu of such evidence, submit certificate from the testing organization, approved by the Owner, certifying that the item was tested in accordance with their test methods and that the item conforms to their standard/code.
5. For materials whose compliance with organizational standards/codes/specifications is not regulated by an organization using its own listing or label as proof of compliance, furnish certificate stating that the material complies with applicable referenced standards or specification.

1.05 ADMINISTRATIVE REQUIREMENTS

1. Conduct a pre-installation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
2. All IP devices must have their IP addresses coordinated with the UW BIT/OT team prior to installation.
3. A full network assignment matrix must be completed and submitted to UW BIT/OT before installation. During the design phase of capital projects, documentation to track IoT/OT building automation systems and devices shall be obtained by filling out the specified columns in the Early Building Services (EBS) sheet of the UW-IT Outlet Schedule spreadsheet:
<https://facilities.uw.edu/files/media/ebs-outlet-schedule-template.xlsx>
4. IP addresses for IoT/OT devices will not be issued without this information. The EBS sheet shall be updated when IoT/OT systems and devices for buildings are introduced and added, during the design, construction, and commissioning phases of the project.
5. A schedule for key IT tasks/requirements shall be presented and updated during the project. Key tasks to be referenced included:
 - a) Early Activation Port Requests
 - b) MDF/IDF Activation Required Dates
 - c) Building DDC Network Tie-in Date to Existing Campus DDC Server

1.06 SUBMITTALS

1. See Section 23 05 00 - Common Work Results for HVAC for submittal procedures.
2. Submissions Requirements:
 - a) Clearly identify each submittal requirement indicated and in which submission the information will be provided.
 - b) Include an updated submittal schedule in each subsequent submission with changes highlighted to easily track the changes made to previously submitted schedule.
 - c) All submittals, record documents, and operations manuals must be indexed. PDF documents must include searchable text. Scanned documents are not acceptable. Provide the following submittals with a minimum drawing size of 11 x 17.
3. The following table defines the required submittals and hierarchy for time of submission:

Submittal Section	Submittal Name	Timeline	Pre-requisite for Review
1.07	Submittal Schedule	asap	None
1.08	Assignments and Qualifications		None
1.09	Specification Compliance Statement		G, H
1.10	Component Data for DDC system	Due 2 weeks prior to installation	I
1.11	Controller Data for DDC system	Due 2 weeks prior to installation	I
1.12	DDC Shop Drawings & Design Submittal - including SOO, physical & virtual Points Lists, Alarms Submittal (minimum Alarmable points), and valve, damper, flow station, etc.	Due 2 weeks prior to installation	I
1.13	Draft Point to Point Checkout Forms	2 weeks prior to energizing controls	N
1.14	Testing Submittals		L
1.15	Acceptance Trend Data		N
1.16	DDC System Programming Submittal	Due 2 weeks prior to Cx	L

1.17	Graphics Submittal		L
1.18	Closeout Submittals		Cx Buyoff

1.07 SUBMITTAL SCHEDULE

Schedule of anticipated dates for each submittal required as part of the specifications. No further submittals will be reviewed until the schedule is received.

1.08 ASSIGNMENTS AND QUALIFICATIONS

Supply names, contact information, and resumes for people assigned to the following construction roles:

1. Project Manager
2. Controls Engineer
3. Primary Controls Programmer
4. Controls Programmers (as would write logic)
5. Controls Technicians (as might perform point-to-point checkout)
6. Any Remote DDC sub-contractors or employees

1.09 SPECIFICATION COMPLIANCE STATEMENT

An electronic copy of the specification will be provided to the vendor. Vendor shall indicate one of the following on every specification requirement paragraph-by-paragraph:

1. Comply - vendor complies or exceeds this requirement.
2. Deviation - vendor deviated from this requirement but provides similar operational and functional capabilities. Vendor to describe the deviation and how its product meets the specification performance requirement.
3. Non-Compliant - vendor's proposed product does not meet the specification requirement.

1.10 COMPONENT PRODUCT DATA

For each type of product include, at minimum, the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Documentation on submitted products that have been tested and listed by the BTL or a letter from manufacturer's indicating the anticipated date by which testing is expected to be complete. If for any reason, BTL testing and listing has not been completed, a written commitment shall be provided to upgrade installed controls to a version that meets BTL testing and listing requirements should deficiencies be found during BTL testing.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product:
 - a) DDC controllers
 - b) Enclosures
 - c) Electrical power devices.
 - d) UPS units
 - e) Accessories
 - f) Instruments
 - g) Control dampers and actuators
 - h) Control valves and actuators
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross-reference specifications and drawings that the submittal is to cover.

1.11 CONTROLLER PRODUCT DATA

For each type of product include, at minimum, the following:

1. Product description with complete technical data, performance curves, and product specification sheets.
2. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
3. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information and the exact application for that product.
4. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

1.12 SHOP DRAWINGS

1. Include plans, elevations, sections, and mounting details where applicable.
2. Include details of product assemblies. Indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
3. Plan Drawings indicating the following:

- a) Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
 - b) Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c) Each desktop operator workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d) Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e) Exact placement of any sensors exterior to mechanical equipment (weather stations, duct pressure sensors, pipe pressure sensors, thermostats, etc.)
 - f) Network communication riser and one-line diagram
4. Schematic drawings for each controlled system indicating the following:
- a) Hardware I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b) Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - c) Unique identification of each I/O that shall be consistently used between different drawings showing same point.
 - d) Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers (for example: low limit shutdown wiring).
 - e) Sequence of operation for all equipment controlled by or wired to DDC
5. Control panel drawings indicating the following:
- a) Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b) Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
 - c) Unique drawing for each panel.
 - d) Unique panel ID for each panel
6. DDC system network riser diagram indicating the following:
- a) The riser shall show on a floor-by-floor basis the DDC controllers, servers, workstations with associated network wiring. All routers, switches, etc. shall be shown.
 - b) All 3rd party interfaces shall be shown including network cabling and communication protocol required.
 - c) Each device connected to network with unique identification for each.
 - d) Network addressing details for each device as appropriate
 - e) Interconnection of each different network in DDC system.
7. DDC system electrical power riser diagram indicating the following:
- a) Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - b) Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.

- c) Each product requiring power with requirements (volts, phase, hertz, amperes, connection type) listed for each.
- d) Power wiring type and size, raceway type, and size for each.
- 8. The contractor shall utilize the Owners point naming convention. See 'UW DDC point naming standards' reference at beginning of document.
 - a) Naming must be applied to BACnet object names. Naming that is only viewable on graphics is not acceptable.
 - b) Points that are not called out specifically within the point naming document, should have a name that is not abbreviated and clear to understand. The naming should align with the naming standard prefixes.
- 9. Show system configuration with peripheral devices, batteries, power supplies, diagrams and interconnections.
- 10. If any Contract Document items were taken exception too at the time of contract award, that exceptions list shall be provided as part of the DDC submittal and the FDS variance log.
- 11. Indicate the manufacturer's installation instructions for all manufactured components.
- 12. Record actual locations of control components, including control units, thermostats, and sensors.
- 13. Revised shop drawings to reflect actual installation and operating sequences.
- 14. Include submittals data in the final "Record Documents" form.

1.13 POINT-TO-POINT CHECKOUT FORMS

- 1. Provide draft I/O checkout forms with date and operator sign off blocks.
- 2. Check digital I/O in active / inactive state
- 3. Check analog I/O at 0%, 50% and 100% levels
- 4. Provide calibration figures for analog sensor inputs

1.14 TESTING SUBMITTALS

- 1. Provide test plan and test procedures for approval.
- 2. Explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification and methods for simulating necessary conditions of operation to demonstrate performance of the system.
- 3. Test plan and test procedures demonstrate capability of the system to monitor and control equipment and to accomplish control and monitoring specified.
- 4. System and product operation under each potential failure condition including, but not limited to, the following:
 - a) Loss of power.
 - b) Loss of network communication signal.
 - c) Loss of controller signals to inputs and outpoints.

1.15 PROJECT-LEVEL SYSTEM ACCEPTANCE TREND DATA

- 1. The DDC Contractor shall provide, as directed by the Cx Agent, 1 week of trend data for every major mechanical system and critical spaces to confirm proper

- operation in graphical and spreadsheet form. All trend data shall be submitted to the CxA, Architect, and Engineer for review prior to final Testing & Balancing.
2. Should the DDC Contractor need to provide a temporary network/server to accomplish/achieve the trending requirements listed herein, this shall be part of this project's scope.
 3. The DDC Contractor shall coordinate with the CM/GC and other contractors to incorporate the necessary time in the schedule to allow for review and acceptance of all trending listed herein.
 4. At a minimum the following trends shall be provided. If further complexities arise during construction on systems or spaces not listed below, those systems or spaces shall be added at no additional cost to the project.
 - a) Systems:
 - Air Handling Units / Exhaust Air Handling Unit
 - Fans
 - Chiller Plant
 - Boiler Plant and Heat Exchanger Systems
 - All Heating and Cooling Pumping Systems
 - Cooking Hood Control Systems
 - b) Critical Spaces:
 - Surgical and Critical Care Spaces/Patient Rooms
 - Laboratory
 - Clean Rooms
 - Large Kitchen/Servery
 5. Points to Trend:
 - a) All points that are associated with a control loop shall have the input, setpoint and output of the loop.
 - b) On/Off status of fans and pumps will also be included in the trend information where applicable with application.
 - c) Outside air temperature and humidity trending information shall also be provided where applicable with application.
 - d) Typical Air Side Equipment (as applicable) points shall include, but not be limited to, the following:
 - Fan Enable Commands
 - Fan Speed Commands
 - Unit Duct Static Pressures & Setpoints
 - Unit Discharge Temperature & Setpoint
 - Zone Temperature & Setpoint
 - Outside Air Temperature
 - Mixed Air Temperature
 - Cooling Signal Command (i.e. valve or DX)
 - Heating Signal Command (i.e. valve or heating element)
 - Heat Wheel Speed if VFD driven or Status if constant volume
 - Economizer Dampers Command
 - Unit Mode or Stage
 - e) Typical Water Side Equipment (as applicable) points shall include, but not be limited to, the following:

- Cooling or Heating Equipment Command
 - Pump Enable Commands
 - Pump Speed Commands
 - Differential Pressures & Setpoints
 - Outside Air Temperature
 - System Leaving Water Temperature & Setpoint
 - System Return Temperature
 - Cooling or Heating Equipment Leaving Water Temperature
 - Cooling or Heating Equipment Entering Water Temperature
 - Cooling or Heating Equipment Temperature Setpoints
 - Cooling or Heating Equipment Load Output
 - Cooling Signal Command
 - Heating Signal Command
 - Flow Meters
 - Unit Mode or Stage
- f) Typical Terminal Unit Equipment (as applicable) points shall include, but not be limited to, the following:
- Fan Enable Commands
 - Fan Speed Commands
 - Zone Temperature & Setpoint
 - Primary Airflow & Setpoint
 - Cooling Signal Command (i.e. valve or DX)
 - Heating Signal Command (i.e. valve or heating element)
- g) Typical Miscellaneous Equipment (as applicable) points shall include, but not be limited to, the following:
- Points as requested by Commissioning Provider.
 - Occupancy sensors where applicable with application.
 - Metering – Totalized Values
 - Metering – Calculated flow and/or Instantaneous flow reading
6. Submittal Format:
- a) Trend data chart digital displays of each system shall be provided for the week of data. The format and information shall be as follows:
- The graphs shall be provided in line chart format with a printout for each day and submitted as a single pdf file for each piece of equipment/space required.
 - The graphs shall be provided so the data is legible and will indicate the piece of equipment and points.
- b) Data files
- Excel spreadsheets of the trend data shall also be provided. The format shall be as follows:
 - The data shall be grouped together by equipment/space.
 - The left most column shall provide the date and time.

- The data shall be organized so the columns for the input point, setpoint, and output point for each control loop are immediately next to one another.
- There shall be 3 additional rows above the header which shall provide the Excel functions for Maximum (MAX), Minimum (MIN) and Average (AVG) for all the columns with numerical data.
- All numerical data shall be displayed to 2 decimal points.
- If point names are provided in acronyms, there shall be a legend provided along with the graphs and spreadsheets.

1.16 SYSTEM PROGRAMMING SUBMITTAL

To assure all sequences have been considered and the DDC system is ready for third-party commissioning, all programming files should be submitted electronically. These will be reviewed by UW Shop 69 HVAC technicians. As examples, include the following:

1. Terminal Unit applications or logic
2. AHU applications or logic
3. DOAS / ERV applications or logic
4. Plant- level logic; pumps, HX, and similar
5. Top-level controller logic such as OAT and FA point sharing, TU demand statistics, or other system-level calculations

1.17 GRAPHICS SUBMITTALS

Provide a sample graphics page of the following types:

1. Building home page
2. Floorplan presentation
3. Plant system presentation
4. AHU presentation
5. Terminal Unit presentation
6. TU summary page
7. Misc Equipment / EF summary presentation

1.18 CLOSEOUT SUBMITTALS

1. DDC System I/O Checkout Report

Submit for approval, a detailed report highlighting the process and results as described in section 3.8 below: "DDC SYSTEM I/O CHECKOUT PROCEDURES".

- a) Provide start-up/checkout documentations for all DDC controllers connected to the DDC network. Documentation shall include, but not limited to, all following active points in use in the controllers:
 - points used and unused (spare)
 - Settings
 - Calibration
 - coefficient values

- K factors
 - Spanning
 - actual spring ranges
- b) Point to point checks must include a physical observation/measurement, manually filled out forms, dated and initialed by the technician with eyes on parts, and a check on the DDC value. Automated outputs from control systems are not acceptable.
2. As-built documentation
- a) Submit for approval, as-built versions of shop drawings and product data in electronic PDF format. The as-built drawings, drawings, sequences, and products shall accurately reflect every change made to the system operation since approval of the shop drawings.
 - b) Revise all control sequences of operation to final turnover conditions. Sequences of operation that restate the Design Engineer's sequences will not be acceptable.
 - c) VAV controller startup/commissioning documentation shall include a controller point/subpoint report and as a minimum but not limited to the following final as-built information:
 - Min/max CFM settings.
 - Controller volume tracking differential.
 - Box size and area multiplier.
 - Box K factor as determined by DDC and TAB.
 - BACnet device instance numbers.
 - Auto-zero enabled/disabled.
 - Auto-zero scheduled time.
 - Communications priority (life safety, critical, normal).
 - Tstat set point override range (+/- 5 DegF).
 - Room set point (base).
 - Generic additional points added to controller.
 - Controller box identifier shall match mechanical tag as called out on mechanical plans.
 - A matrix sheet detailing all system addresses and communication settings for the following:
 - All IP network addresses & settings.
 - All DDC device addresses & communication settings.
3. Operation and Maintenance Data:
- a) Include interconnection wiring diagrams and complete field-installed systems with identified and numbered, system components and devices.
 - b) Include keyboard illustrations and step-by-step procedures indexed for each operator function.
 - c) Include the inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

- d) Hardware Manual: Furnish a hardware manual describing the equipment provided, including:
- e) General description and specifications.
 - Installation and checkout procedures.
 - Equipment electrical schematics and layout drawings.
 - System schematics and I-O wiring lists.
 - Alignment and calibration procedures.
- f) Software Manual:

Describe furnished software. Oriented to programmers and describing calling requirements, data exchange requirements, data file requirements, and other information necessary to enable proper integration, loading, testing, and program execution.

Provide one software manual per Operator's Terminal

- g) Operator's Manual: Provide procedures and instructions for operation of the system, including:
 - DDC Panels and Peripherals
 - System start-up and shutdown procedures.
 - Use of system, command, and applications software.
 - Alarm Presentation
 - Recovery and Restart Procedures
 - Report Generation
 - System Schematic Graphics
 - Provide one Operator's Manual per Operator's Terminal
 - h) Maintenance Manual: Provide descriptions of maintenance for equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
4. Acceptance Test Forms: The maintenance manual includes copies of signed-off acceptance test forms.
 5. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 6. As-built versions of submittal Product Data.
 7. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 8. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
 9. A complete alarm list, with criticality levels, and distribution assignment.
 10. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 11. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 12. Submission of actual programming language used for each system type.
 13. Backup copy of programs, and database: Coordinate with UW to backup project programming, graphics, etc. on UW server or approved location.
 14. List of recommended spare parts with part numbers and suppliers.

15. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
16. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
17. Licenses, guarantees, and warranty documents.
18. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
19. Owner training materials.
20. Warranty: Submit the manufacturer's warranty and ensure forms have been filled out in the Owner's name and registered with the manufacturer.

1.19 MAINTENANCE DATA

For systems to include in maintenance manuals specified in Division Include the following:

1. Maintenance instructions and lists of spare parts for each type of control device, electronic control cabinet.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
4. Calibration records and list of set points.

1.20 COMPLETION CHECKLIST:

Submit with shop drawings, detailed completion checklist including written procedures for adjusting and calibrating each type of instrument and sensor. UW reserves the right to request modifications to any procedure, which is incomplete or not adequate to prove system performance at no cost to the Owner.

Checklist shall include references to the following additional requirements:

1. Controls Contractor and Mechanical Contractor shall walk proposed static pressure sensor and flow meter locations and mark up drawings for review and approval by Owner and Engineer prior to installation.
2. Instruments and sensors shall be calibrated by comparison to known device, which is traceable to National Institute of Standards and Testing.
3. Each point shall be checked for calibration, connection to correct control loop, and proper setting of limit and alarm values.
4. Transducers and other output devices shall be properly zeroed and calibrated at both minimum and maximum output. Document settings for discrete instruments and set points for analog instruments shall include minimum and maximum positions for safe operating conditions where applicable (max. pump speed or max. frequency of fan drive, etc.).

5. Control loops shall be tuned to maintain controlled process variable at set point through seasonal conditions without operator intervention. Provide multiple sets of tuning parameters if necessary. Controller shall automatically use tuning parameters appropriate to existing ambient conditions. Maintain record on completion checklist, of control loops that require tuning at alternate times of year. Instruct technicians to supply default parameters that can approximate stable control until actual load conditions allow proper tuning of control loops.
6. Performance tests of analog control loops shall be performed by changing set points and verifying that sequences can come into stable control within reasonable time period appropriate for each sequence. Simulate load changes for pressure and flow control loops.
7. Performance tests of discrete control loops shall be performed by adjusting set point and verifying sequence action.
8. Alarms, including network failures, shall be tested for each controller and device connected to network. Ensure that alarms may be properly acknowledged.
9. Schedules for each system/device shall be verified.
10. Testing of DDC to ensure cyber security. Coordinate testing requirements with Owner.

1.21 ACCEPTANCE TESTING AND TRAINING

1. Site Testing:
 - a) General: Provide personnel, equipment, instrumentation, and supplies necessary to perform testing. Owner or Owner's representative will witness and sign off on acceptance testing.
 - b) Acceptance Test: Demonstrate compliance of completed control system with contract documents. Using approved test plan, physical and functional requirements of project demonstrated.
2. Training

Refer to UW Div 01 79 00 "DEMONSTRATION AND TRAINING" specification:
<https://facilities.uw.edu/projects/business-opportunities/boilerplate-specs>

1.22 WARRANTY

1. Warranty period shall begin as authorized by the Owner's representative in writing. Authorization will not be given before the following conditions are met at minimum:
 - a) All verified completion checklists provided to Owner.
 - b) Completion of all punch list items.
 - c) Conduction of a preliminary training session for personnel. The training shall consist of an orientation session at the job site to familiarize the 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.
 - d) Completion and distribution of the as-built control drawings, including correction of all items noted by Owner and Engineer after review of the documents.
2. Prior to the beginning of the warranty period, provide a vendor warranty certificate that includes:

- a) Provide warranty issue management practices overview including issue tracking policies.
 - b) Warranty beginning and end dates
 - c) 24-hour dispatch phone number
 - d) Service request Email address.
 - e) Service personnel with cell phone numbers
 - f) Authorized service manager for scheduled repair commitments
3. Provide all services, installation, materials, and equipment necessary for the successful operation of the project DDC system for a period of one (1) year upon issuance of the project's Certificate of Substantial Completion.
4. Warranty shall cover all costs for parts, labor, associated travel, and expenses.
5. This warranty shall apply equally to both hardware and software.
6. Sequence of Operation programming issues due to misinterpretations, sequence program errors or deviations from a system's original or formally changed operation shall be corrected at no additional cost to the owner.
7. Hidden or assumed conditions that initially appear right but later found to be defective or incorrect shall be rectified to their proper state or purpose.
8. Coordinate with the Owner Representative to continuously correct all deficiencies discovered by owner during normal occupied building operation. This shall not be counted as training time.
9. Scheduled Inspections:
 - a) Two inspections shall be performed prior to warranty expiration and all work required shall be performed. Inspections shall be scheduled 6 months after Owner acceptance and one month prior to end of warranty period.
 - b) These inspections shall include:
 - Visual checks and operational tests of equipment.
 - Clean control system equipment including interior and exterior surfaces.
 - Run system software diagnostics and correct diagnosed problems.
 - Resolve any previous outstanding problems.
10. Two (2) months prior to the warranty expiration date herein, provide all program upgrades available from the manufacturer including software revisions, controller firmware revisions and security patches. At the expiration of the warranty period, all software and firmware shall be the manufacturer's latest stable release of market products.
11. An owner request for a Controls Contractor warranty service response shall be on a 24/7 basis. Provide a service request acceptance acknowledgement within one hour.
12. Non-Emergency Service shall be provided within the next two business days after receiving an acceptance notification. Furnish telephone numbers and Email address where service representatives can be reached during normal business hours. Service personnel shall be at the site the next business day after receiving a request for service.
13. Emergency Service shall be provided within two hours after receiving an acceptance notification. Furnish telephone numbers and Email address where

service representatives can be reached. Service personnel shall be at the site within 24 hours of receiving a request for service.

14. Owner will maintain a log of warranty issues. The owner log will be the master project record used to resolve open warranty items.
15. During the warranty period, the Controls Contractor shall maintain a backup of all software installed in the system. The backup shall be updated 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.
16. At the end of the warranty period, the Controls Contractor shall provide updated copies of the latest versions of all project record documentation. This includes but is not limited to final updated drawings, software documentation, and electronic media backups that include all changes that have been made to the system during the warranty period.

PART 2 : PRODUCTS

2.01 MANUFACTURERS

1. Johnson Controls by JCI Bothell Branch
2. Siemens Industry Building Technologies by Siemens Issaquah Branch
3. Alerton by ATS Automation

2.02 SYSTEM DESCRIPTION

1. Provide a complete control system, consisting primarily of electronic direct digital control device
2. System consists of modular and distributed microprocessor based control and monitoring units connected together by communications trunks that are capable of global data sharing and communication between controllers.
3. System architecture distributed and not rely on central processing unit (CPU) for sharing point data between controllers, or for control functions requiring data from other controllers.
4. Multipurpose controller(s) consisting of CPU, system program, memory, power supply, and input/output drivers which communicated with terminal equipment controllers through a communications network.
5. Provide graphical operator's interface at existing UW DDC server. Provide local interface if required per project.
6. Provide equipment, installation, wiring, and accessories as required but not necessarily specified to accomplish operations as described.
7. The DDC shall be designed in accordance with ASHRAE's BACnet standard, 135-2020 or newer, to provide interoperability between different building subsystems.
8. All physical controller components of the Building Automation System shall be listed in conformance with the BACnet Testing Laboratories (BTL) established testing standards, as described for each component in this specification. DDC controllers which are not BTL listed are not acceptable.

9. Contractor shall provide manufacturer's Protocol Implementation Conformance Statement (PICS) for every controller model installed under this contract.
10. BACnet over ARCNET shall not be accepted.
11. No BACnet gateways shall be used for communication to Building Automation System controllers furnished under this section, unless approved by UW -BIT/OT team and/or Owner in writing.
12. All products of the Building Automation System shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products shall be provided. Systems or products not currently offering the following approvals are not acceptable.
 - a) UL-916; Energy Management Systems
 - b) UL-873; Temperature Indication and Regulating Equipment UL-864; Subcategories UUKL, QVAX, UDTZ; Fire and Smoke Control Systems
 - c) UL-864; Subcategories UUKL, QVAX, UDTZ; Fire and Smoke Control Systems where used for smoke control applications as described in this document and/or indicated on the drawings if applicable.
 - d) FCC; Part 15, Subpart J, Class A Computing Devices
13. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National Codes.

2.03 SYSTEM PERFORMANCE REQUIREMENTS

1. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a) Flame-Spread Index: 25 or less.
 - b) Smoke-Developed Index: 50 or less.
2. Building Automation System Speed: Response Time of Connected I/O from the field level:
 - a) AI point values connected to DDC shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
 - b) BI point values connected to DDC shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
 - c) AO points connected to DDC shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
 - d) BO point values connected to DDC shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
3. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision, shall be provided with the specified point name, and shall all have the specified engineering units associated with the points:
 - a) Current:
 - Milliamperes: Nearest 1/100th of a milliampere.
 - Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

- b) Electric Power:
 - Rate (Watts): Nearest 1/10th of a watt through 1000 W.
 - Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
 - Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
- c) Thermal, Rate:
 - Heating: For Btu/h, nearest 1 Btu/h between 0 to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh.
 - Cooling: For tons, nearest ton up to 1000 tons.
- d) Thermal, Usage:
 - Heating: For Btu, nearest 1 Btu between 0 to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu.
 - Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours.
- e) Flow:
 - Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
 - Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm.
- f) Gas:
 - Carbon Dioxide (ppm): Nearest ppm.
- g) Moisture (Relative Humidity):
 - Relative Humidity (Percentage): Nearest 1 percent.
- h) Speed:
 - Rotation (rpm): Nearest 1 rpm.
 - Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
- i) Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
- j) Pressure:
- k) Air, Ducts and Equipment: Nearest 1/10th in. w.c.
 - ii. Water: Nearest 1/10 psig through 100 psig; nearest psig above 100 psig.
- l) Temperature:
 - Air, Ducts and Equipment: Nearest 1/10th of a degree.
 - Outdoor: Nearest degree.
 - Space: Nearest 1/10th of a degree.
 - Chilled Water: Nearest 1/10th of a degree.
 - Heating Hot Water: Nearest degree.
- m) Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

4. Environmental Conditions for Controllers, Gateways, and Routers:
 - a) Products shall operate without performance degradation under at a minimum between the following conditions:
 - 1.6-48.8°C (35°F – 120°F)
 - 10-95% RH
 - b) Instrumentation and control elements rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installation.
 - c) Install control devices in an enclosure suitable for the installed environment.
 - d) If product alone cannot properly operate in the final installed location, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
 - e) Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - Outdoors, Protected: Type 3.
 - Outdoors, Unprotected: Type 4X.
 - Indoors, Heated with Filtered Ventilation: Type 1.
 - Indoors, Heated with Non-Filtered Ventilation: Type 2.
 - Indoors, Heated and Air Conditioned: Type 1.
 - Localized Areas Exposed to Washdown: Type 4X.
 - Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
 - Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
5. Environmental Conditions for Instruments and Actuators:
 - a) Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - b) Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - Outdoors, Protected: Type 3.
 - Outdoors, Unprotected: Type 4X.
 - Indoors, Heated with Filtered Ventilation: Type 1.
 - Indoors, Heated with Non-Filtered Ventilation: Type 2.
 - Indoors, Heated and Air-conditioned: Type 1.
 - Localized Areas Exposed to Wash down: Type 4X.

- Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
 - Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
6. DDC System Reliability-Continuity of Operation after Electric Power Interruption:

Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.04 CONTROL CABLE AND WIRING

1. Instrument and output device wiring shall be labeled at every termination including both sides of interim splices within panels. Labels are required for wire pairs, and not for individual wires. Labels shall be installed within two inches of termination, or in the case of I/O devices around the wire jacket anywhere in the device wiring cavity within six inches of termination. Labels shall be machine printed with indelible ink on heat shrinkable plastic tubing (Brady Sleeve Wiremaker Label WMS-211-319 or equal). In no case are self-adhesive labels accepted, unless machine printed and protected with clear heat shrinkable tubing.
2. Control wiring shall be in accordance with National Electrical Code and Local Electrical Codes. Final connection points at devices and panels shall be made either at terminal blocks integral to device or at separate terminal blocks mounted inside of control panel enclosures.
3. Refer to Division 26 for specification requirements for conduits and conductors, except as noted.
4. Terminal Blocks: Terminal blocks which are not integral to other equipment shall be insulated, modular, feed-through, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or shall have enclosed sides.
5. Signal and Power Conductors (24 V and Under):
 - a) Wires smaller than #18 AWG shall not be used, except for manufacturer supplied instrument specific wire, or where otherwise specified. Use 2-wire stranded twisted/shielded pair 24 VDC for analog and discrete input and 24 VAC/VDC output devices. For 3-lead RTD signal wiring, use #18
 - b) AWG stranded, tinned copper twisted/shielded 3-conductor. Provide isolated instrument grounding system as per manufacturer's recommendations.
 - c) Conductors not concealed in raceway shall have UL Listed plenum rated Teflon insulation.
 - d) Provide 250/500-ohm, 5 watt, 0.1% tolerance dropping resistors in 0 - 20 mA circuits as required to generate 0 to 10 volt signals in 24 VDC powered instrument loops.

- e) Stranded twisted/shielded control conductors are required with shields to be terminated within controller or per the manufacturers installation instructions to reduce effects of noise from VFD. Follow VFD manufacturer's installation instructions for wiring control conductors to VFD.
- 6. Ethernet Communication Cable (Division 27):
 - Cable not concealed in raceway shall have UL Listed plenum rated insulation.
 - Interior LAN Horizontal Communication Cable:
 - a) Refer to DIV 27 17 52 "COPPER & FIBER OPTIC COMMUNICATION CABLE" design specifications documents for cabling type requirements: <https://it.uw.edu/wp-content/uploads/2025/03/27-17-52-COPPER-A-ND-FIBER-OPTIC-COMMUNICATIONS-CABLE-PLANT-20250310-CIF.pdf>
 - b) Horizontal copper LAN cabling shall not exceed 295 ft.
 - c) Provide minimum of 10' of slack at electrical room and 12" of slack at outlet.
- 7. Controls cabling:

Service	Control Wiring Type
Backbone, any peer-to-peer, Incoming Service	EMT
Exposed in labs, offices, corridors, above baffles etc., below 8' AFF	EMT
Concealed (above drop/GWB ceilings, over 8' AFF in wall etc.)	Plenum Rated Cable*
Mechanical, Equipment Rooms, Outdoors	EMT
Loading Dock	EMT

*For all wiring within new wall construction, provide steel EMT from the wall mounted sensor/thermostat as required to reach the ceiling cavity. All plenum cable to be routed along building structure lines using bridal hooks or j-hooks. Diagonal routing and zip-tie are not acceptable.

- a) Exposed wiring in equipment rooms and inside walls (both line and low voltage) shall be routed in conduit, wire or cable trays. Installation shall be square with the walls of the buildings.
- b) Above accessible ceilings, low voltage conductors may be UL listed plenum cable. Install the cable parallel to building walls.
- c) In buildings with cable trays, plenum cable shall be run in the cable trays.
- d) Wiring in control panels shall be neat and orderly in workmanship. Label wiring with point name.
- e) Conduit run between any two interface or control panels shall be sized to provide an additional twenty-five percent of wiring capacity for future control modifications.

2.05 LOCAL CONTROL PANELS

1. Control panels shall meet the following minimum requirements:

- a) Outdoors, Protected: Type 3.
 - b) Outdoors, Unprotected: Type 4X.
 - c) Indoors, Heated with Filtered Ventilation: Type 1.
 - d) Indoors, Heated with Non-Filtered Ventilation: Type 2.
 - e) Indoors, Heated and Air Conditioned: Type 1.
 - f) Localized Areas Exposed to Washdown: Type 4X.
 - g) Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
 - h) Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
 - i) Other Locations: Control panels in other locations, including but not limited to occupied spaces, above ceilings, and plenum returns shall comply with NEMA 1 requirement.
2. Local control panels shall be constructed of steel or extruded aluminum with hinged door and keyed lock, with baked enamel finish of manufacturer's standard color and removable sub-panel.
 3. Provide panels of adequate size to accommodate instruments for future expansion of approximately 10% beyond space required for this scope of work.
 4. Confirm UPS panel requirements with the UW-BIT/OT.

2.06 DDC SYSTEM CONTROLLER

1. System Controllers shall be typically utilized for the following applications. Anything with a home-run IP trunk (not string or ring) will be considered a system controller.
 - a) Air Handling Unit
 - b) Lab Exhaust Fans
 - c) Plenum Exhaust Fan
 - d) Building Chilled/Heating Hot Water Systems
 - e) Miscellaneous controlled loads as defined by the plans and specifications.
2. Provide approved I/O controller with remote input output modules to adequately cover all objects listed in the plans and specifications. Any remote I/O shall reside in same control enclosure. This controller to be installed in the same panel or adjacent to the main system controller panel.
3. Advanced programming ability shall include but not be limited to PID loops, time delay, schedules, real-time clock, stage sequencing, logical gates, mathematical and comparator functions, psychometric functions, and persistent values.
4. Programming of System Controller shall be completely modifiable in the field over installed LANs or remotely using the site IP network.
5. Inputs shall be software configurable for contact closure, resistance, 0-10VDC and 4-20 mA.
6. Outputs shall include, relay (0-10 VDC), analog 0-10 VDC or 4-20 mA.
7. All controllers shall interface to Building Supervisor using BACnet IP protocol.
8. No auxiliary or non-BACnet controllers shall be used.
9. All Programs, points, setpoints, and parameters as well as panel setup, point definitions and sequencing diagrams shall be backed up and stored in non-volatile EEPROM memory.

10. Install all systems controllers (AHU's and all HHW/CHW systems) with spare hardware capacity for future additions of at least 4 of each type of point and 25% spare memory capacity for future connection.
11. Onboard or Modular hardware and connections:
 - a) Primary Network communication module, if needed for primary network communications.
 - b) Secondary Network communication module, if needed for secondary network communications.
 - c) RJ45 port 10/100Mbaud
 - d) RS485 ports for sub-networks and point expansion.
 - e) USB Port
12. The operator shall have the ability to manually override automatic or centrally executed commands at the primary control panels via local, point discrete, on-board hand/off/auto operator override switches. If on board switches are not available, provide separate control panels with HOA switches. Mount panel adjacent to primary control panel. Provide hand/off/auto switch for each digital output, including spares.
13. Power loss: In the event of the loss of power, there shall be an orderly shutdown of all Building System Controllers to prevent the loss of database or operating system software. 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 30 days.
14. System Level Controllers shall have the capability to serve as a gateway between Modbus sub-networks and BACnet objects. Provide software, drives and programming.
15. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587 1980.
16. Spare Capacity: Provide enough inputs and outputs to handle the equipment shown to be "future" on drawings and 10% more of each point type. Provide all hardware modules, software modules, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

2.07 DDC ZONE CONTROLLER

1. Zone Controller units shall be typically utilized for the following applications:
 - a) VAV Terminal Units
 - b) Fan Coil Units (certain Fan Coil Unit applications may be better served with system controller)
 - c) Miscellaneous points.
 - d) Constant Air volume (CAV)
 - e) Hot water and electric reheat Coils (RH)
 - f) Heat Pumps
 - g) Fan Powered Boxes (FPB)
 - h) Unit Conditioners
 - i) Unit Ventilators

- j) Baseboard radiator
- k) Chilled/heated ceiling panels/ beams/ sails
- l) DX cooling and chilled water coils
- m) Airflow Tracking Supply and Exhaust (single controller)
- 2. Advanced customizable programming shall include PID loops, time delay, schedules, real-time clock, stage sequencing, logical gates, mathematical and comparator functions, psychometric functions, and persistent values.
- 3. Inputs shall be software configurable for contact closure, resistance, 0-10VDC and 4-20 mA.
- 4. Outputs shall include relay (0-10 VDC), analog 0-10 VDC or 4-20 mA.
- 5. The Zone Controller shall be BACnet BTL listed as an Application Specific Controller, and Free Programmable Controller.
- 6. For VAV applications a differential pressure sensor shall be provided integral to the controller for airflow measurement applications.
- 7. Mount zone controller units outside of equipment and accessible for maintenance.
- 8. Zone controllers shall provide sufficient internal memory for the specified control sequences and have at least 25 percent of the memory available for future use.
- 9. Provide weather protection where required for control devices located outdoors. Include provisions for supplemental ventilation when control devices must be located within outdoor control panels.
- 10. All Programs, points, setpoints, and parameters shall be backed up shall be stored in nonvolatile memory.
- 11. The ability to access parameters and program remotely.
- 12. Each controller shall provide at least two Ethernet ports with active switch allowing the controllers to be wired in a daisy-chain or string configuration of up to 20 controllers per chain, utilizing standard Ethernet cables of up to 300ft in length between each controller.
- 13. The Zone controllers shall be able to support BACnet/IP communication protocols with the following configurations:
 - Supporting IPv4 addressing
 - Supporting Static IP setting
- 14. Each UAC shall support fail-safe or fail-through technology so that if a controller in the string fails or loses power, subsequent devices are still connected to the network.

2.08 DDC THIRD PARTY CONTROLLER INTEGRATIONS

- 1. Final points list for third party integrated devices is the responsibility of the Controls Contractor and should be included in DDC submittal package for coordination and review by owner. It is the control contractor responsibility to lead the coordination with the third party controllers.
 - a) Coordination of Initial Points List
 - b) Startup coordination
 - c) Finalization of Control Points.

2.09 BUILDING NETWORK COMMUNICATION

2. BACnet IP and MSTP protocols are the required protocols of the network between the optimization server and system or zone controllers. BACnet/SC protocol is not permitted.
3. Controllers must allow for the exposure of all data points as readable and writable BACnet objects. All AI, AV, AO, BI, BV, BO, MV, schedule objects, or other data point relevant to configuration or operation of the controller must be made available. Controllers that do not comply are prohibited. All points must be named per the contract documents, and have the proper engineering units assigned.
4. The network shall never be used for any direct loop control except as indicated specifically by the sequence of operation. Any field device for that system shall be wired directly to the controller hosting the program and providing the control function.
5. UW-IT will coordinate CAT6 cabling from IT closet to "FacNet data wall jack" and the DDC contractor is responsible for wiring between "FacNet data wall jack" and their controller as well as their own network backbone. Reference UW-IT design guide here:

https://uwconnect.uw.edu/it?id=kb_article_view&sysparm_article=KB0034227.

6. There will be a biscuit jack installed for the Controls Contractor to connect to. This will be housed inside a locked Milbank box, with specifications provided in the UW-IT Div 27 17 51 section 2.10 E.1 design specification document:
<https://facilities.uw.edu/projects/business-opportunities/boilerplate-specs>
7. The Controls Contractor shall coordinate with the UW-BIT/OT department for all network configuration and setup requirements during the shop drawing phase of the project.
8. Submit DDC outlet schedule early building services (EBS) matrix tab to request IP addresses. All BACnet device instance numbers (Coordinate #'s & naming with UW) and network numbers and *UDP port number (47808)* shall be coordinated with the UW Facilities OT team to ensure alignment with owner's network provisioning and Enterprise DDC standards.
9. Controls Contractor shall be responsible for providing and installing all cable and networking components for a complete, functional building automation system. The building automation system network (DDC Network) shall be a complete system capable of stand-alone operation if the connection to UW-IT network is not present. The DDC Network shall be connected and integrated with UW-IT network at designated connection points coordinated with UW-IT. All networking components and addressing shall be compatible with UW-IT networks and coordinated in advance with UW-IT staff.
10. Controls Contractor shall install all DDC Network Components in accordance with UW Specifications Communications Cable Plant Section 27 17 52. Note to DDC contractor these specific sections of the UW Cable Plant Section 27 17 52 concerning the following must be complied with:
 - a) Subcontractor Qualifications for the party responsible for the DDC Network Installation.
 - b) All field terminated cable shall be tested post installation and the test reports provided to UW.
 - c) Station Outlets refer to DDC Network Equipment connection points that exist outside of MDF/IDFs.

- d) Station Outlets will be located within DDC Equipment enclosures or Milbank boxes as detailed in the specifications.
 - e) All DDC Network cables shall be Labeled. All labeling will be coordinated with and approved by UW-IT.
11. All network switches shall be industrial grade DIN rail mounted and 24VDC powered. Network switches shall be unmanaged and with the following requirements:
- a) Input Voltage:
 - Nominal: 12-48V DC
 - Supported Range: 9-60V DC
 - Reverse polarity protection required
 - b) Ethernet Ports:
 - Auto-Negotiation, Auto MDI/MDIX
 - IEEE 802.3, 802.3u, 802.3ab compliance
 - c) Forwarding Rate:
 - 1Gbps line-speed forwarding
 - Packet buffer: Minimum 512 KB
 - d) MAC Address Table:
 - Minimum 8K MAC addresses
 - e) Jumbo Frame Support:
 - Up to 9,216 bytes
 - f) Environmental Requirements
 - Standard: -10°C to 60°C
 - Extended Industrial: -40°C to 75°C
 - g) Operating Temperature:
 - Standard: -10°C to 60°C
 - Extended Industrial: -40°C to 75°C
 - h) Storage Temperature:
 - 40°C to 85°C
 - Humidity: 5% to 95% non-condensing
 - i) Ingress Protection (IP) Rating:
 - Minimum IP30 (protected against solid objects)
 - IP40 or IP50 preferred for dusty environments
 - j) Certifications:
 - Safety UL62368-1
 - EMC CE, FCC, BSMI
 - EMI FCC Part 15 Subpart B Class A
 - EMS
 - EN 61000-4-2 ESD (Level 4)
 - EN 61000-4-3 (Level 3)
 - EN 61000-4-4 EFT (Level 4)
 - EN 61000-4-5 Surge (Level 4, LAN Surge ±6KV)
 - EN 61000-4-6 (Level 3)
 - EN 61000-4-8 (Level 3)
 - Shock IEC 60068-2-27

- Freefall IEC 60068-2-32
- Vibration IEC 60068-2-6
- k) Approved Manufacturers:
 - Moxa EDS-2000 Series
 - Hirschmann SPIDER III Series
 - Phoenix Contact FL SWITCH 1000 Series
 - Advantech EKI-2700 G Series

2.10 THIRD-PARTY INTERFACES

1. The DDC Contractor shall integrate real-time data from systems supplied by other trades as required by project design drawings & specifications.
2. DDC/BAS contract is required to perform final coordination of interface protocols, and wiring with the equipment vendors. DDC contractor to coordinate device instance numbers with UW and ensure that duplications are avoided.
3. The DDC shall include necessary hardware equipment and software with sufficient storage to allow data communication and trending between the DDC and 3rd party systems.
4. The trade contractor supplying other systems will provide their necessary hardware and software and will cooperate fully with the DDC Contractor in a timely manner and at their own cost to ensure reliable communications and complete data integration as required in this document.
5. The DDC Contractor shall provide all necessary coordination with vendors, contractors, owners, engineers, and other representatives at no additional cost to the Owner. Provide a completed fully functional, operational, integrated and seamless communicating infrastructure system.
6. BACnet MSTP shall only be used after explicit approval by the owner and only if there is no BACNet IP option available. Specific configuration is required of MSTP networks, refer to owner's Enterprise DDC standards for more information.

2.11 POWER FAIL/AUTO RESTART

1. Provide for the automatic, orderly and predefined shutdown of parts or all of the DDC System following total loss of power to parts or all of the DDC System.
2. Provide for the orderly and predefined scheduling of controlled return to normal, automatically time scheduled, operation of controlled equipment as a result of the auto restart processes.
3. Maintain the DDC System real-time clock operation during periods of power outage for a minimum of 72 hours.

2.12 DOWNLOADING AND UPLOADING

1. Provide all DDC manufacturer software tools necessary to generate Building Automation System software-based sequences, database items and associated operational definition information and user-required revisions to same on designated Operator Workstations and the means to download same to the associated Application Nodes.
2. Provide the capability to upload Building Automation System operating software information, database items, sequences and alarms to the designated Operator Workstations with automatic archiving of same on the Operator Workstations. The

functions of this Part shall be governed by the codes, approvals and regulations applying to each individual Building Automation System application.

3. The entire control system shall be approved and listed by UL 916 - Energy Management.
4. Any uploads/downloads are coordinated with the UW with advanced notice to ensure that building operations & maintenance activities are not impacted. The upload/download must only affect the controller being modified.

2.13 CHANGE OF VALUE CONFIGURATION STANDARD

For all local controllers, the controls contractor shall implement the following properties:

1. BACnet IP & BACnet MS/TP 115k baud rate
 - a) If COV increments are utilized, the DDC Contractor will coordinate COV increment intervals with UW. The default "COV Increment" (hardware and software points) shall be as following:
 - Temperature: 0.1 °F
 - Humidity: 1 %RH
 - Pressure values: 0.01 in/w.c.
 - Flow values: 5 (cfm/gpm)
 - Enthalpy values: 0.1 btu/lb
 - General percentage (speeds/commands/positions): 1%
 - Boolean, enumerated, strings: N/A
 - b) COV minimum send time (all points): 5 seconds.
 - c) COV maximum send time (all points): 300 seconds.
 - d) Broadcast mode: none
2. BACnet MS/TP: 76.8k & 38.4k baud rate

If COV increments are utilized, the DDC Contractor will coordinate COV increment intervals with UW. The default "COV Increment" (hardware and software points) shall be as following:

- a) Temperature: 0.2 °F
- b) Humidity: 2 %RH
- c) Pressure values: 0.05 in/w.c.
- d) Flow values: 10 (cfm/gpm)
- e) Enthalpy values: 0.5 btu/lb
- f) General percentage (speeds/commands/positions): 2%
- g) Boolean, enumerated, strings: N/A
- h) COV minimum send time (all points): 10 seconds.
- i) COV maximum send time (all points): 300 seconds.
- j) Broadcast mode: none
- k) BACnet msMS/tpTP 19.2k & 9.6k: Do not use

PART 3 – EXECUTION

3.01 GENERAL

1. Install control equipment and wiring in neat and workmanlike manner.
2. Coordinate timely delivery of materials and coordinate activities of other trade contractors to install devices such as immersion wells, pressure tappings, any associated shut-off valves, flow switches, level switches, flow meters, air flow stations, valves, dampers, and other such items furnished by Control Contractor, which are to be installed by Mechanical Contractor.
3. All devices must be mounted in an accessible location for calibration, repair/maintain or replace. Due to unforeseen conditions if mounting is not accessible submit a RFI to address issue.
4. All DDC associated 120 VAC power wiring (including all input and output power supplies) shall originate from clearly marked, DDC-dedicated circuit breakers. All input/output transducers shall be powered from the same circuit that supplies power to the associated DDC controller. All DDC equipment shall be fused in accordance with manufacturer's recommendations.
5. DDC controllers shall be labeled with the source of electrical power including panel number, circuit breaker number, and room number where electric panel is located in accordance with the electrical labeling specification by the Controls Contractor.
6. All sensor and actuator instrumentation shall be hard wired to the controller the program is primarily executing.
7. All instrument displays shall be readable from ground level in normal walkways for service personnel.
8. Control panels shall include a laminated wiring diagram with sequence of operation permanently affixed to the inside of the common keyed panel door.
9. Ensure proper labeling of all I/O and communication cabling.
10. Devices containing mercury are not allowed.
11. Coordinate mounting height and location of control devices so that NEC workspace clearances are maintained.
12. For retrofit projects with existing Ethernet network, the UW Facilities OT team must perform network packet capture and produce Optigo Network Performance/Health report/score prior to project start time. After project initiation by the Controls Contractor, the Optigo Network Health score must not be negatively impacted by more than 15% or have any critical issues. If the Optigo Network Health score drops more than 15% or discover any critical issues post project initiation, the Controls Contractor is responsible to identify and resolve any network issues that might cause have negatively affected the network health at no cost to the Owner.

3.02 PROJECT MANAGEMENT

Provide a designated project manager who will be responsible for the following:

1. Construct and maintain project schedule, pricing, and manpower.
2. On-site coordination with all associated trades.
3. Attend project meetings to avoid conflicts and delays

4. Make necessary field decisions relating to this scope of work
5. Coordination/single point of contact

3.03 CONTROL WIRING

1. Provide electrical wiring required for complete functional control system.
2. Where multiple controllers reside in a single control panel, provide a separate disconnect for each controller.
3. Install control wiring in metal conduit or raceway system. Refer to Division 26 - Electrical for additional requirements.
4. All TCP, Enclosures, Sub-Panels, Junction Boxes, Pull Boxes, Troughs, Trays, Raceways, and Conduits, &c. shall not exceed 75% maximum conductor fill.
5. Each Input / Output device shall be controlled from a dedicated cable. Multi-pair conductors are not allowed. Provide shielding as required by manufacturer.
6. Label each wire termination at control panels. Label junction boxes as DDC.
7. Low voltage wiring concealed above accessible ceilings does not require raceway. Cables not in raceway shall be routed along building structure lines using Bridal Rings, J-hooks or other mounting methods as approved by Engineer. Use of wire-ties for attaching cabling to duct brackets, piping or structure is not acceptable. Diagonal routing is not allowed.
8. Terminate low voltage DC instrument signal cable with black terminated on positive terminal and white terminated on negative unless otherwise noted.
9. Install special sensor to transmitter cables in accordance with manufacturer's installation drawings or in compliance with manufacturer's instructions. Extra precautions shall be taken when pulling and shortening these "vendor furnished" cables. Any extra length on these cables shall be neatly coiled into minimum 3" diameter coils and installed into junction box.
10. All field wiring to be terminated on controller terminals or terminal strips. No wire nuts allowed inside control panels.
11. Only home-run or string network topologies should be used. Ring topology is not permitted.

3.04 LOCAL CONTROL PANELS

1. Mount panels on wall with suitable brackets or on self-supporting stand. Mount top of panels no higher than 6 ft above floor. Install panels so front cover door can swing fully open without interference.
2. Label local control panels with respective unique ID numbers in accordance with the submitted panel schedules and controls As-Built documentation.
3. All control panels located in accessible areas be provided with keyed locks. Locks shall utilize a single master key. Provide 2 spare key sets to Owner.
4. All control panels shall be mounted in accordance with NEC requirements, at or near eye level, with clear clearance to open door and access interior.
5. A minimum 8 foot (from floor) stub out of EMT conduit must be installed from panel gutter to above ceiling line for open wire installations. Open wire leaving conduit, Conduit shall be grommited and wire will be tie wrapped neatly and routed parallel to building lines, concealed whenever possible above piping or ductwork.

6. 120 vac power will be supplied from a dedicated 3-wire circuit unless specified otherwise.
7. 120 vac power is NOT to be terminated on 'open' terminal strips. Transformer leads may be buttspliced to lengthen the lead so it can be terminated on a 'closed' (fully insulated) terminal strip.
8. All transformers, transducers, and/or interface devices shall be mounted within a screw cover, hinged cover panel enclosure, mounted adjacent to controller served. Single transformers feeding a designated panel may be mounted in the lower left corner of the panel served provided that all exposed terminals are covered and/or wire leads are terminated to a terminal strip.
9. Where applicable, forked crimped connectors shall be installed on end devices with screw terminal such as relay bases and terminal strips.
10. Panel Layout:
 - a) Controls Contractor may provide their recommended panel layout for owner/EOR approval as replacement for the below panel layout requirements.
 - b) Locate controllers in lower half of panel first and upper half second.
 - c) Subcontractor shall locate and wire a 20amp, 120 VAC receptacle in the lower left hand corner of each panel.
 - d) Locate terminal strips either horizontally in upper half of back panel or vertically. Do not locate terminal strips below 2'-0" or above 6' above finished floor.
 - e) Separate 24 VDC and 120 VAC, wire, cable, and devices by 6" minimum space.
 - f) Enclose wire and cable in wireways or bundle w/ wire ties and secure to back-panel. This does not apply to wire exiting wireways to terminal strips or panel mounted devices.
 - g) Space controllers according to manufacturer's requirements with 3" minimum between controllers and other devices on panel and 6" between controller front and door mounted devices. Ensure adequate space is allowed for device heat dissipation.
11. Do not place controller on enclosure sides.
12. Install control valve per manufacturers instructions. Ensure serviceability is maintained.
13. Actuators with indicators are to be mounted in a way that allows the indicator to be viewable.
14. Unless otherwise noted, install wall mounted sensors, thermostats and humidistats at 5'-0" above the finished floor measured to the centerline of the instrument. Submit device locations, mounting heights and details for approval.
15. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.
16. Corrosive Environments:
 - a) Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:
 - b) Process exhaust-air streams.
 - c) When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

- d) Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.05 POWER SUPPLIES AND LINE FILTERING

Power Supplies:

1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
2. Limit connected loads to 80 percent of rated capacity.
3. Match DC power supply to current output and voltage requirements.
4. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
5. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
6. Operational Ambient Conditions: 32 to 120 degrees F.
7. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD-810 for shock and vibration.
8. Line voltage units UL recognized and CSA approved.

3.06 LOCAL AREA NETWORK (LAN)

The system shall be a distributed programmable controller network using the latest protocols and local area network (LAN) standards as defined by ANSI/ASHRAE Standard 135-2016 BACnet for Building Automation and Control Systems. Control Contractor shall provide all hardware and software necessary to add, modify and delete system objects; add or change application programs; create or modify time schedules; and setup trend logs.

3.07 DDC SYSTEM I/O CHECKOUT PROCEDURES

1. Check installed products before continuity tests, leak tests and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.
5. For pneumatic products, verify that air supply for each product is properly installed.
6. Control Damper Checkout:
 - a) For pneumatic dampers, verify that pressure gages are provided in each air line to damper actuator and positioner.
 - b) Verify that control dampers are installed correctly for flow direction.
 - c) Verify that proper blade alignment, either parallel or opposed, has been provided.
 - d) Verify that damper frame attachment is properly secured and sealed.

- e) Verify that damper actuator and linkage attachment is secure.
 - f) Verify that actuator wiring is complete, enclosed and connected to correct power source.
 - g) Verify that damper blade travel is unobstructed.
7. Control Valve Checkout:
- a) For pneumatic valves, verify that pressure gages are provided in each air line to valve actuator and positioner.
 - b) Verify that control valves are installed correctly for flow direction.
 - c) Verify that valve body attachment is properly secured and sealed.
 - d) Verify that valve actuator and linkage attachment is secure.
 - e) Verify that actuator wiring is complete, enclosed and connected to correct power source.
 - f) Verify that valve ball, disc or plug travel is unobstructed.
 - g) After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.
8. Instrument Checkout:
- a) Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
 - b) Verify that attachment is properly secured and sealed.
 - c) Verify that conduit connections are properly secured and sealed.
 - d) Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
 - e) Inspect instrument tag against approved submittal.
 - f) For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
 - g) For flow instruments, verify that recommended upstream and downstream distances have been maintained.
 - h) For temperature instruments:
 - Verify sensing element type and proper material.
 - Verify length and insertion.
9. The Controls Contractor shall coordinate with the Cx agent and provide a step-by-step procedural checklist to confirm the individual controller's sequence of operation is operating properly. If the single controller is part of an additional large system strategy, a procedural checklist shall be provided for the higher-level strategy to confirm total sequence operation. The following shall be confirmed at a minimum:
- a) Start/Stop in automatic, manual, failure and restart mode.
 - b) All software ramps, time delays, etc. have been checked out for response times and stable operation.
 - c) All control loops have been checked for correct setpoints, loop tuning and stable operation.
 - d) Normal and Failure mode of operation confirmation. All failure modes should be detailed to confirm recovery from failure occurs without user intervention. If any manual intervention is required, it should be per the sequence only.
 - e) All controllers/systems that have any interaction with Fire Alarm shall have a detailed strategy for testing and confirmation of operation.

- f) All sequences shall be confirmed in both normal and emergency power (if applicable).
- g) Documentation of loop tuning shall be provided with final tuning parameters. The DDC Contractor shall make sure that all cooling system loop tuning is done during mid-summer months and heating system loop tuning is done during mid-winter months with the temperature as close to the cooling and heating design day conditions as possible. This shall be confirmed with trend data submitted as indicated in the Submittal section of this specification under "System Acceptance Trend Data". This includes the potential for the DDC Contractor to coordinate coming back after Occupancy to complete system operation properly. THIS IS MANDATORY.

3.08 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

Refer to the Input-Output control devices specification for adjustment, calibration, and testing procedures.

3.09 SYSTEM STARTUP

- 1. Controls Contractor shall conduct comprehensive startup and checkout of DDC-provided devices.
- 2. The graphics must be 100% ready at the time of the controller/system becoming online on the network.
- 3. Third party commissioning or functional testing shall not be used for the purposes of startup and checkout.
- 4. Controls Contractor to provide at a minimum the following startup task and associated documentation:
 - a) Point to point checkout of all devices connected to a DDC controller. Including but not limited to sensors, actuators, relays. and integrations. These points shall be verified through the graphic.
 - b) Verify proper scaling of control I/O signals between controller and devices.
 - c) Verify all controlled devices/equipment operate per the submitted sequence of operation.
- 5. All controls loops shall be tuned, prior to the start of functional testing with the commissioning agent, to deliver responsive & stable setpoint control within the minimum tolerances as follows:
 - a) Temperature. Obtain stable control of +/- 0.5°F of setpoint within 5 minutes of startup & within 1 minute of setpoint adjustment.
 - b) Differential Pressure. Obtain stable control of +/- 0.5psi of setpoint within 5 minutes of startup & within 1 minute of setpoint adjustment.
 - c) Duct Static Pressure. Obtain stable control of +/- 0.25" w.c. of setpoint within 5 minutes of startup & within 1 minute of setpoint adjustment.
 - d) Water Flow Control. Obtain stable control of +/- 5% or 10gpm of setpoint (whichever is larger) within 5 minutes of startup & within 1 minute of setpoint adjustment.
 - e) Airflow Control. Obtain stable control of +/- 5% or 25cfm of setpoint (whichever is larger) within 5 minutes of startup & within 1 minute of setpoint adjustment.

- f) Other. Obtain stable control of +/- 5% of setpoint within 5 minutes of startup & within 1 minute of setpoint adjustment.

3.10 FUNCTIONAL SEQUENCES OF OPERATION

1. Approved sequences of operation that prove non-functional, non-code compliant or unsafe under a specific mode of operation, shall have an RFI, to assure the design intent sequence at no expense to the Owner.
2. Any deviation due to safety concerns, improved system stability, or improved performance shall be documented and turned over to the MEOR and Commissioning agent within 7 days of implementation.
3. Testing will include network communications loss to ensure stand-alone operations of zone controllers independent of the network connection.

3.11 COMPONENT IDENTIFICATION

1. The controls vendor shall label each system device with a point address or other clearly identifiable notation inside the device cover. Labels shall be permanent, and method of labeling shall be approved by the owner.
2. All control equipment shall be clearly identified by control shop drawing designation as follows:
 - a) Control valves and damper actuators: brass tags or engraved phenolic ("Bakelite") tags.
 - b) Other Remote Control Devices: Metal tags or laser printed, adhesive backed, metalized polyester film labels.
 - c) Control Enclosures and Panels: Engraved nameplate with panel number and system served.
3. Duct static-pressure sensors and piping differential-pressure sensors locations shall be:
 - a) indicated on the Installation Mark-up Drawings (kept on-site) for transfer of this information onto the As-Builts; and
 - b) identified on the DDC Floor Plan online graphic; and
 - c) identified in the building using a label on the nearest ceiling grid, or access-panel where concealed.
4. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 26 0553 "Identification for Electrical Systems" for identification products and installation.
5. Where product is installed above accessible tile ceiling, also install matching engraved phenolic nameplate with identification on face of ceiling grid located directly below.
6. Where product is installed above an inaccessible ceiling, also install engraved phenolic nameplate with identification on face of access door directly below.

3.12 HVAC CONTROL PROGRAMS

1. Support Inch-pounds and SI (metric) units of measurement.
2. Identify each HVAC Control system.
3. Optimal Run Time:
 - a) Control start-up and shutdown times of HVAC equipment for both heating and cooling.

- b) Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
- c) Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
- d) Use outside air temperature to determine early shut down with ventilation override.
- e) Analyze multiple building mass sensors to determine seasonal mode and worse case condition for each day.
- f) Operator commands:
 - Define term schedule.
 - Add/delete fan status point.
 - Add/delete outside air temperature point.
 - Add/delete mass temperature point.
 - Define heating/cooling parameters.
 - Define mass sensor heating/cooling parameters.
 - Lock/unlock program.
 - Request optimal run time control summary.
 - Request optimal run time mass temperature summary.
 - Request HVAC point summary.
 - Request HVAC saving profile summary.
- g) Control Summary:
 - HVAC Control system begin/end status.
 - Optimal run time lock/unlock control status.
 - Heating/cooling mode status.
 - Optimal run time schedule.
 - Start/Stop times.
 - Selected mass temperature point ID.
 - Optimal run time system normal start times.
 - Occupancy and vacancy times.
 - Optimal run time system heating/cooling mode parameters.
 - 8. Mass temperature summary:
 - Mass temperature point type and ID.
 - Desired and current mass temperature values.
 - Calculated warm-up/cool-down time for each mass temperature.
 - d. Heating/cooling season limits.
 - Break point temperature for cooling mode analysis
- h) HVAC point summary:
 - Control system identifier and status.
 - Point ID and status.
 - Outside air temperature point ID and status.
 - Mass temperature point ID and point.
 - Calculated optimal start and stop times.
 - Period start.

END OF DOCUMENT

APPENDIX A: REVISION HISTORY
(none)

APPENDIX B: SUGGESTED EDITS
(none)