

APPENDIX B – WCPSS PROVIDED FULL SPECIFICATION SECTIONS

2026

SECTION 01 91 13
GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning Defined:

Commissioning (Cx) is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass both MEP and Envelope Systems, and coordinate the traditionally separate functions for systems documentation, equipment startup, control system calibration, testing adjusting and balancing, performance testing, and training. Commissioning is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational and functional checkout by the installing contractors.

2. Verify and document proper functional performance of equipment and systems.

3. Verify that O&M documentation is complete.

4. Verify that the Owner's operating personnel are adequately trained.

B. Contractor Responsibilities:

1. This Section and other sections of the specification detail the Contractor's responsibilities relative to the Cx process. It expands on the Cx Plan, which covers the roles and responsibilities of Parties outside of the construction contract.

2. The Commissioning Authority (CxA) shall work with the Contractor and the Design Engineers to direct and oversee the Cx process and perform Functional Performance Testing of defined scopes of work for both Envelope and MEP systems.

1.2 RELATED WORK

A. Section 01 1100 – Summary of Work

B. Section 01 3100 – Project Management and Coordination

C. Section 01 3150 – Coordination Drawings

D. Section 01 3300 – Submittal Procedures

E. Section 01 7700 – Closeout Procedures

F. Section 01 7823 – Operation and Maintenance Data

G. Section 01 7900 – Demonstration and Training

H. Section 01 9115 – Envelope Commissioning Requirements

I. Section 21 1318 – Fire Protection Systems

J. Section 22 0800 – Plumbing Commissioning Requirements

K. Section 23 0800 – Heating, Ventilating and Air Conditioning Commissioning Requirements

L. Section 25 0800 – Integrated Automation Commissioning

M. Section 26 0800 – Electrical Commissioning Requirements

1.3 REFERENCE STANDARDS

1. ASHRAE Standard 202-2018, "The Commissioning Process for Buildings and Systems"
2. ASHRAE NIBS Guideline 3-20XX “Building Enclosure Commissioning Process BECx”
3. AAMA 501.2 “Field Check of Metal Storefronts, Curtain Walls and Sloped Glazing Systems For Water Leakage.”
4. ASTM E783 “Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors”
5. ASTM E1105 “Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference”
6. ASTM E1186 “Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems”
7. ASTM C1153 Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging and Capacitance.
8. ASHRAE Guideline 4-2019, “Preparation of operating and Maintenance Documentation for Building Systems”
9. NEBB - Procedural Standards for Building Systems Commissioning
10. AABC – National Standards for Total System Balance
11. USGBC - LEED v4.1 for Building Design and Construction

1.4 ABBREVIATIONS AND DEFINITIONS

1. Acceptance Phase: This is the phase of the project when the facility and its systems and equipment are inspected, tested, verified, and documented; and when most of the Functional Performance Testing and final training occurs. This will generally occur after the Construction Phase is complete (after Start-Up Documentation have been completed). The Acceptance Phase begins upon System ‘Turn-Over’ with certification by the Contractor that the systems have been placed into service in accordance with the approved protocols and after the submission of the approved Start-Up Documentation. The Acceptance Phase ends with the successful completion of all Functional Performance Testing and sign-off by the CxA and Owner.

2. Action Item (AI): Any Cx-related issue that requires a response, completion, corrective or additional work, or any other action. Examples include a Request for Information (RFI), a work directive, a clarification request, a to-do item, an identified deficiency, or any other like item. Action Items must be categorized as appropriate.

3. Action List: This is a list that is maintained and updated by the CxA that includes all Action Items that relate to Cx activities.

4. A/E: General reference to the Architect/Engineer lead-design entity.

5. ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers.

6. Building Automation System (BAS): The computer-based control or automation system. BAS is used throughout these Sections. Alternate references common in the industry include facility management

system, automatic temperature control system, direct digital control system, building management system, building management and control system, digital control system, Energy Management System, Energy Management and Control System or System Control and Data Acquisition (SCADA) System.

7. Basis of Design (BOD). A document that records concepts, calculations, decisions and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. Also known as the Design Criteria.

8. Building Enclosure Commissioning (BECx)- The process of facilitating the quality installation of the building enclosure materials, components, and systems in accordance with the OPR and contract documents.

9. Building Enclosure Commissioning Authority (BECxA)- The Owners QA/Cx consultant representative retained by the Owner and CxA who will oversee and manage the Envelope Cx process, develop and stipulate many of the BECx requirements, and ensure and validate that enclosure systems are designed, installed and tested to meet the Owner's requirements.

10. Checklist Item: An item to inspect to verify proper installation of equipment or systems by the Contractor. Checklist items simply require a 'Yes/No' or 'OK/Not' response. Start-Up Checklist items are one component of the Start-Up Documentation.

11. Commissioning (Cx): The process of ensuring that all building systems perform interactively according to the design intent, that the systems are efficient and cost effective, and that they meet the Owner's operational needs.

12. Commissioning Authority (CxA): The Owners QA/Cx representative or consultant representative retained by the Owner who will oversee and manage the total Cx process, develop and stipulate many of the Cx requirements, ensure and validate that systems and equipment are designed, installed and tested to meet the Owner's requirements.

13. **Commissioning Supervisor (CxS): Member of Construction Management Team assigned to oversee and manage the Cx process; coordinate/facilitate contractor responsibilities to support the CxA scope of work.**

14. Commissioning Coordinator (CxC): This refers to the Individual within each of the various Parties that is designated the POC for that Party relative to Cx activities. Each of the Contractors subject to the Cx process should designate a CxC and make that person available to the CxA as the point-of-contact for that Contractor.

15. Commissioning Specifications: Generic reference to any of the Cx-specific specification Sections, as inferred by the usage. Divisions 01, 22, 23, 26 and others contain Sections that are specific to or reference the Cx process. All Contractor requirements relating to Cx should be conveyed within the Cx Specs. Cx Specs should be referenced but not duplicated within the Cx Plan (the Cx Plan is designed to govern non-Contractor-related Cx issues).

16. Commissioning Team: The group of Parties involved in the Cx process for any given system. The Cx Team will include a core group involved with all systems, consisting of the CxA and CxC members representing the CM and the Owner. On any given system, the Cx Team will additionally include the CxC's for the Contractors responsible for the system or equipment.

17. Cx Web Tool: is a Web-based Internet hub used to electronically collaborate and coordinate activities throughout the Cx process. The Web-based interface is hosted by the CxA and is accessible by all Parties participating in the Cx program.

18. Contractor: As used herein, 'Contractor' is a general reference to the installing Party and can therefore refer to the CM, subcontractors, or vendors as inferred by its usage.

19. Construction Manager (CM): The Party acting as the primary coordinator of all the major subcontractors (MC, EC, TAB, BAC, etc.) as applicable.

20. Controls Contractor (CC): Contractor generally responsible for the installation, start-up, checkout and testing of the BAS system.

21. Construction Phase: Phase of the project during which the facility is constructed and/or when systems and equipment are installed and started. Contractor and subcontractors complete the installation, complete Start-Up Documentation, submit O&M information, establish trends, and perform any other applicable requirements to make systems operational. Contractor and Vendors may also conduct 'Equipment and Systems Training' events during this phase. The Construction Phase concludes upon completed Start-Up and TAB of systems and equipment.

22. Contract Documents: The documents governing the responsibilities and relationships between Parties involved in the design and construction of this project including (but not necessarily limited to):
    a. Agreements/Contracts;
    b. Construction Plans and Drawings;
    c. Specifications;
    d. Addenda;
    e. Change Orders;
    f. Commissioning Plan (for reference only)
23. Construction Documents: Refers generally to the Contract Documents that dictate the details of the installation (all but item a. above).

24. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents, does not perform properly or is not complying with the design intent.

25. Design Engineer: Generic reference to the engineer-of-record or a specific engineering disciple as inferred by its usage.

26. Design Intent Document (DID): Outdated term that is synonymous with Owner's Project Requirements (see below). OPR is now used by both ASHRAE and LEED.

27. Design Phase: This is the phase of the project when the facility and its systems and equipment are developed and defined. The A/E Teams work to define the required features, functions, characteristics, qualities and/or properties of the project per the Owners Design Intent.

28. Electrical Contractor (EC): Contractor generally responsible for Division 26 work.

29. Factory-Authorized Representative: An individual fully trained on the equipment and certified by the manufacturer to perform the respective task.

30. Factory Testing: Testing of equipment off-site at the manufacturer's facility. May be witnessed by the members of the project team.

31. Fire Alarm Contractor (FAC): Contractor generally responsible for the fire alarm system installation

32. Functional Completion: A Cx program milestone that marks the successful completion of the FPTs by the CxA and therefore completion of the Acceptance Phase.

33. Functional Performance Tests/Testing (FPT): The detailed and thorough tests (and test procedure) developed and performed by the CxA to document proper operation of building systems and the

components and equipment making up those systems during the Acceptance Phase. References made to FPT throughout the documents are inclusive of ISFPT unless specifically indicated otherwise.

34. IAQ: Indoor Air Quality

35. LEED (Leadership in Energy and Environmental Design): The LEED® Green Building Rating System is a voluntary, consensus-based rating system designed to encourage building owners to apply leading proven technologies for new construction. Areas of concentration include “Sustainable Sites”, “Water Efficiency”, Energy and Atmosphere”, “Materials and Resources”, and “Indoor Environmental Quality”. Contractor activities from demolition to procurement to commissioning to waste handling can be impacted by the LEED program.

36. Manufacturer’s Representative: Either an individual in direct employ of the manufacturer of the applicable system, or an individual who is certified by that manufacturer to perform the applicable work for which the reference is made. This is synonymous with Factory-Authorized Representative.

37. Mechanical Contractor (MC): Contractor generally responsible for Division 23 work.

38. O&M Documentation: Contractor-developed documentation designed to address the needs of facilities personnel and customized for the context of the specific facility and installation. The foundation of O&M Documentation is manufacturer’s literature (O&M Manuals), with additional Contractor-developed step-by-step instructions for manual start/stop, emergency procedures, operating sequences, preventative maintenance, and other installation-specific information. O&M Documentation content is indexed/organized by equipment-type.

39. O&M Manuals: Generic reference to manufacturer-published O&M materials, which have no information specific to the facility, but may be edited or marked up to indicate specific equipment or systems installed. O&M Manuals include documents covering installation, operation, maintenance, troubleshooting guides, parts numbers, engineering and design parameters, applications manuals, and any/all information available from the manufacturer pertaining to the installed equipment or systems. Specifications should strive for this information to be submitted in electronic form whenever possible. The electronic versions of these documents can also be electronically edited to indicate equipment installed and to delete or mask-over equipment and content that is not installed on the project.

40. Opposite Season: The season opposite that when the majority of the testing occurs.

41. Owner’s Project Requirements (OPR): The OPR is intended to provide the basis from which all design, construction, acceptance, and operational decisions are made. It details the functional requirements of the project, including systems subject to commissioning. The OPR defines the benchmarks and metrics by which the success of the project is ultimately judged, and evolves through each project Phase. The OPR is typically developed early in the project cycle by the Owner and the A/E and provides the user needs, requirements, goals, and metrics that are defined by the Owner to be important. The OPR criteria are referenced by and should be the foundation of the BoD narrative.

42. Party: Entity (company, corporation, etc.) legally responsible for portion of work.

43. Point-of-Contact (POC): General reference to a key individual within each Party.

44. Prefunctional: The term “Prefunctional” is synonymous with “Start-Up”, but not used in these specifications. It is a modifier for checks, tests, and other activities that occur prior to and are prerequisites for Functional Performance Testing.

45. Project Phases: Phases of the project include the Construction Phase, Acceptance Phase, Warranty Phase, and Occupancy. Earlier Phases include Program Phase and Design Phase.

46. Project Officer (PO): Individual or entity directly employed by the Owner who is in charge of the design and construction coordination for the project. Alternately, the Owner may employ a separate DM to perform this function.

47. Quality Assurance Project Manager (QAPM): The Owners QA/QC Project Representative who will retain and manage the Cx Consultant third-party Agency (as applicable), oversee and manage the application of the ASHRAE Guideline 202 Commissioning Process, ensure and validate systems and equipment are designed, installed and tested to meet the Owner's Project Requirements.

48. RFI: Request for Information.

49. Room Data Sheet: The Room Data Sheet is a spreadsheet or database which lists the control and occupancy requirements - including the temperature and humidity setpoints, pressurization, etc. - for each room or control zone in the facility. This list also includes the control range tolerances and the alarm ranges for the zone. Additionally, the Room Data Sheet may include occupancy schedules or lighting control parameters (typical for vivariums and some laboratories) which must be programmed for initial occupancy. This should be updated through the construction process to reflect any changes generated during construction.

50. Start-Up: Refers to the quality control procedures whereby the Contractor verifies the proper installation of a device or piece of equipment, executes the manufacturer's starting procedures, completes the 'Start-Up Checklist', energizes the device, verifies that it is in proper working order and ready for dynamic testing, and completes the 'Start-Up Tests'. Start-Up procedures are performed by the Contractor with or without a formal Cx process, although the documentation is more formalized when the Cx process is used.

51. Start-Up Checklist: A list of items to inspect to verify proper installation of equipment or systems by the Contractor. Checklist items simply require a 'Yes/No' or 'OK/Not' response. These include primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension checked, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). Start-Up Checklist items are one component of the Start-Up Documentation (Start-Up Tests being the other).

52. Start-Up Documentation: Refers to the combination of Start-Up Checklists + Start-Up Tests. The Contractor documents the Start-Up procedure by completing and submitting the Start-Up Documentation. Start-Up Documentation may be a combination of procedures prepared by the CxA, those included in the Contractors in-house quality assurance process, and those required by the manufacturer. Regardless of the context of the checklist or format of the form used to documents it, the reference to 'Start-Up Documentation' includes all of the stated checklists and tests.

53. Start-Up Test: This is a quality-assurance test that is required to ensure the system is ready to be placed into service. It differs from a checklist item in that it requires more than a binary (yes/no, OK/Not OK) response - an observation, measurement, or sequence of events must be documented. Start-Up Tests are one component of the Start-Up Documentation (Start-Up Checklists being the other).

54. System Turn-Over Meeting ("Turn-Over"): Turn-Over is a quality control milestone in which all Contractors responsible for completing the installation and start-up of a system or equipment, along with the PO and CM, meet to validate that the system or equipment is completed and operational per the contract documents and ready for Functional Performance Testing, and that all the Start-Up Documentation and nameplate data is complete and accurate. The CxA will in many cases participate in this. CM shall organize and lead the process in all cases.

55. Systems Matrix: A table that lists systems and equipment as individual rows (typically using the specifications sections as a guide) and columns that indicate different tasks, documentation, and work elements. The content of the cells of the matrix summarizes the requirement for system as it relates to that column. It provides and effective summary of requirements.

56. Test: A task, procedure or measurement that confirms capacity, functionality, accuracy, etc. Tests have a status of “Pass”, “Fail”, “Couldn’t Test” or “Didn’t Test”. May refer to Start-Up or Functional Performance Tests.

57. TAB: Can refer to the test, adjust, and balance process or the Testing, Adjusting, and Balancing Contractor as inferred by its usage.

58. Temporary Conditioning Plan: A plan that summarizes the logistics, procedures and protocols for taking permanent equipment and using it to maintain conditions throughout construction. All members of the Cx Team must approve the Temporary Conditioning Plan prior to placing equipment into temporary service.

59. Testing Agency: An independent agency typically retained by the Contractor to perform specialized testing of systems or equipment (most commonly electrical). The Testing Agency shall be qualified and equipped to perform the testing and shall submit appropriate qualifications.

60. Trending: Monitoring and recording a history of parameters typically using the building automation system.

61. Turn-Over: See “System Turn-Over Meeting” above.

62. Vendor: Refers to the organization that sold a system or equipment to the subcontractor. This may be a branch office of the manufacturer or a value-added reseller.

63. Warranty Period: The period defined by the construction documents where elements of the facility are under contractual warranty.

64. Warranty Phase: Includes the early occupancy of the building and can continue through the contractual Warranty Period and at least into the opposite season from when the facility systems were initially tested.

[DESIGNER NOTE: section 1.4 to be edited to fit scope of project]

1.5 EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

The following equipment and systems shall be commissioned by the commissioning team.

A. MECHANICAL SYSTEMS (AND ALL INTEGRAL EQUIPMENT CONTROLS)

1. Building automation systems, including linkages to remote monitoring and control sites
2. Laboratory control systems and pressurization
3. Lab HVAC systems
4. Chilled water system, chilled water pumps, piping, and associated equipment.
5. Heat recovery system, Glycol heat recovery system, associated pumps.
6. Humidification / Dehumidification systems
7. Heating hot water system, associated pumps, piping, and equipment
8. Preheat and Reheat water systems and associated pumps and piping
9. Heat exchanger, pumps, piping, condensate and associated equipment

10. Air Handling Units

11. Heat Recovery Units

12. Supply and Exhaust and other specialty fans

13. Fan Coil Units, Unit Heaters, and Ventilators

14. Variable Air and Constant Volume Air terminal units, both supply and exhaust

15. Ductwork

16. Utility metering systems

17. Refrigeration systems

18. Fire and smoke dampers

19. Smoke control systems – interfaces, egress pressurization

20. Domestic hot/cold water systems

21. Test, Adjust, and Balance of HVAC air and water systems

22. Test, Adjust, and Balance /verify Fume Hoods and bio-safety cabinets

B. PLUMBING SYSTEMS TO BE COMMISSIONED

1. Laboratory and Domestic water heating equipment

2. Laboratory compressed air equipment

3. Sump pumps and sump pump controls

4. Domestic cold water (piping, pressure, balance, associated contractor tests – ie: smoke test)

C. AUTOMATION SYSTEMS

1. All integral automation equipment controls, including building automation systems, laboratory control systems, and linkages to remote monitoring and control sites; to include integrated enterprise management system (EMS) and links to fire protection and alarm systems, plumbing systems, HVAC systems, electrical systems, communication system, electronic detection and alarm systems, building automation operator workstation graphics, smoke control system, and elevators.

D. ELECTRICAL SYSTEMS

1. Controls and occupancy sensors for Lighting and Day lighting Systems

2. Electrical system from the building entrance through the main switchboard, switchgear, and to the distribution panels.

3. Metering equipment

4. Motor Control Centers, Variable Speed Drives, Motor Starters, protective devices.

5. Building lighting and lighting control – Verify sequence of operations, and luminaries for proper operation, lamping and lighting levels.
6. Emergency power system including generator set, Uninterruptible Power Supply (UPS), transfer switch, fire pump controller interface, associated equipment and testing.

E. TELECOMMUNICATION SYSTEMS

1. Intercom systems

2. Security systems

3. BDA Communication System (Consultant Test Reports)

F. ENVELOPE SYSTEMS

1. Exterior Windows (Aluminum frame, Glazing, Curtainwall)

2. Building Exterior Envelope (fenestration components, interfaces to adjacent building systems)

3. Roof Systems

4. Foundation (water-proofing/damp-proofing, interfacing components)

1.6 COMMISSIONING TEAM COORDINATION

A. Members

The members of the commissioning team consist of the Commissioning Authority (CxA), the OPM, the CM firm's CxS, the MC, the EC, the TAB representative, the CC, the water treatment contractor, the fire protection contractor, and any other installing Subs or suppliers of equipment. In addition, representatives of the A/E team are also commissioning team members and are invited to observe critical procedures and attend Cx coordination meetings.

B. Management

The CxA is hired by the Owner and directs and coordinates the commissioning activities and reports to the OPM. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.

C. Commissioning Sequence

The Cx process will be categorized into Phases as indicated below and defined under the definitions section above. Different systems and/or areas may be in a different phase at any given time in the overall construction process:

1. Design Phase
2. Construction Phase
2. Acceptance Phase
3. Warranty Period

D. Scheduling

1. Prior to submission of the baseline schedule, the CM will coordinate with the CxA to specifically include the detailed tasks involved in the Cx process in the master project schedule. CxA shall consult directly with the CM to incorporate the Cx tasks in the project schedule. The process logic

and integration shall ultimately be a collaboration between CM, CxA, and subcontractors. The effort will start with CxA and CM proposing initial logic. Then subcontractors will join the discussion and work out the final details, (precedent logic and durations).

2. The Cx schedule will outline generic Cx tasks with prerequisites to each task. Contractor shall incorporate the tasks into schedule as applicable to each system. This will require a detailed track for each system and as such the scheduler must schedule and code by system as well as by area. Contractor shall collaborate with the CxA to determine impacts of project phasing as applicable. Examples of integrated tasks include:
   a) Contractor preparation of draft Start-Up Documentation;
   b) Contractor preparation of *Training Plan;*
   c) Preparation of *O&M Documentation* content
   d) Testing Agency activities – Envelope Testing, MEP Testing
   e) Electrical System Start-Up
   f) Mechanical System Start-Up (by system – ie: chilled water, hot water, air)
   g) BAS Start-Up Test and Balance (by system – ie: chilled water, hot water, air)
   h) Training Events (by system – ie: chilled water, hot water, air)
   i) Functional Performance Testing (by system – ie: chilled water, hot water, air, window)

1.7 SUBMITTALS

A. The CM shall provide the CxA a list of required equipment/system submittals to the CxA. The CxA will identify submittals to be submitted to the CxA concurrent with submission to the A/E for review.

B. All Subcontractor, through the CM, shall submit required installation, start-up, and preventive maintenance equipment data sheets to the CxA within 45 days of equipment approval by the A/E.

C. All Subcontractor, through the CM, shall submit O&M data for system and equipment being commissioned under this specification. O&M data shall be submitted within 45 days of equipment approval by the A/E, but no less than 8 weeks prior to the beginning of functional testing.

D. The CM shall submit a copy of the construction meeting minutes, updated construction schedule, RFI log, and ASI log to the CxA within seven days of each meeting or update.

1.8 COMMISSIONING COORDINATION

A. Coordination responsibilities and management protocols relative to Cx are outlined below. Contractor shall have input in the protocols and all Parties will commit to process and scheduling obligations. The CxA will document and distribute as applicable.

1. Commissioning kick-off meeting: CxA shall schedule and conduct a Cx coordination meeting near the beginning of construction. There may be two separate Coordination meetings – one for envelope Cx and one at a later date for MEP/Controls Cx. At a minimum, the following should be discussed at the meeting:
   a) The commissioning documents (specifications and Cx Plan)
   b) Requirements and sequence of commissioning
   c) Responsibilities of the project stakeholders
   d) Management protocols
   e) Required submittals
   f) Schedule

2. Submittals and Shop Drawings: A/E shall distribute these to the CxA. CxA shall edit the project's submittal log to communicate which submittals must be forwarded to CxA.

3. CxA Review Comments on Submittals/Shop Drawings: CxA will review and document comments and a copy will be made available to the A/E by the CxA. A/E shall consider and incorporate at their discretion.
4. Deficiencies Identified by the CxA: When the CxA identifies a deficiency, CxA shall make a good faith assessment of responsible parties. Those parties, as well as A/E and CM shall be notified of the perceived deficiency. This communication is FOR INFORMATION ONLY and is not a directive to any party to resolve the deficiency. Contractor may accept responsibility and resolve the deficiency voluntarily. If Contractor contests either the deficiency or responsibility for that deficiency, Contractor shall respond to that deficiency indicating disagreement. If responsibility is not agreed to via the Cx dialogue, CM shall issue a work directive or RFI via the normal contractual channels to resolve the issue.
5. Requests for Meetings: Request by the Contractor for a meeting with the CxA shall be routed through CM who will then determine the validity. Note that every attempt should be made to deal with Cx issues at regularly scheduled Cx Meetings.
6. Control Sequence Modifications: CxA shall make every attempt to thoroughly review the sequences during the submittal process and address any issues prior to the submittal approval. However, CxA and the contractor may incorporate minor changes to the sequence during testing when it is apparent that it improves the control of the equipment, but does not fundamentally change the sequence. Any and all changes must be thoroughly documented in the contract documents.
7. Scheduling Coordination: CxA shall consult directly with the CM to incorporate the Cx tasks in the project schedule. The process logic and integration shall ultimately be a collaboration between CM, CxA, and subcontractors. The effort will start with CxA and CM proposing initial logic. Then subcontractors will join the discussion and work out the final details, (precedent logic and durations).
8. Notification of Completion Milestones: Contractor shall notify CM at least two weeks prior to an anticipated Cx activity (ie: envelope inspections or testing) or milestone (such as ready for MEP/Controls Testing). CM shall then coordinate the scheduling of the activity (as applicable) between all required parties as applicable. Notification shall be via electronic communication (ie: email) with an associated Action Item distributed to interested parties.
9. Issue Log: CxA maintains a categorized deficiency/issue log which tracks the Cx-related items for corrective action. All content of the deficiency/issue log will be made available to all parties. Contractors with an assigned issue are responsible for making corrections and reporting updates and actions for each assigned item to the CxA via an agreed upon method of communication.
10. Start-Up Checklist and Test Documents: CxA will provide initial ‘generic’ Start-Up Documents to the Contractor (checklists). The Contractor shall cross check these with the manufacturer-specific start-up procedures/checklists and submit both to the CxA for review and approval. The Contractor has the option of modifying the supplied generic checklists in the delivered format, or by supplementing the checklists with their own procedures/checklists. The Contractor then executes, signs, and submits the final reviewed and approved Start-Up Documentation. The CxA will review the procedures/checklists for completeness. The Start-Up Documentation is then included in the final commissioning report documents.
11. Functional Performance Test Documents: Functional Performance Tests (FPT) are prepared and completed by the CxA. They are developed during the construction phase, typically after submittal reviews are completed. CxA forwards the FPT procedures to the CM to be subsequently distributed to the Contractors for review. Contractors review and have the option to comment on the procedures. Throughout the Cx process, CxA maintains a current record of the FPTs and their results and keeps the documentation up to date and accessible for all to review progress. CxA may distribute copies of the FPTs at the completion of any significant stage of commissioning.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment or system being tested. For example, the contractors associated with Divisions 3, 4, 5, 7, 8 relative to envelope systems shall ultimately be responsible for all envelope testing support and certain test appurtenances to support testing. The mechanical or controls contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system in Division 23. Likewise, the electrical contractor has Division 26, and Plumbing contractor has Division 22

B. Special equipment, tools, instruments, and setup software (only available from vendor/Subcontractors, specific to a system or piece of equipment) required for testing, according to these Contract Documents shall be provided by the Contractor and left on site for the CxA/BECxA and supporting subcontractor to use to support functional testing, seasonal testing, and deferred testing. The equipment, tools, instruments, and setup software will be returned to the vendor/Subcontractor after successful conclusion of the commissioning effort.

C. The controls contractor shall provide the CxA with a temporary software license to be loaded on the CxA's and/or TAB firm's computer, and any necessary network connection cables, for accessing the direct digital control system field panels for system testing. If applicable, the controls contractor shall also provide a palm device with attachments, software, and cables, to check setpoint values of terminal device controllers. The controls contractor shall provide the CxA with log-on ID and password for remote connection to direct digital control system. All of the software and misc interface appurtenances provided to the CxA will be returned at the successful conclusion of the commissioning effort.

D. All testing equipment used by the contractors shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified by the Engineer of Record in the Contract Documents. If not otherwise noted, the following minimum requirements shall apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.1°F and a resolution of +/- 0.1°F. Humidity sensors shall have a certified calibration within the past 6 months and a resolution of +/- 1%. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. Accuracy of other sensors shall be at least twice that of the instrumentation being used. All equipment shall be calibrated according to the manufacturer's recommended intervals, in addition to just after being dropped or damaged. Calibration tags shall be affixed or certificates readily available.

E. Cx WEB-BASED COMMISSIONING TOOL
   1. General: A Web-based internet hub may be used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The tool is hosted by the CxA and shall be accessible to all parties participating in the Cx program. The tool needs to provide a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative hub to facilitate, automate, and track communications between parties relating to the Cx process. The Cx web-based tool should have the capability to interface with other web-based database tools that may be used by the Construction Manager or Owner to facilitate the exchange of information.
   2. Participation: All general and major subcontractors participating in the Cx process shall participate in the use of the Cx web-based tool in support of the Cx process and file management capabilities.
   3. Requirements for Use: Options for accessing and interfacing with the Cx tool are as follows:
      a. Hardcopy - Print, Test, and File: Using this approach, Contractors simply go online to the Cx interface using a web browser, print checklists and tests as needed, fill them out in the field, and enter the results back into the Cx database when completed.

b. Electronically - online in the field: The applicable documents can be accessed and filled out live and online if the Contractor has the means to access the Internet while working in the field using a local Wi-Fi network or wireless device.
c. Optional Database Client: If the Cx interface tool is capable, the CxA can provide the Contractor with an offline software interface tool that will allow the Contractor to download electronic test database files from the interface, work on the database files in the field electronically (but offline), and later synchronize their entries with the master database.

4. Training: If requested by the Owner, the Cx Authority should include in their scope of work at least one Contractor training session given by the CxA, and shall send at least one representative to the training session.

PART 3 - EXECUTION

3.1 COMMISSIONING PROCESS

The following narrative provides an overview of the commissioning tasks during construction and the general order in which they occur.

A. Commissioning during construction begins with a scoping meeting conducted by the CxA/BECxA where the commissioning process and the draft Cx Plan is reviewed with the commissioning team members. After this meeting, the draft Cx Plan, which is initially provided prior to the scoping meeting, is then updated with the project specific communication protocols, Cx team contact information, and the preliminary commissioning schedule, which is developed during the scoping meeting.

B. Additional meetings will be conducted as needed throughout construction. These meetings will be scheduled by the OPM, CxA/BECxA and CM with necessary parties attending. The meetings will be conducted in order to plan, scope, coordinate, schedule future activities and resolve problems. In general, the commissioning meetings will be held monthly during the construction period.

C. System and Equipment documentation is submitted to the CxA/BECxA, concurrent with the normal submittals to the A/E, including detailed pre-startup checklists and startup procedures. Specific submittals requirements are detailed as referenced above, and in section 1.6 above.

D. The CxA/BECxA works with the CM and Subcontractors in developing startup plans and startup documentation formats, including providing the Subcontractors with prefunctional checklists to be completed, during the startup process. The prefunctional checklists are developed by the CxA/BECxA for the equipment listed in 1.4 above, using the A/E approved submittals.

E. In general, the checkout and performance verification proceeds from simple to complex, from component level to equipment to systems and intersystem levels with prefunctional checklists being completed before functional testing.

F. The CxA/BECxA will review shop drawings and material certifications, review reports from independent testing agencies, conduct independent on-site periodic construction observation and attend selected quality control-related and construction progress meetings.

G. The Subcontractors, under their own direction, execute and document the prefunctional checklists and perform initial check out and startup. The CxA/BECxA documents that the checklists and startup were completed by the Subcontractor, obtains copies of all of the startup and/or preliminary test documentation. This will include the CxA/BECxA witnessing selected envelope systems, and start-up of selected equipment.

H. The CxA/BECxA develops specific building envelope system and MEP/Controls equipment functional performance test procedures. The CxA/BECxA submits the proposed functional tests to the OPM, A/E and CM for their review and comment, and provides a copy of the proposed functional tests to the responsible Subcontractor who shall review the tests for feasibility, safety and equipment warranty protection.

I. O&M data is submitted to the CxA/BECxA prior to execution of functional tests. The CxA reviews the documentation for completeness. The CxA/BECxA also uses the documentation for reference during the functional testing.

J. Manufacturers will perform and document all specified Factory Testing and start-up. Copies of test reports are provided to the A/E and CxA/BECxA for review.

K. The functional test procedures are executed by the contractor, under the direction of, and documented by the CxA/BECxA.

L. Items of non-compliance in material, installation or startup are corrected at the Subcontractors expense and the system retested.

M. The CxA reviews, pre-approves and coordinates the training provided by the Subcontractors and verifies that it was satisfactorily completed.

N. Commissioning is completed before owner occupancy/use.

O. Deferred testing is conducted, as specified in these specifications.

3.2 RESPONSIBILITIES

A. Construction Manager

1. Shall verify completeness of the building envelope, perimeter and interior items, which affect the enclosure systems and proper operation and control of equipment and systems.

2. Shall schedule and coordinate participation and cooperation of all subcontractors required for the commissioning process.

3. Shall incorporate commissioning tasks into the master construction schedule.

4. Shall be responsible for providing written responses to the CxA's submittal review comments.

5. **Shall provide a Commissioning Supervisor (CxS) who will be responsible for communication between each individual contractor/subcontractor and the CxA.** This representative shall be responsible to: coordinate meetings, plan and schedule Cx activities into the project schedule, distribute Cx documentation to responsible contractors, receive written notification from contractors that Cx issues are corrected, perform corrective actions for resolution of deficiencies, and handle required submittals to the CxA.

6. Review and approve the completion of the Pre-functional Checklists, then notify the CxA that functional testing can proceed.

7. Ensure Installing Contractors or their Vendors provide all specialized tools or the use of specialized tools that may be required to check-out, start, and functionally test equipment and systems.

8. Shall meet requirements of other commissioning requirements within the Project Manual.

9. Shall schedule and coordinate participation and cooperation of all subcontractors and vendors in owner training.

B. Subcontractors/Suppliers

1. Shall be responsible for providing labor, material, equipment, etc., required within the scope of their specialty to implement and facilitate the commissioning process.

2. Shall include all special tools, riggings, software, and instruments (only available from vendor, specific to a piece of equipment or a system) required for testing systems according to these contract documents in the base bid price to the contractor, except for stand-alone data-logging equipment that may be used by the CxA.

3. Shall demonstrate the operation of the equipment and systems is per the contract documents.

4. Shall assist the CM in the development of the master schedule as relates to commissioning and milestones.

5. Shall respond in writing to written submittal review comments by the CxA.

6. Shall respond in writing as to the completion or resolution of each issue in the commissioning issue log.

7. Shall meet requirements of other commissioning requirements within the Project Manual.

C. Owner QA Representative

1. Oversees the Commissioning Process; facilitates, supports, and assists in coordinating deliverables, provides direction and resolution to Cx Team as required.

2. Coordinates the participation of facilities personnel in the commissioning process in writing.

3. Advises the CxA of any changes to the building's use or occupancy.

3.3 MEETINGS

A. Scoping Meeting: The CxA/BECxA will schedule, plan, and conduct a commissioning scoping meeting with the respective commissioning teams in attendance. Due to the timing of each Cx scope of work – ie: Envelope beginning earlier than MEP/Controls, it is recommended that two independent scoping meetings occur. The envelope BECxA will engage in construction activities earlier than other building systems. Meeting minutes will be distributed to all parties by the CxA/BECxA within 1 week after the meeting. Information gathered from this meeting will allow the CxA/BECxA to revise the Commissioning Plan to its “final” version.

B. Commissioning Meetings: Other meetings will be planned and conducted by the CxA/BECxA as construction progresses. These meetings will cover coordination, deficiency resolution, and planning issues with particular subcontractors.

3.4 START-UP, PRE-FUNCTIONAL CHECKLISTS, AND INITIAL CHECKOUT

A. The following procedures apply to all equipment and building systems to be commissioned, according to Section 1.4, Systems to be commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., envelope systems, electrical system power quality, may have very simplified Pre-functional Checklist and start-up.

B. General. Prefunctional Checklists are important to ensure that the equipment and systems are completely installed and integrated with other building components and systems, finalized and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment or assembly receives full Prefunctional checkout. No sampling strategies are used. The Prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of the equipment or subsystems of the given system.

C. Start-up and Initial Checkout Plan. The CxA shall assist the commissioning team members responsible for start-up of any equipment in developing detailed start-up plans for all equipment. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for Prefunctional checklists and start-up are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements in Sections 01 9115, 21 1318, 22 0800, 23 0800, 25 0800, 26 0800, 27 0800, 28 0800 and any other sections where test requirements are found.

1. The CxA generates generic and representative Prefunctional checklists and procedures as required in Section 01 9115, 22 0800, 23 0800 and 26 0800. These checklists will indicate required procedures to be executed as part of start-up and initial checkout of the systems and the party responsible for their execution.

2. These generic checklists and tests are provided by the CxA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each procedure and associated forms may have more than one trade responsible for its execution.

3. The subcontractor responsible for the purchase of the system components or equipment develops the full start-up plan by combining (or adding to) the CxA's checklists with the manufacturer's detailed installation or start-up or checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines/fields for recording and documenting the checking and inspections of each procedure and a summary statement with an initial block/ "completed by" associated with each procedure. The responsible party marks the applicable areas in the procedures and makes initial and date lines at each test procedure.

4. The full start-up plan could consist of something as simple as:

    a. The CxA's prefunctional checklists.

    b. The manufacturer's standard written installation procedure, or start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.

    c. The manufacturer's normally used field checkout sheets.

    d. The subcontractors internally developed startup/checkout documentation (ie: a lug torque report, a DDC point verification checklist, an envelope construction checklist)

5. The subcontractor submits the full start-up plan to the CxA for review and approval.

6. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

7. The full start-up procedures and the approval form may be provided to the CxA/CM for review and approval, depending on management protocol.

3.5 TEMPORARY CONDITIONING

A. Contractor shall be allowed to utilize permanent building equipment to provide temporary conditioning ONLY upon the approval of the A/E, Owner, and the CxA. Approval for such will only be given upon acceptance of a detailed plan provided by the individually involved subcontractors and compiled by the CM. The Temporary Conditioning Plan shall consider/address the following at a minimum:

1. Indicate that the full Start-Up protocol, including development and documentation of Start-Up Documentation as required by the specification will be performed for the temporary start-up. The Temporary Conditioning Plan shall include the Start-Up Documentation to be used, which shall be the same as those that will be used for final Start-Up.
2. Contractor shall address how equipment will be maintained in good, clean condition. Specifically address:
   a. Temporary Filtering of Air: Air filters used for construction shall be as or more effective than those specified for permanent use. Contractor shall remove construction filters and replace with new filters prior to FPT. Filters shall be maintained and replaced at the specified final pressure drop. Contractor shall install a magnehelic gauge for visual indication of pressure drop as well as setting and adjusting the loaded filter DP switch for monitoring on the BAS.
   b. Temporary Filtering of Water and Condensate: Construction strainers shall be used while circulating fluid during construction. Construction strainer shall be finer than that specified for final strainers.
   c. Sealing/Filtering of Open Ducts: Address that all open ducts shall be either sealed or protected with filter media. Return or exhaust systems shall not be used during construction unless otherwise approved.
   d. Lubrication and Maintenance: Contractor shall maintain the systems and equipment in accordance with the manufacturer's instructions. Contractor shall coordinate lubricants used with Owner's operators. Frequency of lubrication and inspection shall be as recommended by manufacturer's literature. Applicable maintenance lubrication schedules shall be included in the Plan. Draft maintenance logs shall be submitted with Plan and completed as maintenance is performed.
   e. Operation Outside of Normal Ranges: Systems and equipment shall not be operated outside the range of specified conditions. The Temporary Conditioning Plan shall address how the Contractor will ensure that operation will not harm the equipment.
   f. Emergency Condition Identification and Response Protocols: The Temporary Conditioning Plan shall address protocols for responding to equipment malfunctions and or harmful operation. Automatic safeties and remote enunciation shall be in place to protect people and property.

3.6 FUNCTIONAL PERFORMANCE TESTING

A. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

B. In general, each system shall be operated through all modes of operation where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions shall also be tested. Specific modes required in this project are given in Sections 01 9115, 23 0800, 25 0800, 26 0800, 28 0800 and any other sections where test requirements are found.

C. The CxA shall review Owner-contracted, factory testing or required Owner acceptance tests which the CxA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the *Specifications*. Redundancy of testing shall be minimized.

D. The Subcontractors shall provide sufficient notice to the CxA regarding their completion schedule for the Prefunctional checklists and start-up of all equipment and systems. The CxA will schedule functional tests through the QAPM, CM, and affected Subcontractors. The CxA shall direct, witness and document the functional testing of all equipment and systems. The CxA shall generally execute most standard tests with initial participation of the affected subs.

3.7 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Documentation

The CxA/BECxA will witness and document the results of all functional performance tests using the specific functional checklist forms developed for that purpose. Prior to testing, these forms are provided to the A/E, QAPM and Subcontractors for review.

B. Non-Conformance

1. The CxA/BECxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues will be noted and reported to the QAPM in writing.

2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA/BECxA. In such cases the deficiency and resolution will be documented.

3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA/BECxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the QAPM. A test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating contractor team member of which participation is specified is not present for the test.

4. As tests progress and a deficiency is identified, the CxA/BECxA discusses the issue with the executing contractor.

    a. When there is no dispute on the deficiency and the Subcontractor accepts responsibility to correct it:

        1) The CxA/BECxA documents the deficiency and the Subcontractors response and intentions and they go on to another test or sequence. After the day's work, the CxA/BECxA submits the non-compliance reports to the QAPM for signature, if required. A copy of the deficiencies is provided to the CM and Subcontractors. The Subcontractor corrects the deficiency, then signs-off that the correction has been made, certifying that the system or equipment is ready to be retested and sends it back to the CxA/BECxA.

        2) The CxA/BECxA reschedules the test and the test is repeated.

    b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

1) The deficiency shall be documented, along with the Subcontractors' response, and a copy given to the QAPM, the CM and to the Subcontractor representative assumed to be responsible.

2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the QAPM.

3) The CxA/BECxA documents the resolution process.

4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs-off that the correction is complete, and provides the written sigh-off to the CxA/BECxA. The CxA/BECxA and CM shall reschedule the test, and the test is repeated.

5. Cost of Retesting

   a. The cost for the Subcontractor to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs.

   b. The time and expenses for the CxA/BECxA to direct any retesting, above one retest, required because a specific prefunctional checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the CM, who may choose to recover costs from the responsible Subcontractor.

6. The CM shall respond in writing to the CxA/BECxA and QAPM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.

7. Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.

C. Failure Due to Manufacturer Defect

If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment or system fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units or assemblies may be considered unacceptable by the CM, the QAPM, the A/E, or the CxA/BECxA. In such case, the responsible Subcontractor shall provide the Owner with the following:

1. Within one week of notification from the QAPM, the Subcontractor or manufacturer's representative shall examine all other identical units or assemblies making a record of the findings. The findings shall be provided to the QAPM within two weeks of the original notice.

2. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

3. The QAPM will determine whether a replacement of all identical units or a repair is acceptable.

4. Two examples of the proposed solution shall be installed by the Subcontractor and the QAPM will be allowed to test the installations for up to one week, upon which the QAPM will decide whether to accept the solution.

5. Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

6. The time and expenses for the CxA/BECxA to direct any retesting, above one retest, required because of an equipment, system, or assembly system failure, will be backcharged to the CM, who may choose to recover costs from the responsible Sub-contractor(s). An example would be motor failures in air handling unit or a window assembly in an envelope system. Once all motors or window assembly have been replaced, prefunctionals checklists completed, and documents submitted that all repairs and corrections have been completed, the CxA/BECxA will direct one retest. If any failures occur during the retest, the CxA/BECxA will backcharge the CM for additional testing.

D. Approval

The CxA/BECxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA/BECxA, if necessary. The CxA/BECxA recommends acceptance of each test to the QAPM. The QAPM gives final approval on each test.

3.8 OPERATION AND MAINTENANCE MANUALS

A. Standard O&M Manuals.

1. The specific content and format requirements for the standard O&M manuals are detailed in Section 01 XXXX. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include at minimum level 1 bookmarks that link to each main section of equipment or system. Special requirements for Envelope Systems are found is Divisions 07 & 08. The TAB contractor and Controls Contractor are found in appropriate Division 23 Sections. Electrical requirements are located in the appropriate Division 26 Sections. Communication and Security requirements are found in appropriate Division 27 and 28 Sections.

2. A/E Contribution. The A/E will include in the beginning of the O&M manuals a separate section describing the systems including:

   a. The design intent narrative prepared by the A/E, updated to as-built status by the A/E.

   b. Simplified professionally drawn single line system diagrams on 8 ½" x 11" or 11" x 17" sheets. These shall include chilled water distribution system, water system, condenser water system, heating system, supply air systems, exhaust systems, and others as designated. These shall show major pieces of equipment such as pumps, heat exchangers, humidifiers, control valves, expansion tanks, coils, service valves, etc.

3. CxA Review and Approval. Prior to substantial completion, the CxA shall review the O&M manual documentation and redline as-builds *for systems that were commissioned* and list other systems documentation that the CxA should review to verify compliance with the *Specifications.* The CxA will communicate deficiencies in the manuals to the PM or A/E, as requested. Upon a successful review of the corrections, the CxA recommends approval and acceptance of these sections of the O&M manuals to the PM or A/E. The CxA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.

3.9 TRAINING OF OWNER PERSONNEL

A. The CM shall be responsible for training coordination and scheduling and ultimately for ensuring that training is complete.

B. The CxA will be responsible for overseeing and approving the adequacy of the training of Owner personnel for **commissioned equipment.**

1. Levels of training modules to be provided:

   a. I - Overview level: An introductory or entry level of training including general features and overview of a system or equipment with related operation procedures.

   b. II - User level: A more in-depth level of training including specific features and functions of a system or equipment, related operation and maintenance, and interaction with other systems and equipment.

   c. III - Support level: An advanced level of technical training for maintenance and repair support staff including classroom plus hands-on comprehensive instruction with review of components, schematics, wiring diagrams and functions of a system or equipment, and related service, troubleshooting, repair and recommended spare parts.

2. Instructor capabilities shall be commensurate with level of instruction required. Instructor qualifications shall be submitted to Owner and CxA for review prior to training.

3. In addition to these general requirements, the specific training requirements of Owner personnel by Subcontractors and vendors is specified in Divisions 1, 03, 05, 07, 08, 21, 22, 23, 25, 26, 27 and 28.

4. Each Sub-contractor and vendor responsible for training shall submit a written training plan to the CxA for review and approval prior to training. The plan shall include the following elements:

   a. Equipment (included in training)

   b. Intended audience

   c. Location of training

   d. Objectives

   e. Subjects covered (description, duration of discussion, special methods, etc.)

   f. Duration of training on each subject

   g. Instructor name and qualifications for each subject

   h. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

5. All training sessions shall be recorded by the contractor and backed-up on DVD or flash drive for delivery to Owner after completion of training. The recordings shall be organized by specification section.

6. The CxA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CxA recommends approval of the training to the OPM.

3.10 DEFERRED TESTING

A. Unforeseen Deferred Tests

If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, or weather (in the case of envelope systems), execution of checklists and functional testing may be delayed upon approval of the QAPM, A/E and CxA/BECxA. These tests will be conducted in the same manner as a seasonal test, as soon as possible.

B. Seasonal Testing

During the warranty period, applicable seasonal testing shall be completed as part of this contract. Seasonal testing is intended to test the performance of non-envelope systems under full load conditions that cannot be simulated during the functional testing period. For example, it is impossible to test the heating system under full load conditions in July, so the heating system would be full load tested during the winter months. The CxA will coordinate this activity. Tests will be executed, documented, and deficiencies corrected by the appropriate Subcontractors, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made by the CM and its Subcontractors.

END OF SECTION

SECTION 01 9115
ENVELOPE COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. Building Enclosure Commissioning (BECx) facilitates a quality-oriented process to verify that all building enclosure components are installed and perform collectively and that the installation is adequately tested and that the specified performance is verified and documented. It serves as a tool to identify deficiencies in the building enclosure during the preconstruction and construction phases in an effort to advance the building enclosure components from mock-up installations, through installation of the separate components on the structure, to a fully integrated, weather-tight assembly prior to occupancy, thereby reducing impact on the building end user. The building envelope commissioning process shall encompass foundation, fenestrations and roofing for the Envelope Systems, and coordinate the traditionally separate functions for systems documentation, component integration, performance testing, and training. BECx is intended to achieve the following specific objectives:

1. Verify that applicable building interfaces and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational and functional checkout by the installing contractors.

2. Verify and document proper functional performance of the scoped envelope systems.

3. Verify that O&M documentation left on site is complete.

4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

Individual Building Enclosure Specification Sections: Individual building enclosure technical sections (Divisions 03-09) stipulate requirements for material testing, and warranties for the material, product or assembly specified in the Section. Installation, product testing, and assembly testing are included in each section.

section.

A. Division 1 Section "Summary of Work"
B. Division 1 Section "Submittal Procedures"
C. Division 1 Section "Closeout Procedures"
D. Division 1 Section "Operation and Maintenance Data"
E. Division 1 Section "Project Record Documents"
F. Division 1 Section "General Commissioning Requirements"
G. Division 3 Section "Concrete"
H. Division 4 Section "Unit Masonry"
I. Division 7 Section "Self-Adhering Sheet Waterproofing"

J. Division 7 Section “Thermal Insulation”
K. Division 7 Section “Fluid Applied Membrane Air Barriers”
L. Division 7 Section “Composite Metal Wall Systems”
M. Division 7 Section “Modified Bitumen Roofing System”
N. Division 7 Section “Sheet Metal Flashing and Trim”
O. Division 7 Section “Joint Sealants”
P. Division 8 Section “Steel Doors and Frames”
Q. Division 8 Section “Aluminum Entrances and Storefronts”
R. Division 8 Section “Glazed Aluminum Curtain Walls”
S. Division 8 Section “Aluminum Windows”
T. Division 8 Section “Glass and Glazing”
U. Division 9 Section “Gypsum Board Assemblies”
V. Attachment ‘A’ to this specification section: Sample Prefunctional Checklist

1.3 ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, Engineer and/or Design-Builder

B. ASI: Architectural Supplemental Instruction

C. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR.

D. BECxA: Building Envelope Commissioning Authority

E. CxA: Commissioning Authority

F. CM: Construction Manager

G. Cx: Commissioning

H. Cx Plan: Commissioning Plan

I. Cx RFI: Commissioning Request for Information

J. Deficiency: A condition in the installation or function of a component, or system that is not in compliance with the Contract Documents and cannot be corrected in fifteen (15) minutes time.

K. FBO: Furnished By Others

L. FT: Functional Performance Test

M. IAW: In Accordance With

N. O&M: Operation and Maintenance

O. OPM: Owner Project Manager

P. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

Q. PC: Prefunctional Checklist

R. RFI: Request for Information

S. Sub(s): Subcontractor(s)

T. TBD: To be determined

1.4 ENVELOPE SYSTEMS TO BE COMMISSIONED

A. Foundation
   1. Wall water-proofing
   2. Wall damp-proofing
   3. Wall/slab on grade interfacing components

B. Exterior Windows
   1. Aluminum frame/interfaces
   2. Glazing
   3. Curtainwall
   4. Storefronts

C. Exterior Envelope
   1. Openings
   2. Air barriers
   3. Joints and adjoining system interfaces
   4. Deck slab interfaces

D. Roof Systems
   1. Wall/structural interfaces
   2. Horizontal component interfaces

1.5 SUBMITTALS

A. Refer also to Specification Section 01 9113, Subsection 1.6.

B. Provide the BECxA a copy of the following items, for the systems to be commissioned:

   1. Envelope System Submittals to include, at minimum, the following:

      a. Fenestration Components Data Sheets

      b. Performance data

      c. Manufacturer's pre-install checklists, to include:

         1) Pre-construction Test Reports
         2) Source Quality Control Reports

      d. Installation Instructions

   2. Field Quality Control Reports

   3. Shop drawings (including any resubmittals required by the A/E)

   4. Operational and maintenance documentation

   5. Training plan and training materials

   6. As-built documentation

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 9113, Subsection 2.1.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 9113, Subsection 2.1.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 9113, Subsection 3.3.

3.2 PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all envelope systems to be commissioned, according to Section 1.4 above.

B. General

Prefunctional or Pretest checklists are primarily the responsibility of the Building Envelope Contractors. Other Contractors such as Structural, Suppliers, or Manufacturers may be required to participate in portions of the Building Envelope pre-functional checkout's. For these activities, the Building Envelope Contractor is to coordinate with the CM and other Division Contractors to ensure checklist completion and accuracy. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each envelope system receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

C. Initial Checkout (pre-test) Plan

1. The BECxA will provide prefunctional checklists (PFCs). PFCs indicate the required procedures to be executed as part of initial checkout of the systems. An example of a standard Envelope PFC is provided in Attachment 'A.'

2. The subcontractor responsible for providing and installing the envelope system develops the pre-test plan by combining (or adding to) the BECxA's prefunctional checklists with the manufacturer's detailed checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with

specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

3. The full pre-test plan shall consist of:

    a. The BECxA's prefunctional checklists.

    b. The manufacturer's standard written install procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end

    c. The manufacturer's normally used field checkout sheets (as applicable)

4. The contractor submits the full Pretest checklist to the BECxA for review and approval.

5. The BECxA reviews and approves the checklists and the format for documenting them, noting any plans that need to be added.

D. Execution of Prefunctional Checklists

1. Two weeks prior to initial testing, the Sub-contractor and vendors schedule checkout with the OPM, CM and BECxA. The performance of the prefunctional checklists and checkout are directed and executed by the Subcontractor or vendor. When checking off prefunctional checklists, signatures may be required of other Subcontractor for verification of completion of their work.

2. The BECxA and possibly the A/E will observe the procedures for selected pieces of primary equipment.

3. The BECxA will observe the physical installation of scoped major envelope systems.

4. The Subcontractors and vendors shall execute initial checkout and provide the CM with a signed and dated copy of the completed prefunctional checklists. The CM reviews for completion and accuracy, then submits to the BECxA.

5. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

6. Completed pretest checklists must be provided to BECxA prior to functional testing.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Subcontractors shall clearly list any outstanding items of the initial pre-test and prefunctional procedures that were not completed successfully. The procedures form and any outstanding deficiencies shall be provided to the BECxA within two days of test completion.

2. The BECxA will work with the Subcontractor and vendor to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The BECxA will involve the PM and others as necessary. The installing Subcontractor(s) or vendor(s) shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the BECxA as soon as outstanding items have been corrected.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in back charges to the responsible party. Refer to Section 01 9113, 3.7 – Documentation, Non-Conformance and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. This sub-section applies to functional testing and demonstration for Envelope systems in this division.

B. The general list of systems to be commissioned is found in section 1.4.

C. Objectives and Scope

1. The objective of functional performance testing is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full completion. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.

2. The objective of Performance Testing is to demonstrate that each Building Enclosure system, and system-to-system interfaces meet or exceed the performance requirements of the Contract Documents.

3. Building Envelope FPT’s are primarily the responsibility of the Building Envelope Contractor(s) (Subcontractor). Other Contractors such as Structural, Vendors or Manufacturers may be required to participate in portions of the Building Envelope FPT’s. For these activities, the Subcontractor is to coordinate with the CM and other Division Contractors to ensure FPT completion and accuracy.

4. Subcontractors are responsible for portions of FPT’s which are primarily the responsibility of other Contractors such as Structural, Vendors or Manufacturers. For these items, the Subcontractor is to coordinate with the CM and other Division Contractors to ensure FPT completion and accuracy.

5. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, etc, of the FPTs. Contractor supplied personnel must be competent with and knowledgeable of all project-specific envelope and roofing systems. All documentation – submittals and installation manuals shall be at the job site before functional testing commences.

D. Development of Test Procedures

1. The BECxA develops specific functional test procedures and forms to verify and document proper operation of each envelope system. The BECxA provides a copy of the test procedures to the A/E, OPM and installing Subcontractor who shall review the tests prior to testing. The A/E and Subcontractor(s) shall point out to the BECxA any specific problems as related to feasibility, safety, equipment and warranty protection.

2. Building Envelope Functional Performance Tests are generally performed on a random sampling basis. A specific number of tests have been included to be witnessed by the BECxA. The Subontractors shall anticipate performing this same number of pre-tests under the Pre-Verification Test requirements.

3. The type of Standard BECx Tests to be conducted by the Subcontractor(s) and witnessed by the BECxA include, but are not limited to:

    a) pressurized chamber tests (ASTM E1105)
    b) spray nozzle tests (AAMA 501.2)
    c) infrared Thermography (ASTM C1060/1153)
    d) exterior joint sealant adhesion tests (ASTM C1521)
    e) fluid applied air barrier leakage tests (ASTM E1186 section 4.2.7)

E. Coordination and Scheduling

1. The Subcontractor shall complete all phases of work so the building can be enclosed, dried-in and interior installations can commence on schedule. This includes the complete installation of all exterior installations per the contract documents and related directives, clarifications, and change orders.

2. Work is to be scheduled and completed such that all Commissioning Activities including Pre-Verification Tests and Functional Performance Tests can be executed with sufficient time for issue resolution prior to Beneficial Occupancy. It is the Contractors responsibility to determine the amount of time needed to test, troubleshoot and retest the Building Envelope Systems such that all deficiencies are resolved prior to Final Acceptance.

3. The CM shall provide sufficient notice to the BECxA regarding the Subcontractor completion schedule for the prefunctional checklists of the envelope systems. The BECxA will schedule functional tests after written notification from the CM and affected Subcontractors. Completed checklist reports must be provided to the BECxA prior to functional testing. The BECxA shall direct, witness and document the functional testing of all systems. The Subcontractor shall support the execution of the tests.

4. **Work is to be scheduled and completed such that any concealed installations are inspected prior to concealment. Premature closure or concealment of any installation which requires inspection without proper inspection or proof of correct installation will result in destructive measures to allow for the required proof or inspections at no cost to the Owner or schedule extension. It is the responsibility of the CM and Subcontractor to coordinate installations and schedule timely inspections with the required authorities, allowing for required pre-inspection notification.**

5. **Work is to be scheduled and completed such that any deficiencies or required inspections are conducted prior to closure or concealment of the noted deficiency. Premature closure or concealment of any deficiency without proper inspection or proof of corrective action will result in destructive measures to allow for the required proof or inspections at no cost to the Owner or schedule extension**. It is the responsibility of the Construction Manager and Building Envelope Contractors to coordinate, disseminate deficiencies and pause construction to remedy issues.

6. In general, functional testing shall not be scheduled until all submittals are approved, and Prefunctional checklists are approved and satisfactorily completed. Scheduling of functional testing shall be done with a minimum of two weeks notice prior to testing. Functional testing of the systems listed in section 1.4 of this specification section shall not be conducted out of the presence of the BECxA and OPM, unless specifically approved to do so in writing by the BECxA or OPM. Any functional testing which occurs outside the presence of the BECxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Refer to Specification Section 01 9113, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to Installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the BECxA for the systems to be commissioned. The O&M Manuals shall be provided to the BECxA at least prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include at minimum level 1 bookmarks that link to each main section of envelope system – ie: Foundations, Fenestrations, Roof, etc.

B. Refer to specification section 01 9113, Subsection 3.8 for further details.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 9113, Subsection 3.9.

B. BECxA shall document the completion of Owner training (as needed). Training shall include the understanding of the specialty system components and the operation and maintenance of each major Envelope system.

3.7 DEFERRED TESTING

A. Deferred seasonal testing is anticipated to be limited for Envelope commissioning activities. If envelope testing is impacted due to weather constraints or other unforeseen circumstance, see Specification Section 01 9113, Subsection 3.10.

011915 - ATTACHMENT 'A'

EXAMPLE ENVELOPE PREFUNCTIONAL CHECKLISTS

(Not all inclusive)

WATERPROOFING CHECKLIST

Item	Installing Contractor Y/N	BECxA Notes
1. Are exposed areas masked to protect adjacent work?		
2. Are acceptable weather conditions present for application (above 40 degrees F, not damp or foggy, depending on material used)?		
3. Are substrates free of standing water, dirt and debris, loose material, voids and protrusions or deformations, which may inhibit application or performance of waterproofing?		
4. If waterproofing will be installed on concrete and/or masonry, are substrates free of voids deeper than 3/8" and free of surface protrusions more than 1/4" above the surface.		
5. If waterproofing will be installed on concrete footings, is wood float or better finish provided to surfaces scheduled to receive the vapor-protective waterproofing?		
6. If waterproofing will include bentonite water stop strips, are concrete surfaces provided as required for that installation?		
7. Are laps between membrane sheets consistent with approved details (flashings, changes of plane in membrane showing overlap, etcetera)?		
8. Is joinery between each day's work adequate?		
9. Is interstitial moisture not present?		
10. Are stored materials protected against moisture?		
11. Are proper fasteners and adhesives used?		
12. Is membrane applied smooth without buckles or "fish mouths"?		
13. Are appropriate protective measures taken to ensure that finished work is not penetrated or damaged by other trades?		
14. Are pipes, ducts, conduits, and other items penetrating membrane watertight?		
15. Is there proper coverage and quantities of materials such as mil thickness?		
16. Is a protective covering provided and installed as required? Is backfilling taking place immediately with the covering to remain in place during backfilling?		

OPENING (DOOR, WINDOW, STOREFRONT, & CURTAINWALL) CHECKLIST

Item	Installing Contractor Y/N	BECxA Notes
1. Are openings installed and include thermal breaks?		
2. Is rough or masonry opening correct size with required clearance for proper installation of opening?		
3. Are openings of type, size, finish, and operation as approved?		
4. Is flashing installed around opening?		
5. Is caulking and sealant applied around opening complete and smooth without air pockets & wrinkles?		
6. Is field-applied sealant of proper type and color and applied where required?		
7. Are sealant joint widths correct?		
8. Are rain drips, weep holes, and drainage systems provided and clean of sealant, mortar and debris?		
9. Is weather stripping provided on doors and operable window sections?		
10. Are all hardware provisions coordinated and installed?		
11. Is hardware of required type, metal, finish, and function?		
12. Are electric or pneumatic outlets and locations provided if required?		
13. Is window/door hardware adjusted to provide smooth operation and weather-tight sealing when doors and operable sections are closed and locked?		
14. Are openings clean and free of mortar, plaster, paint spattering spots, and other foreign matter?		
15. Is there any corrosion or deterioration of materials or fasteners?		
16. Are air barrier components continuous and sealed?		
17. Is connection between openings & wall air barriers sealed?		
18. Do doors open per ABA guidelines?		
19. Are dissimilar metals and materials isolated? For example, aluminum, in contact with other metals and cementitious surfaces, may require nylon, polystyrene or pressure tape, separators or stainless steel bolts.		
20. Are installation tolerances maintained regarding horizontal and vertical alignment and plumbness.		
21. Is anchorage to structure secure for transfer of wind/blast loads and permanently tightened after alignment?		
22. Has a water test (hose test) of the installed assemblies been conducted if required?		

END OF SECTION

SECTION 22 08 00
PLUMBING COMMISSIONING REQUIREMENTS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

2. Verify and document proper functional performance of equipment and systems.

3. Verify that O&M documentation is complete.

4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

A. Section 01 10 00 – Summary of Work

B. Section 01 33 00 – Submittal Procedures

C. Section 01 77 00 – Closeout Procedures

D. Section 01 78 23 – Operation and Maintenance Data

E. Section 01 78 39 – Project Record Document

F. Section 01 79 00 – Demonstration and Training

G. Section 01 91 13 – General Commissioning Requirements

H. Division 22 - Plumbing

1.3 ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, and/or Engineer

B. ASI: Architectural Supplemental Instruction

C. BAS: Building Automation System

D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR

E. CxA: Commissioning Authority

F. Controls Contractor

G. CM: Construction Manager

H. Cx: Commissioning

I. Cx Plan: Commissioning Plan

J. Cx RFI: Commissioning Request for Information

K. DDC: Direct Digital Control System

L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.

M. EC: Electrical Contractor

N. FBO: Furnished By Others

O. FT: Functional Performance Test

P. IAW: In Accordance With

Q. MC: Mechanical Contractor

R. O&M: Operation and Maintenance

S. OPM: Owner Project Manager

T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

U. PC: Prefunctional Checklist

V. RFI: Request for Information

W. Sub(s): Subcontractors or Prime Contractor

X. TC: Testing Contractor

Y. TBD: To Be Determined

1.4 PLUMBING SYSTEMS TO BE COMMISSIONED

A. Domestic hot water systems

B. Sump pumps and sump pump controls

1.5 SUBMITTALS

A. Refer also to Specification Section 01 91 13, Subsection 1.6.

B. Provide the CxA a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at minimum, the following:

   a. Cut Sheets

   b. Performance data

2 Manufacturer's pre-startup checklists

   a. Manufacturer's start-up checklists

   b. Installation Instructions

2. Shop drawings (including any resubmittals required by the A/E)

3. Test plan

4. Completed field test report, including all completed forms and checklist; and list of all outstanding deficiencies and uncompleted items

5. Operational and maintenance documentation

6. Training plan and training materials

7. As-built documentation

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 91 13, Subsection 2.1.

B. Instrumentation required to verify readings and test system and equipment performance shall be provided by Contractor and made available to Commissioning Authority. Camera equipment capable of viewing an entire pipe assembly at one time.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 91 13, Subsection 2.1.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 91 13, Subsection 3.3.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Section 1.4 above.

B. General

Contractor shall complete plumbing testing as required in sections 22 11 18, 22 13 14, and 22 33 14.

C. Testing Plan

1. The subcontractor responsible for providing and installing the equipment completes the testing plan. The test plan will include checklists and procedures with specific boxes or lines for recording and documenting the tests, and a summary statement with a signature block at the end of the plan.

2. The contractor submits the full test plan to the A/E and CxA for review and approval.

D. Execution of Testing Plan

1. Two weeks prior to testing, the Subs and vendors schedule testing with the OPM, CM and CxA. The performance of the tests are directed and executed by the Sub or vendor.

2. The CxA and possibly the A/E will observe the testing procedures for selected pieces of equipment.

3. The Subs and vendors shall execute testing and provide the CM with a signed and dated copy of the completed testing report. The CM reviews for completion and accuracy, then submits to the CxA and A/E.

4. Only individuals that have direct knowledge and witnessed that a line item task on the testing was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Sub(s) shall clearly list any outstanding items of the initial testing that were not completed successfully. The testing forms and any outstanding deficiencies shall be provided to the CxA within two days of test completion.

2. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.

3. Items left incomplete, which later cause deficiencies or delays during functional performance testing may result in backcharges to the responsible party. Refer to Section 01 9113, 3.7 – Documentation, Non-Conformance and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING, VERIFICATION AND VALIDATION

A. Objectives and Scope

1. The contractor will perform functional performance testing of the water heating equipment and any plumbing automation system integration with the EMS.

2. The objective is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.

3. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment and warranty protection.

4. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

5. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems. All training documentation, submittals, installation manuals, and O&Ms, shall be at the job site before demonstration testing commences.

B. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the testing of all equipment and systems. The CxA will schedule demonstration and validation after written notification from the CM and affected Subs. The CxA shall direct, witness and document the demonstration retesting of equipment and systems. The Subs shall execute the tests.

2. In general, functional performance testing shall not be scheduled until all equipment submittals are approved, testing plans are approved, testing has been satisfactorily completed, and testing report has been provided. Scheduling of testing shall be done with a minimum of two weeks notice prior to testing. Testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

C. Problem Solving

1. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Refer to Specification Section 01 91 13, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 01 9113, subsection 3.8 for further detail.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 91 13, Subsection 3.9.

B. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of cabling systems.

C. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment.

3.7 DEFERRED TESTING

A. See Specification Section 01 91 13, Subsection 3.10.

END OF SECTION

SECTION 23 08 00
HVAC COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing adjusting and balancing, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

2. Verify and document proper functional performance of equipment and systems.

3. Verify that O&M documentation left on site is complete.

4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

A. Section 01 10 00 – Summary of Work

B. Section 01 33 00 – Submittal Procedures

C. Section 01 77 00 – Closeout Procedures

D. Section 01 78 23 – Operation and Maintenance Data

E. Section 01 78 39 – Project Record Documents

F. Section 01 79 00 – Demonstration and Training

G. Section 01 91 13 – General Commissioning Requirements

H. Section 25 08 00 – Integrated Automation Commissioning

1.3 ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, Engineer and/or Design-Builder

B. ASI: Architectural Supplemental Instruction

C. BAS: Building Automation System

D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR.

E. CxA: Commissioning Authority

F. CC: Controls Contractor

G. CM: Construction Manager

H. Cx: Commissioning

I. Cx Plan: Commissioning Plan

J. Cx RFI: Commissioning Request for Information

K. DDC: Direct Digital Control System

L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.

M. EC: Electrical Contractor

N. FBO: Furnished By Others

O. FT: Functional Performance Test

P. IAW: In Accordance With

Q. MC: Mechanical Contractor

R. O&M: Operation and Maintenance

S. OPM: Owner Project Manager

T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

U. PC: Prefunctional Checklist

V. RFI: Request for Information

W. Sub(s): Subcontractors or Prime Contractor

X. TAB: Test, Adjust and Balance

Y. TBD: To Be Determined

[DESIGNER NOTE: The below list in section 1.4 to be edited on a per project basis]

1.4 MECHANICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

A. Mechanical Systems

1. Building automation systems, including linkages to remote monitoring and control sites
2. Science room control systems and pressurization
3. Chilled water system, chilled water pumps, piping, and associated equipment.
4. Heat recovery system and associated pumps.
5. Humidification / Dehumidification systems
6. Heating hot water system, associated pumps, piping, and equipment
7. Preheat and Reheat water systems and associated pumps and piping
8. Heat exchanger, pumps, piping, condensate and associated equipment
9. Air Handling Units
10. Heat Recovery Units
11. Dedicated Outside Air Systems
12. Supply and Exhaust and other specialty fans
13. Fan Coil Units, Unit Heaters, and Ventilators
14. Variable Air and Constant Volume Air terminal units, both supply and exhaust
15. Ductwork
16. DX systems
17. Test, Adjust, and Balance of HVAC air and water systems
18. Test, Adjust, and Balance Fume Hoods and bio-safety cabinets

B. Building Automation Systems (BAS)

1. The entire BAS shall be subject to commissioning, including all hardware components, software, networking, programming and engineering services, and controls documentation.
2. Any systems connected to the BAS (monitoring or otherwise) are subject to be commissioned.

1.5 SUBMITTALS

A. Refer also to Specification Section 01 91 13, Subsection 1.6.

B. Provide the CxA a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at minimum, the following:

    a. Equipment Data Sheets

    b. Performance data

    c. Manufacturer's pre-startup checklists

    d. Manufacturer's start-up checklists

    e. Installation Instructions

2. Test, Adjust, and Balance (TAB) Reports

    a. Planning Report - TAB contractor shall submit one copy of planning report (execution plan) to the CxA for review prior to beginning TAB work. At a minimum this report should include:
        1) Certifications on all instruments to be used throughout the testing. Certification must be documented within the previous 6 months.
        2) Résumés and Certification of individuals who will be balancing the systems.
        3) Detailed step-by-step plans for each procedure to be performed by the TAB Contractor.
        4) Sample forms to be used for each measurement.

    b. Initial Test Report – Prior to starting final Balance Phase, submit a copy of the initial test report (TAB punchlist) to the CxA to indicate problem areas to be resolved before final balance is completed.

    c. Final Report – Submit one copy of final test report to the CxA within 7 days after fieldwork is complete.

3. Shop drawings (including any resubmittals required by the A/E)

4. Ductwork - Supply one copy of the duct leakage test results for each test section

5. Piping - Supply one copy of all of hydrostatic pressure test results

6. Initial Pre-startup and start-up plan

7. Startup Testing Report

    a. Prepare startup testing report on a per system basis, documenting the results of executed testing plan.

    b. Copies of all completed test forms and checklists shall be provided

    c. List of all outstanding deficiencies and uncompleted items

8. Operational and maintenance documentation

9. Training plan and training materials

10. As-built documentation

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 91 13, Subsection 2.1.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 91 13, Subsection 2.1.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 91 13, Subsection 3.3.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Section 1.4 above.

B. General

Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

C. Start-up and Initial Checkout Plan

1. The CxA will provide prefunctional checklists (PFCs). PFCs indicate the required procedures to be executed as part of startup and initial checkout of the systems.

2. The subcontractor responsible for providing and installing the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

3. The full start-up plan shall consist of:

    a. The CxA's prefunctional checklists.

    b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end

    c. The manufacturer's normally used field checkout sheets

    d. Specifically, the mechanical start-up plan shall also include the contractors TAB plan.

4. The contractor submits the full startup plan to the CxA for review and approval.

5. The CxA reviews and approves the procedures and the format for documenting them, noting any plans that need to be added.

D. Execution of Prefunctional Checklists and Startup

1. Two weeks prior to startup, the Subs and vendors schedule startup and checkout with the OPM, CM and CxA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.

2. The CxA and possibly the A/E will observe the procedures for selected pieces of primary equipment.

3. The CxA will observe the physical start-up of all major systems.

4. The CxA will witness piping cleanout procedures and verify any required water or lab tests.

5. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA will observe a sampling of the prefunctional and start-up procedures.

6. The Subs and vendors shall execute startup and provide the CM with a signed and dated copy of the completed start-up and prefunctional tests and checklists. The CM reviews for completion and accuracy, then submits to the CxA.

7. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

8. Completed startup test report must be provided to CxA prior to functional testing.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully. The procedures form and any outstanding deficiencies shall be provided to the CxA within two days of test completion.

2. The CxA will work with the Subs and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party. Refer to Section 01 91 13, 3.3 – Documentation, Non-Conformance and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING

A. This sub-section applies to functional testing and demonstration for equipment and system in this division.

B. The general list of equipment and systems to be commissioned is found in section 1.4.

C. Objectives and Scope

1. The objective of functional performance testing is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.

2. In general, each system shall be operated through all modes of operation where there is a specified system response.

3. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

4. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems, and automation hardware and software. All training documentation, submittals, installation manuals, and O&Ms, shall be at the job site before functional testing commences.

D. Development of Test Procedures

1. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment and warranty protection.

E. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule functional tests after written notification from the CM and affected Subs. Completed startup testing report must be provided to CxA prior to functional testing. The CxA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

2. In general, functional testing shall not be scheduled until all hardware and software submittals are approved, Prefunctional checklists are approved, and start-up has been satisfactorily completed. Further, mechanical system functional testing shall not be scheduled until the final TAB report is approved and all reported deficiencies by TAB firm are corrected. Scheduling of functional testing shall be done with a minimum of two week notice prior to testing. Functional testing of the equipment and systems listed in section 1.4 of this specification section shall not be conducted out of the presence of the CxA and OPM, unless specifically approved to do so in writing by the CxA or OPM. Any functional testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

F. Test Methods

1. Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers.

2. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

3. Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair dryer rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.

4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.

5. Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55ºF, when the outside air temperature is above 55ºF, temporarily change the lockout setpoint to be 2ºF above the current outside air temperature.

6. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the

tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.

7. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

G. Demonstration, Verification and Validation

1. TAB Validation

a. The air balancing and water balancing is de-bugged, completed and approved before the CxA completes a TAB validation of air-related and water-related equipment or systems. The CxA will direct a TAB checkout by verifying the values reported in the final TAB report. The contractor shall supply all personnel and equipment for the checkout, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. The TAB verification shall verify:

1) grilles, diffusers, and registers

2) terminal devices

3) all main HVAC systems, including energy recovery systems

4) general exhaust fans

5) kitchen hood exhaust

5) fume hoods – as applicable

6) hydronic systems (e.g. HW/CHW) equipment and distribution components

2. Metering System

a. Demonstrate meters are calibrated in accordance with the manufacturer's published data approved.
b. Demonstrate accuracy of all meters.
c. Demonstrate utility monitoring integration with BAS.

H. Problem Solving

1. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Refer to Specification Section 01 91 13, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to Installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 01 91 13, subsection 3.8 for further detail.

B. Refer to specification section 01 91 13, Subsection 3.8 for further details.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 91 13, Subsection 3.9.

B. CxA shall document the completion of comprehensive Owner training. Training shall include the understanding of the systems and the operation and maintenance of each major piece of HVAC equipment or system.

C. Training shall include classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including AHUs, pumps, VAV terminals, VFDs, etc.

3.7 DEFERRED TESTING

A. See Specification Section 01 91 13, Subsection 3.10.

END OF SECTION

SECTION 23 09 00 - BUILDING AUTOMATION SYSTEM

PART 1 GENERAL SCOPE

1.01 RELATED DOCUMENTS

A. The provisions of the General Conditions, Supplementary Conditions, and the Sections included under Division 1, General Requirements, are included as a part of this Section as through bound herein.

1.02 SUMMARY

A. This document contains the specification for a Building Automation System (BAS).

B. The system shall provide the Direct Digital Control (DDC), Energy Management and Building Automation System (BAS) for the air conditioning, heating and ventilating systems, lighting controls and shall interface with other microprocessor based building subsystems as shown on the drawings and as specified.

C. Related Work Specified Elsewhere:

1. Section 23 05 13 – Common Motor Requirements for HVAC Equipment.

2. Section 23 52 16 – High Efficiency Condensing Boilers.

3. Section 23 64 26 – Rotary Screw Water Chillers.

4. Section 23 08 00 – HVAC Systems Commissioning.

D. Refer to Division 01 for Alternates that may affect the Work of this Section.

1.03 SCOPE OF WORK

Contractor's Responsibilities: The Contractor shall furnish a complete, tested, fully integrated and completely operational Building Automation System including all necessary software and hardware, wiring, and control equipment in compliance with this Specification and the Construction Documents.

1. Standard Material/Products: All material and equipment used shall be standard components and software, regularly manufactured and available, and not custom designed especially for this project.

2. Modular Design: The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.

3. Performance: The system, upon completion of the installation and prior to acceptance of the project, shall perform all operating functions as detailed in this specification.

4. The intent of this specification is to provide a system that is consistent with BMS systems throughout WCPSS facilities running the Niagara AX™ or N4 Framework.

5. System architecture shall fully support a multi-vendor environment and be able to integrate third party systems via existing vendor protocols including, as a minimum, LonTalk, BACnet, and Modbus.

6. System architecture shall provide secure Web access using MS Internet Explorer from any computer on the WCPSS LAN.

7. BAS Communication trunk shall be independent from the WCPSS network and operate without switches. There shall be a single point connection from the BAS to the WCPSS network for remote monitoring.

8. BAS Contractor shall be responsible for providing a temporary wireless building wide BAS communication network with adequate speed and capacity to allow for efficient contractor systems start up, Test & Balance, and pre-functional testing as well as to support all facets of 3rd Party Commissioning testing prior to WCPSS permanent network installation/activation.

B. Equipment:

1. System Hardware:

The Contractor shall provide the following:

a. All sensing devices, relays, switches, indicating devices, and transducers, power supplies, interface modules, etc. required to perform all require functions.

b. All monitoring and control wiring.

c. Owner shall furnish remotely located database server hardware.

2. System Software:

a. Prior to installation, the Controls Contractor shall determine the current system software version utilized by WCPSS. The Controls Contractor shall request written approval from WCPSS for any deviations from the currently installed version. The Controls Contractor shall provide Niagara N4™ Framework Version 4.14.X.X of all software required to configure, monitor, link and program all components of the completed system, including the BAS Server Software. The existing software version located on the server is Version 4.14.X.X. The controls contractor shall provide the latest version of all third-party software required (excluding computer operating system software). The system shall be fully configured, including database, graphics, reports, schedules, alarm/events, trends etc. The Graphical User Interface (GUI) shall be Web based as specified herein.

3. Acceptable field controllers are Schneider Electric MPC series – Space Logic for Niagara Framework, Honeywell Spyder, Distech by Johnson Controls, Trane Tracer UC or approved equal.

C. General Notes to Designers and Contractor

1. Coordination with the appropriate sections of the mechanical and electrical specifications is required by the design team in order for mechanical and electrical systems to interface with the BAS control standards. The Construction Documents and Specifications must appropriately reference the BAS Specifications.

2. Coordinate power requirements with electrical engineer and cross-reference responsibilities with other system designers (e.g. HVAC, electrical, fire protection, plumbing, etc…). Coordinate power requirements for HVAC system and show all bas power points on electrical drawings. The goal of WCPSS is to insure 120 vac power is provided within a common area (e.g. mechanical room) adjacent to control devices. The control contractor would then be responsible for all final power (120 vac and >) and low voltage (24vac and <) to all control components within the common area. Locate BAS panels on the mechanical room floor plan drawings.

3. All BAS controller and point names shall reference final WCPSS approved room numbers, not construction document room numbers. The BAS contractor shall submit all naming conventions to WCPSS for approval by the prior to programming. See 2.02.2 E

4. Project Sequence

   a. The control system work for this project shall proceed in the following order:

      1) Submit and receive approval on the Shop Drawings, Product Data, and Certificates specified under the paragraph entitled "SUBMITTALS."
      2) Perform the control system installation work, including all field check-outs and tuning.
      3) Provide support to TAB personnel
      4) Submit BAS Graphics for review by WCPSS personnel for approval
      5) Submit and receive approval of the Controls System Operators Manual Submit and receive approval of the Performance Verification Testing Plan and the Pre-PVT Checklist
      6) Perform the Performance Verification Testing.
      7) Submit and receive approval on the PVT Report.
      8) Submit and receive approval on the Training Documentation. Submit at least 30 days before training.
      9) Deliver the final Controls System Operators Manuals.
      10) Conduct Training.
      11) Submit and receive approval of Closeout Submittals

1.04 GENERAL CONDITIONS

A. Correction of Work:

1. Contractor's Responsibility. The Contractor shall promptly correct all work the Owner finds defective or failing to conform to the Contract Documents. The Contractor shall bear all cost of correcting such work.

2. During Warranty. If, within the warranty period required by the Contract Documents, any of the work is found to be defective in material or workmanship or not in accordance with the Contract Documents, the Contractor shall correct it promptly after receipt of notice from Owner to do so. Owner shall give notice promptly after discovery of the condition. Contractor shall notify owner within 24 hours of proposed corrections and schedule.

B. Coordination of Work During Construction:

1. The Contractor shall protect the installed works by other trades.

2. The Contractor shall coordinate with other trades.

3. The Contractor shall repair any damage caused by his work to building(s) and equipment.

4. The contractor shall maintain functionality of all existing systems throughout the project.

C. Warranty and Service:

1. Standard Warranty
   a. The Contractor shall warrant the system to be free from defects in material and workmanship for a period of one (1) years from the date of completion and acceptance of the work by the Owner. Any defects shall be repaired or replaced, including materials and labor at no cost to WCPSS.
   b. Niagara 4 Software Maintenance Agreement
      1. Building automation vendor shall provide 3 year software maintenance agreement (SMA) with any installation of Niagara 4.X system.

2. WCPSS reserves the right to make changes to the BAS during the Warranty Period. Such changes do not constitute a waiver of warranty. Contractor shall warrant parts and

   installation work regardless of any such changes made by WCPSS, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

3. Service Response Requirements During the Warranty Period
   a. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic, text, or email notification by the Owner to the Contractor. Emergency service shall be provided 24 hours per day, 7 days per week, and 365 days per year with no exceptions and at no cost to WCPSS.
   b. Response by telephone, text, or email to any request for service shall be provided within two (2) hours of WCPSS's initial request for service.
   c. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the WCPSS site within four (4) hours of the WCPSS initial request for such services, as specified.
   d. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic, text, or email notification by the WCPSS to the Contractor.
   e. Response by telephone, text, or email to any request for service shall be provided within eight (8) working hours (Contractor specified 40 hours per week normal working period) of the WCPSS initial request for service.
   f. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the WCPSS site within three (3) working days of the WCPSS initial request for such services, as specified.
   g. At any time during the Warranty Period that Contractor is on Site for maintenance, emergency, or normal service, Contractor shall notify WCPSS and the local building operating personnel. Contractor shall notify said personnel of all work anticipated being involved for the service work. In addition, no work affecting system operation shall commence until express permission is granted. After the work is completed a work order ticket describing in detail all work performed (i.e. hardware replaced or serviced, software or firmware modifications made, etc.), hours worked, follow-up work required, etc., must be signed by an authorized building operator.
   h. WCPSS Telephonic Request for Service: Contractor shall specify a maximum of three telephone numbers for WCPSS to call in the event of a need for service. At least one of the lines shall be attended at any given time at all times. Alternatively, text messaging can be used for technicians trained in system to be serviced. One of the three notified technicians shall respond to every call within 15 minutes.
   i. Technical Support: Contractor shall provide technical support by telephone throughout the Warranty Period.
   j. Preventive maintenance shall be provided throughout the Warranty Period in accordance with the hardware component manufacturer's requirements.
   k. In the last month of the Warranty Period, all System software and controller firmware, software, drivers, etc. will be upgraded to the latest release (version) in effect at the end of the Warranty Period.Post-warranty Service

4. Contractor shall ensure accessibility to technical support and replacement parts for ten (10) years past the warranty period.

1.05 SUBMITTALS, DOCUMENTATION, ACCEPTANCE AND TRAINING

A. Product Data Submittals: Submit, manufacturer's technical product data for each control device, panel, and accessory furnished, indicating dimensions, capacities, performance and electrical characteristics, and material finishes. Also include installation and start-up instructions.

1. Products: Within twenty one (21) days after date of execution of General Contractor/Sub-Contractor agreement, submit for acceptance a list of all material and equipment manufacturers whose products are proposed, as well as names of all subcontractors whom the Contractor proposes to employ.
   a. Provide the following in schedule form on 8½ x 11 sheets. The schedule shall be organized by columns to define as a minimum for all new devices to be installed as part of the BAS system upgrade the location, system served, controlling unit, model number and where applicable, performance data, size, range, accuracy, span, operating pressure, etc.
      1) Automatic Valves
      2) Automatic Dampers
      3) Temperature Sensors
      4) Access Doors
      5) Humidity Sensors
      6) Smoke Detectors
      7) Carbon Monoxide Detectors
      8) Heat Detectors
      9) Pressure Transducers and Transmitters
      10) Digital Control Panels
      11) Relay Contactors
   b. Submit documentation indicating interoperability achieved using BACnet Standard ASHRAE/ANSI 135 or for LonWorks Standard Network Variable Types (SNVTs) or for LONMARK® products provide documentation indicating LONMARK compliance and conformance to LONMARK® Interoperability Standards including but not limited to: Product Information Files (XIF) product literature, and standard configuration parameters for the following. All XIF files, product literature, and standard configuration parameters shall be compiled and submitted on CD-ROM in addition to hard copies provided.
      1) Intelligent Sensors and Actuators
      2) Application Specific Controllers
      3) Programmable Control Units
      4) Interface Panels
      5) Network Management Equipment (Routers, Protocol Analyzers, etc.)
   c. Submit detailed cut sheets indicating the features, accessories and sub-assemblies of the following:
      1) All ancillary devices including temperature sensors, flow sensors, and the like, including thermal wells where necessary.
      2) Pressure gauges, thermometers and indicating devices where shown on the drawings.
      3) Transformers required for control devices.
      4) Relays.
      5) Electrical enclosures and back-plates.
      6) Wire for LON, or BACnet, FAC LAN, and all sensors and actuators.
      7) FAC LAN Hub(s), Switches, and Routers.
      8) LON or BACnet Repeaters.

9) Equipment Racks.
10) UPS Modules.
11) Gateway and interface devices.
12) Enterprise Network Controllers and Software.
13) User Interface Workstation Operating System and Associated Software.
14) Network Management Utility Software.
15) Application Programming Tools / Software (DDC controller programming software).
16) Interface devices to Modbus and proprietary devices.
17) Web based configuration and programming for control devices.
18) Note any discrepancies with Section 17860/17865 regarding the Graphical User Interface. Specifically identify features that cannot be provided and submit for Owner's approval as a substitution.

2. Shop Drawings: Within six (6) weeks after date of execution of the contract agreement, submit a list of all shop drawings which will be submitted in the course of the project. The list shall show disposition of each item, including date of submission, date of acceptance, and the like. List shall be kept current throughout entire construction period.

3. Submit Shop Drawings electronically in PDF format for each control system, including a complete drawing for each air handling unit, system, pump, device, etc. with all point descriptors, addresses and point names indicated. Include mounting details and power supplies. Shop Drawings shall contain the following information:

a. System Architecture and System Layout:
   1) One-line diagram indicating schematic locations of all NCs, Controllers, CSS, OWS, FAC LAN interface devices, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each NC. Indicate media, protocol, baud rate, and type of each FAC LAN segment. All controllers, optical isolators, repeaters, end-of- line resistors, junctions, ground locations etc. shall be located on the diagram.
   2) Provide floor plans locating all NCs, controllers, workstations, servers, LAN interface devices, etc. Include all WAN, FAC LAN and LON or BACnet communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each NC. Indicate media, protocol, baud rate, and type of each FAC LAN segment. All controllers, sensors located in finished areas, I/O devices installed in mechanical systems, optical isolators, repeaters, end-of-line resistors, junctions, ground locations, other BAS related components, sensors and actuators, etc. shall be located on the floor plans. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.
b. Schematic flow diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include written description of sequence of operation.
c. All physical and logical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses as identified in the point list schedule.
d. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). If this information is not available at the time of Shop

Drawings submittals, furnish with O&M manual documentation for Owner review and approval. See CSI Master Format for additional requirements.

1) Label each control device with setting or adjustable range of control.
2) Label each input and output with the appropriate range.
3) Provide a Bill of Materials with each schematic. Indicate device identification to match schematic and actual field labeling, quantity, actual product ordering number, manufacturer, description, size, voltage range, pressure range, temperature range, etc. as applicable.
4) With each schematic, provide valve and actuator information including size, Cv, design flow, design pressure drop, manufacturer, model number, close off rating, etc. Indicate normal positions of spring return valves and dampers.

e. Provide detailed schematics for LONWORKS, BACnet and Modbus interface connections including installation and commissioning specifics. Include detailed terminal interconnect diagrams for connecting to equipment manufacture's integral communications boards.
f. Indicate all required electrical wiring. Electrical wiring diagrams shall include both ladder logic type diagram for motor starter, control, and safety circuits and detailed digital interface panel point termination diagrams with all wire numbers and terminal block numbers identified. Provide panel termination Drawings on separate Drawings. Ladder diagrams shall appear on system schematic. Clearly differentiate between portions of wiring that exists, factory-installed and portions to be field-installed. Provide details for wiring color code assignment.
g. Provide details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.
h. Sheets shall be consecutively numbered.
i. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.
j. Table of Contents listing sheet titles and sheet numbers.
k. Provide User Interface Graphic Screens.
    1) Proposed method of Navigation.
    2) Summary.
    3) Floor Plans.
    4) Trends.
    5) Alarms.
l. Legend and list of abbreviations.
m. Memory allocation projections.
n. Submit along with Shop Drawings but under separate cover calculated and guaranteed system response times of the most heavily loaded LON or BACnet segment in the system.
o. Submit in Schedule format a detailed list of all spare parts to be provided per the contract documents.

4. Control Drawings: Laminated control Drawings including system control schematics, Sequence of Operation and panel termination Drawings, shall be provided in panels for major pieces of equipment, such as air handling units, chillers, boilers, etc. Drawings should be of sufficient size to be easily read. Terminal unit Drawings shall be located in the central plant equipment panel or mechanical room panel.

5. Control Logic Documentation:
    a. Submit control logic program listings (for graphical programming) and logic flow charts illustrating (for line type programs) to document the control software of all control units. Submit functional temperature control diagrams for each mechanical system served by the BAS. Indicate and tag each input/output served by each ASC or PCU and show locations and functions of BAS.

b. Submit logical control diagram indicating each node, node address, Network Variables in and out of each node including message bindings. Provide a detailed list of network variable inputs (NVI), network variable outputs (NVO), network configuration inputs (NCI) and use of standard network variable types (SNVT). Indicate total number of NVIs, NVOs and NCIs available for each controller. In the same document list a percentage used in terms of capacity and identify all remaining spare SNVTs on each controller.
c. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation. Include all control parameters, system variables, and constants that will affect the system operation.
d. Include written description of each control sequence.
e. Include control response, settings, set points, throttling ranges, gains, reset schedules, adjustable parameters and limits.
f. Sheets shall be consecutively numbered.
g. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.
h. Include Table of Contents listing sheet titles and sheet numbers.
i. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set will count toward the required number of Operation and Maintenance materials specified below and in Division 01.

6. As Built Drawings. All drawings, documentation and manuals shall be reviewed after the final system checkout and updated or corrected to provide 'as-built' drawings to show exact installation and configuration and programming. The system will not be considered complete until the 'as-built' documentation has received final approval, by owner.

7. Shop Drawings. Shop drawings shall be submitted and shall consist of a complete list of equipment, software, materials, manufacturer's technical literature, cut-sheets, and installation instructions. Drawings shall contain proposed layout, complete wiring, list of I/O points, routing, schematic diagrams, ladder diagrams, communication architecture drawings, tag number of devices, software descriptions, graphical sequence calculations, installation details, control system components, control system schematics, test and verification plan and any other details required to demonstrate that the system will function properly. Shop drawings shall be approved by WCPSS before any equipment is purchased.

B. Documentation: Operating and Maintenance (O&M) manuals for the system shall be made available electronically, accessible from the control system JACE, and include the following categories: User's Manual, Project Engineering Handbook, and Software Documentation. Submit two (2) copies of system documentation directly after receipt of reviewed shop drawings.

1. BAS User's Manual shall contain as a minimum:

a. System overview.

b. Contractor’s name, address, 24-hour telephone number, and job control number. As applicable, also include telephone numbers, and contact names for service during normal hours, service during off-hours, parts ordering, and technical support.

c. Name, signature and title of Contractor’s representative responsible for preparation of technical manual. Include date of issuance and revision number.

d. Warranty information including start and end dates. Coverage's as they pertain to labor, service parts, replacements, etc. Warranty limitations if any exist.

e. Alphabetical list of all system components installed as part of this job, including control devices, relays, power supplies, sensors, and accessory items. List manufacturer name and manufacturer's part number, and include the name, address, and 24-hour phone number of the company responsible for servicing and supplying each item during the first year of operation or warranty period, whichever is greater. Identify where each replacement part can be purchased by the owner for future replacement.

f. Include a wiring identification matrix which shows wire color codes and assignments, and labeling definitions.

g. Generate a maintenance procedure for all aspects of the system. The procedures shall indicate recommended durations and frequency for each task as well as the means and methods to accomplish each item. This procedure shall include the following minimum requirements:
   1) Procedure for updating operating software on the system controllers. This shall include a procedure for obtaining security patches, updates, and network software updates and patches. Coordinate this procedure with the Network Integrator.
   2) Calibration routines, frequency, and procedures for all sensors and actuators.
   3) Required maintenance for all other system components.

h. Include installation and service manuals for each device supplied by the controls contractor as part of this project.

i. Include a documented list of every user name and password required to access all aspects of the system. This shall include user names and passwords to gain access and modify the following components but shall not be limited to:

j. DDC Controllers.

k. Network Electronics.

l. Networking concepts.

m. Launching a web browser from a networked PC and login.

n. Web Browser Graphical User Interface (GUI) screen menus and their definitions.

o. Creating, modifying or deleting schedules.

p. Uploading and downloading software to the field hardware.

q. Creating historical trends, collecting trend data and generating trend graphs.

r. Enabling and assigning alarms and messages to reporting actions/groups.

s. Report generation and 'third party software'.

t. Backing up software and data files.

u. Creating, modifying or deleting control loop logic.

2. Project Engineering Manual shall contain as a minimum:

    a. System architecture overview and networking configuration.

    b. Hardware cut-sheets and product descriptions.

    c. The BAS Contractor shall deliver 'as-built' drawings and written sequences of operation in accordance with Division 1 that reflect final WCPSS assigned device and room numbers. All drawings shall be reviewed after the final system checkout and updated to provide 'as-built' drawings. The system will not be considered complete until the 'as-built' drawings have received their final approval.

    d. Include the following as-built drawings as a minimum. All drawings requested shall be updated to include field modifications and change orders. The drawings shall be printed on 11x17 sheets, folded to 8.5 x 11, and included in the binder.
        1) All submittal drawings updated to include field modifications and change orders, and all information requested below:
            i) Functional temperature control diagrams for each mechanical system served by the BAS. Indicate and tag each input/output served by each ASC or PCU.
            ii) Floor plans indicating the exact installed location of the following equipment and/or devices:
            a. All control panels and miscellaneous control devices.
            b. All network controllers, Web Server, and operator workstations.
            c. Indicate all communications / network wiring between control devices.
            d. Indicate all BAS FACLAN wiring.
            e. All major BAS integrated equipment (i.e. Air Handlers, Boilers etc.)
        2) Additional drawings to include:
            i) Legend of all symbols, line types, and abbreviations used.
            ii) Wiring details for any device wiring or interconnection that varies from accepted industry practices or for which none exist.
            iii) Logical program flow diagram for every programmable controller. Flow diagrams shall be developed and designed in accordance with industry standards and shall indicate the natural flow of the control software. Flow charts shall clearly indicate each source line or program block of programming code.

    e. Installation, mounting and connection details for all field hardware and accessories.

    f. Commissioning, setup and backup procedures for all control modules/accessories, BAS server software, and database.

    g. Listing of basic terminology, alarms/messages, error messages and frequently used commands or shortcuts.

3. BAS Software Documentation shall contain as a minimum:

    a. The Contractor shall provide all Graphical Programs, detailing their application to specific HVAC equipment and electrical/mechanical subsystems, together with a glossary or icon symbol library detailing the function of each graphical icon. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-builts".

    b. Graphical representation of the mechanical equipment hierarchy for the project including all equipment controlled by the BAS. For example: a VAV terminal box

may be the source for increased cooling demand and require the primary VAV AHU to operate which, in turn, requires the chillers to operate.

c. Detailed listing of all alarm and event messages programmed for designated mechanical/electrical equipment and required operator action.

C. On Site documentation:

1. At each field controller provide a laminated diagram, showing all connected control points, point naming, and system name.

2. At building main controller provide laminated diagram of entire controller network. Include device name, and room location.

3. Provide manual for local users describing method to access, monitor and schedule systems operation.

1.06 QUALITY ASSURANCE

A. Comply with all current codes, ordinances, regulations, and WCPSS insurance underwriters. In all cases of conflict between the work of this Division and Building Code, or omission of items required for code compliance, the issue shall be brought to the attention of the WCPSS at the time of bid proposal submission. Any items of conflict or omission shall be identified, resolved and included in the bid proposal price.

B. The BAS work shall comply with all applicable requirements of the following codes. The latest edition is assumed unless stated otherwise or as amended by the Local Code Authorities

1. NFPA

2. BOCA, UBC, SBC

3. Local City and State Building Codes

4. National Electric Code, as modified by Local Code

C. Where codes are listed herein, the applicable portions of the latest editions apply.

D. Drawings, specifications, codes and standards are minimum requirements. Where requirements differ, apply the more stringent.

E. Should any change in Drawings or Specifications be required to comply with regulations, the Contractor shall notify the Owner prior to execution of the work and wait for direction from the Owner.

F. Codes and Regulations:

1. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

2. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

3. Standards Authority. All equipment and material, and its installation, shall conform to the current requirements of the following authorities:

a. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
b. American National Standards Institute (ANSI) ANSI/ASHRA 135BACnet – Data Communication Protocol for Building Automation and Control Networks
c. American Society of Mechanical Engineers (ASME)
d. American Society for Testing and Materials (ASTM)
e. American Refrigeration Institute (ARI)
f. ATA 878.1 Local Area Network
g. Electronics Industries Alliance:
    1) EIA-709.1-A-99: Control Network Protocol Specification.
    2) EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
    3) EIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
    4) EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
    5) EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
    6) EIA-472: General and Sectional Specifications for Fiber Optic Cable.
    7) EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
    8) EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
    9) EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
h. Underwriters Laboratories:
    1) UL 916: Energy Management Systems.
    2) UUKL 864: UL Supervised Smoke Control if the BAS is used for smoke control.
    3) UL 873 Temperature Indicating Equipment
    4) All electrical products to be listed and labeled by UL and comply with NEMA Standards.
i. NEMA Compliance:
    1) NEMA 250: Enclosure for Electrical Equipment.
    2) NEMA ICS 1: General Standards for Industrial Controls.
j. NFPA Compliance:
    1) NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
    2) NFPA 70 National Electrical Code (NEC).
k. Instrument Society of America (ISA)
l. Institute of Electrical and Electronics Engineers (IEEE)
    1) IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
    2) IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
    3) IEEE 519: Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
m. Joint Industrial Council (JIC)
n. LonMark® International
o. Occupational Safety and Health Act (OSHA)
p. Federal Communications Commission (FCC), Parts 15 and 16
q. National Electric Code (NEC).
r. Uniform Mechanical Code.
s. Uniform Building Code.
t. Uniform Plumbing Code.

G. Product Applicable Standards. All distributed, standalone and unitary controllers supplied shall be in compliance with the following listings and standards:

1. UL916 for Open Energy Management (for U.S. and Canada).

2. FCC Part 15, Sub-Part B, Class A.

3. CE Electro Magnetic Compatibility.

H. All microprocessor based control products used shall conform to either the LONMARK® or LonWorks Interoperability Standards or the BACnet ASHRAE/ANSI 135 Standard including all current addenda and annexes dependent upon which communications protocol is being utilized.

I. For equipment types that LONMARK® or BACnet devices do not exist, a Modbus interface to that equipment must be provided upon approval of WCPSS. The use of all proprietary equipment is prohibited. It is the Contractor's responsibility to verify that the equipment manufacturers provide the appropriate interface boards as defined in these specifications and design drawings.

J. The contractor shall provide hardware and software components of the same manufacturer wherever possible.

K. The contractor shall use standard off-the-shelf components and/or products whenever possible. Custom products shall not be used unless approved by WCPSS prior to the installation.

L. Materials and equipment shall be catalogued products and shall be manufacturer's latest standard design that complies with the specification requirements. Where multiple units of the same type or function are required for this project, these units shall be products of a single manufacturer.

M. All equipment shall be manufactured, installed and tested to comply with the acceptance testing requirements specified herein.

N. Product Line Demonstrated History: The product line being proposed for the Project must have an installed history of demonstrated satisfactory operation for a length of two (2) years since date of final completion in at least ten (10) installations of comparative size and complexity. Submittals shall document this requirement with references.

O. Installer's Qualifications: The Contractor shall have a successful history in the design and installation of LONWORKS® or BACnet based Building Automation Systems with web browser based monitoring and control via and Enterprise network. Contractor must demonstrate experience in BAS installations for not less than 5 years and in DDC installation projects with point counts equal to this Project and systems of the same character as this Project. If installer is a Value Added Reseller (VAR) of a manufacturer's product, installer must demonstrate at least three years prior experience with that manufacturer's products. Experience starts with awarded Final Completion of previous projects. Submittals must document this experience with references.

P. Installer's Experience with Proposed Product Line: Firms shall have specialized in and be experienced with the installation of the proposed product line for not less than five years from date of final completion on at least ten (10) projects of similar size and complexity. Submittals shall document this experience with references.

Q. Installer's Field Coordinator and Sequence Programmer Qualifications: Individual(s) shall specialize in and be experienced with LONWORKS® or BACnet and Niagara N4 control system installation for not less than five (5) years. Installer shall include a list of qualified

employees on staff with specific experience that will be committed to the project. Proposed field coordinator shall have experience with the installation of the proposed product line for not less than five (5) projects of similar size and complexity. Installer shall submit the names of the proposed individual and at least one alternate for each duty. Submittals shall document this experience with references. Proposed individuals must show proof of the following training:

1. Product Line Training: Individuals overseeing the installation and configuration of the proposed product line must provide evidence of the most advanced training and certifications offered by the manufacturer(s) on that product line for installation and configuration.

2. Programming Training: Individuals involved with programming the Site-specific sequences shall provide evidence of the most advanced programming training and certifications offered by the vendor of the programming application offered by the manufacturer(s). Engineering services shall be performed by factory-trained engineers. Include relevant documentation in submittal package.

R. Installer's Service Qualifications: The installer must be experienced in control system operation, maintenance and service. Installer must document a minimum five (5) year history of servicing installations of similar size and complexity. Installer must document at least a one year history of servicing the proposed product line. Installer must also provide references and examples of projects that have been completed.

S. Coordinate with the Owner to ensure that the BAS will perform in the Owner's IT environment without disruption to any of the other activities taking place on that LAN or WAN. Coordinate device IDs with owner to prevent duplication within existing WCPSS BAS environment.

T. Uniformity: To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

U. Installer's Response Time and Proximity:

1. Installer shall have an office, which is staffed with LONWORKS® or BACnet and network infrastructure trained engineers and technicians fully capable of providing instruction and routine emergency maintenance service on all system components within 24 hours of notification.

2. Installer shall have a service facility within a 50-mile radius of the job site, staffed with qualified service personnel as defined above, fully capable of providing instructions and routine or emergency maintenance service. The Installer must also have qualified staff able to respond to the job site to insure a response time of one hour or less for all construction and warrantee related issues. The Installer shall provide a dedicated team to the project if working on different projects simultaneously. Provide evidence of this as a condition of acceptance of bid. Local staff shall be qualified in all aspects related to the BAS control system repair and troubleshooting including, HVAC and mechanical equipment operation, network management, and DDC controller programming and configuration.

V. Install control devices in accessible location with reasonable working access. Coordinate all control device locations with other trade contractors. Contractor to report to A/E conditions that prevent reasonable accessibility.

W. Provide weather protection cover or weatherproof control devices where required for control devices located outdoors.

X. All control devices located outdoors shall be rated for the anticipated environment.

1.07 PROJECT CLOSEOUT

A. At conclusion of each day's work, clean up and remove from the site all rubbish, debris and trash accumulated during the day as a result of work of the Contractor. Sidewalks and streets adjoining the property shall be kept broom clean and free of debris, rubbish, trash and obstructions of any kind caused by work of this Contract.

B. Upon completion of the work and at times during progress of the work when requested by WCPSS, the Contractor shall remove all surplus materials, rubbish, and debris resulting from the operation, and shall leave the entire building and involved portions of the site, insofar as the work of the Contract is concerned, in neat, clean and acceptable condition as approved by Owner.

C. Marks on walls or ceiling tiles caused by the Contractor shall be cleaned by the Contractor. Ceiling tiles, drywall, carpet, paint, and all architectural finishes damaged by the Contractor shall be replaced by the Contractor.

1.08 ABBREVIATIONS AND ACRONYMS

AHU	Air Handling Unit
AI	Analog Input
ANSI	American National Standards Institute
AO	Analog Output
Approx.	Approximately
ASC	Application Specific Controller
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASPE	American Society of Plumbing Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATC	Automatic Temperature Control System
AWG	American Wire Gauge (Standard)
BAS	Building Automation System
BMS	Building Management System
CAD	Computer Aided Design
CCC	Central Communications Controller
CCU	Central Control Unit
Contr.	Contractor
COS	Change of State
CPU	Central Processing Unit
CRAC	Computer Room Air Conditioning

CRT	Cathode Ray Tube
DALI	Digital Addressable Lighting Interface
DCP	Digital Control Panel
DDC	Direct Digital Controls
Deg. C or °C	Degree Celsius
DI	Discrete Input
Dia. or diam.	Diameter
DMA	Direct Memory Access
DO	Discrete Output
Dpr.	Damper
Dwgs.	Drawings
EP	Electric-pneumatic
EMCS	Energy Management Control System
FAC LAN	Facility Local Area Network
FPB	Fan powered (VAV) box
FPM	Feet per minute
FACP	Fire Alarm Control Panel
FCC	Fire Command Center
FCIP	Firefighters' Control and Indicating Panel
FMS	Facility Management System
Galv.	Galvanized
GUI	Graphical User Interface
HVAC	Heating Ventilating and Air Conditioning
I/O	Input/Output
ISA	Intelligent Sensor or Actuator
LNS	LONWORKS® Network Services
NC	Network Controller
NSS	Network Services Server
NSI	Network Services Interface
Mfr.	Manufacture
Mfgr.	Manufacturer
Max.	Maximum
Min.	Minimum, Minute
MMI	Man-Machine Interface
MSCP	Mass Storage Control Protocol
MSI	Master System Integrator

NCP	Network Control Panel
NEC	National Electrical Code
NI	Network Integrator
NIC	Not in Contract
NFPA	National Fire Protection Association
O.C.	On Center
O.D.	Outside Diameter
OS	Operating System
PE	Pneumatic-electric
Per	According to, in accordance with
PCU	Programmable Control Unit
PRV	Pressure Reducing Valve
Provide	Furnish and install
RAM	Random Access Memory
ROM	Read Only Memory
RTD	Resistance Temperature Device
SCADA	Supervisory Control and Data Acquisition System
SI	Systems Integrator
SNVT	Standard Network Variable Type
TCP/IP	Transmission Control Protocol / Internet Protocol
THHN	Thermoplastic High Heat Resistant Nylon Coated-Cable coating
TP	Twisted Pair
UBC	Uniform Building Code
UL	Underwriters' Laboratory
UMC	Uniform Mechanical Code
UML	Unified Modeling Language
UPS	Uninterruptible Power Supply
VAV	Variable Air Volume
VCS	Voice Communication System
VFD	Variable Frequency Drive
XIF	LONMARK® Product Information Files
XML	Extensible Markup Language

PART 2 PRODUCTS

2.01 MANUFACTURERS: CONTROLS CONTRACTORS SHALL BE TRIDIUM AND/OR LONMARK OR BACNET FACTORY AUTHORIZED AGENT OR DEALER OF control hardware and controls system interface. The controls contractors' principal business shall be providing building automation systems. Bids by contractors, franchised dealers, wholesalers, or any other firm whose principal business is not that of manufacturing, or installing building automation systems, shall not be acceptable

2.02 BAS SERVER & WEB BROWSER GUI

2.02.1 SYSTEM OVERVIEW:

A. The BAS Contractor shall provide system software based on server/thin-client architecture, designed around the open standards of web technology. The BAS server shall communicate using Ethernet and TCP\IP. Server shall be accessed using a web browser over Owner intranet and remotely over the Internet.

B. Graphic software shall facilitate user-friendly interface to all aspects of the System Software. The intent of this Specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis. The Operator Interface shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, and remote monitoring. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™. No special software, other than free public domain programs such as "JAVA VIRTUAL MACHINE" shall be required to be installed on PC's used to access the BAS via a web browser.

C. The systems shall be configured for mobile devices. Refer to Section 2.03.5 Mobile Device for detailed description.

D. The number of network controllers required is dependent on the type and quantity of devices installed. It is the responsibility of the Contractor to determine the quantity and type of devices. The Contractor shall be responsible to properly install the correct number (increase if required) of network controllers from the designed minimum shown on the BAS documents. The Contractor shall confirm the designed network load and architecture with the capabilities of the selected Network Controller. If network communications issues arise as a result of a limited Network Controller resource count the Network Integrator shall furnish, install, and implement additional Network Controllers to reduce the network traffic on each Network Controllers Local Operating Network to less than 50% of maximum bandwidth as recommended by the manufacturer. The total capacity includes all imbedded applications as well as design specific applications. Refer to Section 1.05.A.3.n for calculated and guaranteed system response time for submittal requirements.

E. The web browser GUI shall provide an interactive user interface and must offer and be configured with the following features as a minimum:

1. Trending.

2. Scheduling.

3. Electrical demand limiting.

4. Real time 'live' Graphic Programs.

5. Tree Navigation.
6. Parameter change of properties.
7. Set-point Adjustments.
8. Alarm / Event information.
9. Configuration of operators.
10. Execution of global commands.
11. Add, delete, and modify graphics and displayed data.

F. Software Components: All software components of the BAS system software shall be provided and installed as part of this project. BAS software components shall include:

1. System Configuration Utilities for future modifications to the system, and controllers shall include all software and programming not specifically itemized in these specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
2. Graphical Programming Tools.
3. Direct Digital Control Software.
4. Application Software.

2.02.2 WEB BROWSER GRAPHICAL USER INTERFACE

A. Web Browser Navigation: The Thin Client web browser GUI shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to “feel” like a single application, and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser to accomplish requirements of this specification. The Web Browser GUI shall (as a minimum) provide for navigation, and for display of animated graphics, schedules, alarms/events, live graphic programs, active graphic setpoint controls, configuration menus for operator access, reports, and reporting actions for events and trends.

B. Login: On launching the web browser and selecting the appropriate domain name or IP address, the operator shall be presented with a login page that will require a login name and password. Navigation in the system shall be dependent on the operator’s role privileges.

1. Sites with multiple JACE’s shall have a single log in to observe graphics and trending for that location. Multiple logins for JACE’s located on the same site will be unacceptable.

C. Navigation: Navigation through the GUI shall be accomplished by clicking on appropriate level of a navigation tree (consisting of expandable and collapsible tree control like Microsoft’s Explorer program), and/or by selecting dynamic links to other system graphics. Both the navigation tree and action pane shall be displayed simultaneously, enabling the operator to select a specific system or equipment, and view the corresponding graphic. The navigation tree shall as a minimum provide the following views: Home, Files, History and Configuration.

1. Home view shall display graphical categories such as Floor Plans, Central Plant, Air Handlers, Service Screens, and As-Builts.

2. Configuration View shall display all the configuration categories (Services, Drivers, Global Folder, Schedules Folder).

D. Action Pane: The Action Pane shall provide several functional views for each HVAC or mechanical/electrical subsystem specified. A functional view shall be accessed by clicking on the corresponding button:

1. Graphics: Using graphical format suitable for display in a web browser, graphics shall include, color building floor-plans, equipment drawings, active graphic set-point controls, web content and other valid HTML elements. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.

2. Properties: Shall include graphic controls and text for the following: Locking or overriding objects, demand strategies, and any other valid data required for setup. Changes made to the properties pages shall require the operator to depress an ‘accept/cancel’ button.

3. Schedules: Shall be used to create, modify/edit and view schedules based on the systems geographical hierarchy (using the navigation tree). 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. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

4. Alarms: Shall be used to view alarm information geographically (using the navigation tree), acknowledge alarms, sort alarms by category, actions and verify reporting actions.

5. Trends: Shall be used to display associated trend and historical data, modify colors, date range, axis and scaling. Refer to O&M documents for definition of trends, i.e. duration, start/stop points and set-points and example graphics.

6. Logic - Live Graphic Programs: Shall be used to display’ live’ graphic programs of the control algorithm, (micro block programming) for the mechanical/electrical system selected in the navigation tree.

7. Other actions such as Print, Help, Command, and Logout shall be available via a drop-down window.

E. Point Structuring and Naming

1. The intent of this Section is to require a consistent means of naming points across WCPSS WAN. Configure the systems from the perspective of WCPSS WAN, not solely the local Project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like. The convention is tailored towards WCPSS WAN and as such, the interface shall always use this naming convention. LonMark and BACnet systems shall also use this naming convention. For non-LonMark and BACnet systems, the naming convention shall be implemented as much as practical, and any deviations from this naming convention shall be approved by WCPSS.

2. Each Network Controller shall have English language descriptors for all system points, variables, parameters etc. located and accessible from the NC memory. All point naming shall match between all system files and record documents.

3. Point Summary Table: The term 'Point' is a generic description for the class of object represented by analog and binary inputs, outputs, and values. With each schematic, Network Integrator shall provide a Point Summary Table listing:

   a. Equipment type.

   b. Equipment number.

   c. Equipment code.

   d. Full point name (see Point Naming Convention paragraph).

   e. Point description.

   f. Object type.

   g. Engineering units.

   h. Network variable.

4. Additional fields for non-LonMark or BACnet systems shall be appended to each row. Point Summary Table shall be provided in both hard copy and in electronic format (ODBC-compliant).

5. Point Summary Table shall also illustrate Network Variable Data Links.

6. The System Integrator shall coordinate with WCPSS representative to compile and submit a proposed Point Summary Table for review prior to any object programming or Project startup. WCPSS shall grant approval of final point names to be verified through Commissioning by issuing the approved alarms to the System Integrator.

7. The Point Summary Table shall be kept current throughout the duration of the Project by the installer as the Master List of all points for the Project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The System Integrator shall deliver to WCPSS the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the Commissioning process.

8. The Point Summary Table shall contain all data fields on a single row per point. The Point Summary Table is to have a single master source for all point information in the building that is easily sorted and kept up-to-date. Although a relational database of Device ID-to-point information would be more efficient, the single line format is required as a single master table that will reflect all point information for the building. The point description shall be an easily understandable English-language description of the point.

Point Summary Table - Example	
(Transpose for a single point per row format)	
Equipment Type	Air Handler (AH)
Equipment Number	031

Point Summary Table - Example	
(Transpose for a single point per row format)	
Equipment Code	SAT
*Point Name (Object Name)	LIB04_1000a_AH031_SAT
*Point Description (Object Description)	AH031 Supply Air Temperature
Object Type	AI
Engineering Units	Deg F
Network Variable	SNVT_temp
*Represents information that shall reside in the relevant property for the object	

F. Color Graphics: The Web Browser GUI shall make extensive use of color in the graphic pane to communicate information related to set-points and comfort. Animated .gifs or .jpg, vector scalable, active set-point graphic controls shall be used to enhance usability. Graphics tools used to create Web Browser graphics shall be non-proprietary and conform to the following basic criteria:

1. Display Size: The GUI workstation software shall graphically display in 1024 by 768 pixels 24 bit True Color.

2. Color Floor Plans: Floor plan graphics shall show heating and cooling zones, as well as lighting, security and refrigeration equipment zones throughout the buildings in a range of colors, as selected by Owner. Provide a visual display of temperature relative to their respective set-points. The colors shall be updated dynamically as a zone's actual comfort condition changes.

3. Mechanical Components: Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components and shall include selected I/O points being controlled or monitored for each piece of equipment shall be displayed with the appropriate engineering units. Animation shall be used for rotation or moving mechanical components to enhance usability.

4. Minimum System Color Graphics: Color graphics shall be selected and displayed via a web browser for the following:

   a. Each piece of equipment monitored or controlled including each terminal unit.

   b. Each building.

   c. Each floor and zone controlled.

G. Zone Set-point Adjustments: Color floor plans displayed via a web browser shall utilize a contiguous band of colors, as selected by Owner. Each corresponding actual zone

temperatures shall vary color relative to the desired active set-point. The ideal temperature shall be shown as a neutral (white, transparent) color band. Temperatures slightly warmer than ideal shall be shown in light red, and even warmer temperature band shall be shown in red. Temperatures slightly cooler than ideal shall be light blue, and even cooler temperatures shall be shown as dark blue. Active Zone Graphic Set-point Controls: Utilizing a mouse, it shall be possible to select occupied or unoccupied set-points to increase or decrease heating and cooling set-points. In addition, an operator may type the numeric value of the heating and cooling set-points.

H. Hierarchical Schedules: Utilizing the Navigation Tree displayed in the web browser GUI, an operator (with password access) shall be able to define a Normal, Holiday or Override schedule for an individual piece of equipment or room, or choose to apply a hierarchical schedule to the entire system, site or floor area. For example, Independence Day 'Holiday' for every level in the system would be created by clicking at the top of the geographic hierarchy defined in the Navigation Tree. No further operator intervention would be required and every control module in the system with would be automatically downloaded with the 'Independence Day' Holiday.

1. Schedules: Schedules shall comply with the LonWorks or BACnet standards, (Schedule Object, Calendar Object, Weekly Schedule property and Exception Schedule property) and shall allow events to be scheduled based on:

    a. Types of schedule shall be Normal, Holiday or Override.

    b. A specific date.

    c. A range of dates.

    d. Any combination of Month of Year (1-12, any), Week of Month (1-5, last, any), Day of Week (M-Sun, Any).

    e. Wildcard (example, allow combinations like second Tuesday of every month).

2. Schedule Categories: The system shall allow operators to define and edit scheduling categories (different types of "things" to be scheduled; for example, lighting, HVAC occupancy, etc.). The categories shall include: name, description, icon (to display in the hierarchy tree when icon option is selected) and type of value to be scheduled.

3. Schedule Groups: In addition to hierarchical scheduling, operators shall be able to define functional Schedule Groups, comprised of an arbitrary group of areas/rooms/equipment scattered throughout the facility and site. For example, the operator shall be able to define an 'individual tenant' group – who may occupy different areas within a building or buildings. Schedules applied to the 'tenant group' shall automatically be downloaded to control modules affecting spaces occupied by the 'tenant group'

4. Intelligent Scheduling: The control system shall be intelligent enough to automatically turn on any supporting equipment needed to control the environment in an occupied space. If the operator schedules an individual room in a VAV system for occupancy, for example, the control logic shall automatically turn on the VAV air handling unit, chiller, boiler, and/or any other equipment required to maintain the specified comfort and environmental conditions within the room.

5. Partial Day Exceptions: Schedule events shall be able to accommodate a time range specified by the operator (ex: board meeting from 6 pm to 9 pm overrides Normal schedule for conference room).

I. Alarms: Alarms associated with a specific system, area, or equipment selected in the Navigation Tree, shall be displayed in the Action Pane by selecting an 'Alarms' view. Alarms, and reporting actions shall have the following capabilities:

1. Alarms View: Each Alarm shall display an Alarms Category (using a different icon for each alarm category), date/time of occurrence, current status, alarm report, and a bold URL link to the associated graphic for the selected system, area or equipment. The URL link shall indicate the system location, address and other pertinent information. An operator shall easily be able to sort events, edit event templates and categories, acknowledge or force a return to normal in the Events View as specified in this section.

   a. System shall support displaying of alarms on any display as a user defined sizable object, which may be placed by itself or along with other objects in a window. It shall be possible to scroll forward or backward through the alarm displays by depressing command buttons. Current Alarms shall be available as an Alarm Summary Object and a chronological summary of Alarms shall be available as an Alarm History object.

   b. The operator shall be able to select the alarms displayed by an object alarms by group and/or priority by using command buttons. Up to 999 priority levels shall be supported.

2. Alarm Categories: The operator shall be able to create, edit or delete alarm categories such as HVAC, Maintenance, Fire, or Generator. An icon shall be associated with each alarm category, enabling the operator to easily sort through multiple events displayed.

3. Alarm Notification: It shall be possible to configure the system such that the operator is notified of an alarm no matter what display he or she is currently viewing. Notification shall include the option of a pop-up alarm display window, a flashing process symbol, such as a process vessel, an alarm text message that is available on each display, or a dedicated alarm display window on the screen.

   a. The user shall be able to display alarms on an individual or a group basis, with support for sixteen (16) groups, each having up to sixteen (16) subgroups. The alarm hierarchy shall be capable of being nested up to eight (8) levels deep.

   b. It shall be possible to inform the operator of an alarm condition via an audible tone, a pop-up display, or any combination of animation types on the screen. Alarm acknowledgment may be performed on all alarms, alarms in a single group, and alarms in a collection of groups as defined in an alarm group hierarchy or on a point-by-point basis.

4. Alarm File Capability:

   a. Alarms shall be logged to a file for future viewing or review of alarm history data. The user shall have the capability to review the file for cause and event analysis.

   b. The alarms that are logged shall be configurable from a choice of the parameters.

5. Alarm Transmission Capability:

   a. Alarms shall be transmitted over WCPSS secure internal wide area network.

b. Each alarm shall be associated with a priority level and unique user-defined list of operator devices including any combination of local or remote workstations, printers, workstation disk files, e-mail addresses, and pagers. All alarms associated with a given priority level shall be routed to all operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the event that alarms are unable to be routed to any operator device assigned to the priority level.

6. Alarm Templates: Alarm template shall define different types of alarms and their associated properties. As a minimum, properties shall include a reference name, verbose description, severity of alarm, acknowledgement requirements, and high/low limit and out of range information.

7. Alarm Areas: Alarm Areas enable an operator to assign specific Alarm Categories to specific Alarm Reporting Actions. For example, it shall be possible for an operator to assign all HVAC Maintenance Alarm on the 1st floor of a building to email the technician responsible for maintenance. The Navigation Tree shall be used to setup Alarm Areas in the Graphic Pane.

8. Alarm Time/Date Stamp: All events shall be generated at the DDC control module level and comprise the Time/Date Stamp using the standalone control module time and date.

9. Alarm Configuration: Operators shall be able to define the type of Alarm generated per object. A ‘network’ view of the Navigation Tree shall expose all objects and their respective Alarm Configuration. Configuration shall include assignment of Alarm, type of Acknowledgement and notification for return to normal or fault status.

10. Alarm Summary Counter: The view of Alarm in the Graphic Pane shall provide a numeric counter, indicating how many Alarms are active (in alarm), require acknowledgement, and total number of Alarms in the BAS Server database.

11. Alarm Auto-Deletion: Alarms that are acknowledged and closed shall be auto-deleted from the database and archived to a text file after an operator defined period.

12. Alarm Reporting Actions: Alarm Reporting Actions specified shall be automatically launched (under certain conditions) after an Alarm is received by the BAS server software. Operators shall be able to easily define these Reporting Actions using the Navigation Tree and Graphic Pane through the web browser GUI. Alarms shall be color coded according to the state of the alarm, including an acknowledged alarm, unacknowledged alarm, and an alarm that has returned to normal, but is not yet acknowledged. The user shall be able to choose from 32 different colors for display of each of these alarm states. The alarm display object may also support event display with the color used for events also being one of the 32 different colors. Reporting Actions shall be as follows:

    a. Email: Email shall be sent via any POP3-compatible e-mail server (most Internet Service Providers use POP3). Email messages may be copied to several email accounts.

    b. Note: Email reporting action shall also be used to support alphanumeric paging

    c. Services, where email servers support pagers.

    d. File Write: The ASCII File write reporting action shall enable the operator to append

e. Operator defined alarm information to any alarm through a text file. The alarm information that is written to the file shall be completely definable by the operator. The operator may enter text or attach other data point information (such as AHU discharge temperature and fan condition upon a high room temperature alarm).

f. Write Property: The write property reporting action updates a property value in a hardware module.

g. SNMP: The Simple Network Management Protocol (SNMP) reporting action sends an SNMP trap to a network in response to receiving an alarm.

h. Run External Program: The Run External Program reporting action launches specified program in response to an event.

J. Trends: Trends shall both be displayed and user configurable through the Web Browser GUI. Trends shall comprise all analog, digital or calculated points simultaneously. A trend log's properties shall be editable using the Navigation Tree and Graphic Pane.

1. Viewing Trends: The operator shall have the ability to view trends by using the Navigation Tree and selecting a Trends button in the Graphic Pane located on every page. The system shall allow y- and x-axis maximum ranges to be specified and shall be able to simultaneously graphically display multiple trends per graph.

2. Local Trends: Trend data shall be collected locally by the JACE or Web Supervision, and periodically uploaded to the BAS server if historical trending is enabled for the object. Trend data, including run time hours and start time date shall be retained in non-volatile module memory. Systems that rely on a gateway/router to run trends are NOT acceptable.

3. Events: Events shall be logged for review by the operator, engineering or management personnel. The system shall log each new operator log-on, and whenever an operator changes a set-point or turns any device on or off. Each time the event log records an event, it will record the operator logged in and the type of action taken (set-point change, state change, etc.), along with a date and time stamp

4. Resolution. Sample intervals shall be as small as one second. Each trended point will have the ability to be trended at a different trend interval. When multiple points are selected for displays that have different trend intervals, the system will automatically scale the axis.

5. Dynamic Update. Trends shall be able to dynamically update at operator-defined intervals.

6. Zoom/Pan. It shall be possible to zoom-in on a particular section of a trend for more detailed examination and 'pan through' historical data by simply scrolling the mouse.

7. Numeric Value Display. It shall be possible to pick any sample on a trend and have the numerical value displayed.

8. Trend Point Naming. The naming convention for points shall be in plain English and separate the data using the underscore (_). (Example: AHU01_SupplyAirTemp, Vav01_15_SpaceTemp, ChilledWater_ChillerEnable, HotWater_Boiler02_FireRate).

9. Copy/Paste. The operator must have the ability to pan through a historical trend and copy the data viewed to the clipboard using standard keystrokes (i.e. CTRL+C, CTRL+V).

K. Security Access: Systems that Security access from the web browser GUI to BAS server shall require a Login Name and Password. Access to different areas of the BAS system shall be defined in terms of Roles, Privileges and geographic area of responsibility as specified:

1. Roles: Roles shall reflect the actual roles of different types of operators. Each role shall comprise a set of 'easily understood English language' privileges. Roles shall be defined in terms of View, Edit and Function Privileges.

a. View Privileges shall comprise: Navigation, Network, and Configuration Trees, Operators, Roles and Privileges, Alarm/Event Template and Reporting Action.

b. Edit Privileges shall comprise: Set-point, Tuning and Logic, Manual Override, and Point Assignment Parameters.

c. Function Privileges shall comprise: Alarm/Event Acknowledgement, Control Module Memory Download, Upload, Schedules, Schedule Groups, Manual Commands, Print, and Alarm/Event Maintenance.

2.02.3 GRAPHICAL PROGRAMMING

The system software shall include a Graphic Programming Language (GPL) for all DDC control algorithms resident in all control modules. All systems shall use a GPL as a method used to create a sequence of operations by assembling graphic microblocks that represent each of the commands or functions necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex DDC and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

Graphic programming shall be performed while on screen and using a mouse; each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires," each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires then forms a graphic function block which may be used to control any piece of equipment with a similar point configuration and sequence of operation.

A. Graphic Sequence: The clarity of the graphic sequence must be such that the operator has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming must be self-documenting and provide the operator with an understandable and exact representation of each sequence of operation.

B. GPL Capabilities: The following is a minimum definition of the capabilities of the Graphic Programming software (Refer to Part 4 – Appendix for specific examples):

1. Function Block (FB): Shall be a collection of points, microblocks and wires which have been connected together for the specific purpose of controlling a piece of equipment or a single mechanical system.

2. Logical I/O: Input/Output points shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.

3. Microblocks: Shall be software devices that are represented graphically and may be connected together to perform a specified sequence. A library of microblocks shall be submitted with the control contractors shop drawings, submittals and as-builts.

4. Wires: Shall be Graphical elements used to form logical connections between microblocks and between logical I/O.
5. Reference Labels: Labels shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, i.e. two points labeled 'A' on a drawing are logically connected even though there is no wire between them.
6. Parameter: A parameter shall be a value that may be tied to the input of a microblock.
7. Properties: Dialog boxes shall appear after a microblock has been inserted which has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields, and shall contain 'push buttons' for the purpose of selecting default parameter settings.
8. Icon: An icon shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes its function.
9. Menu-bar Icon: Shall be an icon that is displayed on the menu bar on the GPL screen, which represents its associated graphic microblock.
10. Live Graphical Programs: The Graphic Programming software must support a 'live' mode, where all input/output data, calculated data, and setpoints shall be displayed in a 'live' real-time mode.

For each piece of equipment, the entire graphic program shall be displayed through the Web Browser GUI. The operator must have the ability to scroll or page through the entire 'live' graphic program as necessary. Piecemeal graphic programs that only show one part of equipment program at any one time are NOT acceptable. For example, when viewing an AHU live graphic program, the operator shall see as much of the AHU graphic program as practical, not just the Heating Coil control.

2.03 BAS SYSTEM HARDWARE

2.03.1 BAS SERVER HARDWARE

A. Computer Configuration (Hardware Independent):

1. Central Server. Owner shall provide a dedicated BAS server.

B. Standard Client: The thin-client Web Browser BAS GUI shall be Microsoft Internet Explorer compatible to the latest version available at the time of project execution, (8.0 or later) capable of running on the latest Microsoft OS version available at the time of project execution. No special software shall be required to be installed on the PCs used to access the BAS via a web browser.

2.03.2 BUILDING LEVEL SUPERVISORY CONTROLLER (JACE):

A. These controllers contain the Niagara N4™ Framework. These controllers are designed to manage communications between the General Purpose Multiple Application Controllers, General Purpose Single Application Controllers, and Unitary Controllers which are connected to its communications trunks, manage communications between itself and other JACE's and with any operator workstations (OWS) that are part of the BAS, and perform control and operating strategies for the system based on information from any controller connected to the BAS.

B. The communication protocols utilized for peer-to-peer communications between Building Level Supervisory Controllers will be Niagara N4, BACnet TCP/IP and SNMP. Use of a proprietary communication protocol for peer-to-peer communications between Building Level Supervisory Controllers is not allowed.

C. Building Level Supervisory Controller must provide the following hardware features as a minimum:

1. One Ethernet Port-10/100 Mbs (min) Gbs preferred
2. One RS-232/485 port
3. One LonWorks Interface Module – 78KB FTT-10A, or BACnet equivalent.
4. Battery Backup for JACE soft shutdown
5. Flash memory for long term data backup
6. 2GB DDR3 SDRAM
7. Firmware Updates: The Building level supervisory controllers shall allow firmware updates to be performed remotely
8. Provide Uninterruptible Power Supply (UPS) capable of sustaining 30 minute utility power failure.

2.03.3 STANDALONE CONTROLLERS

The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system utilizing the EIA-709.1 protocol and BACnet or LonMark/LonWorks products, technology communication protocol in one open, interoperable system.

A. General Purpose Multiple Application Controllers:

1. General Purpose Multiple Application controllers must use LonWorks or BACnet as the native communication protocol between controllers.
2. General Specification. Each General Purpose Multiple Application Controller must be capable of standalone direct digital operation utilizing its own processor, non-volatile flash memory, input/output, and voltage transient and lightning protection devices. All non-volatile flash memory shall have a battery backup. Firmware revisions to the module shall be made from the BAS server or remotely over the Intranet or Internet. Controllers that require component changes to implement firmware revisions are NOT acceptable.
3. Point Programming. All point data, algorithms and application software within a controller shall be custom programmable. Program Execution. Each General Purpose Multiple Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for application programs residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the BAS.
4. Self-Test Diagnostics. Each controller shall include self-test diagnostics, enabling the controller to report malfunctions to the BAS.Building level supervisory controller.

5. PID Loops. Each General Purpose Multiple Application Controller shall contain both software and firmware to perform full DDC Proportional, Integral, Derivative (PID) control loops and programs.

6. Digital Outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed

7. Universal Inputs shall be industry standard thermistors, RTD, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, 0-5vdc, dry contact - 0.5mA maximum current.

8. Analog Output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.

B. General Purpose Single Application Controllers:

1. The General Purpose Single Application Controllers must use LonMark or BACnet as the native communication.

2. General Specification: General Purpose Single Application controllers must be capable of stand-alone DDC operation utilizing its own processor, nonvolatile flash memory, input/output, and voltage transient protection devices. Firmware revisions to the module shall be made from the Building level supervisory controller or remote locations over the Internet. Controllers that require component changes to implement Firmware revisions are NOT acceptable.

3. Point Programming: All point data, algorithms, and application software within the controllers shall be custom programmable.

4. Program Execution: Each General Purpose Single Application Controller shall execute application programs, calculations, and commands via a microcomputer resident in the controller. All operating parameters for the application program residing in each controller shall be stored in read/writable nonvolatile flash memory within the controller and will be able to upload/download to/from the Building level supervisory controller.

5. Self-Test Diagnostics: Each controller shall include self-test diagnostics, enabling the controller to report malfunctions the Building level supervisory controller.

6. PID Loops: Each General Purpose Single Application Controller shall contain both software and firmware to perform full DDC PID control loops.

7. Rooftop Mounting. The General Purpose Single Application Controllers shall be capable of being mounted directly in or on rooftop AHU equipment.

8. Operating Temperature. The General Purpose Single Application Controllers shall be capable of proper operation in an ambient temperature environment of -20°F to +150°F. (-28.9° to 65.6°C.).

9. Input-Output Processing:

   a. Digital Outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, 3 amp maximum current. Each configured as normally open or normally closed

   b. Universal Inputs shall be industry standard thermistors, RTD, 0-20mA - 24 VDC loop power, 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.

c. Analog Electronic Outputs shall be voltage mode 0-10VDC or current mode 4-20mA.

d. Enhanced Zone Sensor Input shall provide a digital display of room temperature and setpoint, setpoint adjustment and push button override with status indicator. The sensor shall provide capability for connection to the controller network for controller programming. Selected locations will have this connection wired.

C. Unitary Controller Network (VAV TERMINALS):

1. Unitary Controllers:

a. The Unitary Controllers shall LonMark or BACnet using EIA-709.1 as the native communications protocol between controllers on the unitary controller network.

b. Enhanced Zone Sensor Input shall provide a digital display of room temperature and setpoint, adjustment and push button override with status indicator. The sensor shall provide capability for connection to the controller network for controller programming. Selected locations will have this connection wired.

c. Airflow Transducer. In order to provide reliable Pressure Independent VAV operation, Unitary Controllers for pressure independent VAV applications shall have airflow transducer for accurate air measurement.

d. Actuator. Each Unitary Controller for VAV applications shall have a direct coupled electronic actuator with the following features:

1) The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque, or greater if required due to terminal size or system pressure.

2) The assembly shall mount directly to the damper operating shaft.

3) The actuator shall not require any limit switches and shall be electronically protected against overload.

4) The actuator shall automatically stop when reaching the damper or actuator end position.

5) A visual pointer for the position of the actuator.

6) The assembly shall have an anti-rotational strap supplied with the assembly that will prevent lateral movement.

7) The actuator may be an integral controller/actuator assembly or a matched controller/actuator pair

e. Visual Status. Each Unitary Controller and Unitary Controller Interface shall have LED indication for visual status of communication, power, and faults.

f. Standalone Algorithm. In the event of a loss of communication, each Unitary Controller shall control from a standalone algorithm, which maintains the assigned space temperature until communication with the Building level controller is restored.

g. Input/Output Processing:

1) Digital outputs shall be relays, or solid state switching 24 Volts AC or DC maximum, having a 1 Amp maximum current. Each relay shall be configured as normally open or normally closed, and provide a dry contact. Each unitary controller shall have a minimum of one spare programmable digital output.

2) Universal inputs shall be dry contacts or 0-5VDC. 0-20ma dc or 0-20K Ohm input impedance.

3) Analog output electronic, voltage mode 0-10VDC, current mode 0-20ma.

2.03.4 MOBILE DEVICE

A. Mobile Device Interface:

1. General Purpose. A graphical interface shall be made available to mobile devices as a way to observe and address alarms, view general graphics and make minor setpoint changes.

2. Interface. The graphics shall be made available for use on Apple or Android technology, as specified by WCPSS. The display shall utilize English language descriptors rather than cryptic code and a menu penetration technique to access data.

3. Points of Interest. Control interface points for the mobile devices shall include but not be limited to the following:

a. Alarms

b. Temperature setpoints

c. On/off status of equipment in graphical or line based form.

2.03.5 BUILDING SYSTEMS INTEGRATION

A. The BAS System shall establish a seamless interconnection with other building, electrical and/or mechanical subsystems that employ the LONTALK or BACnet protocol (Chillers, Variable frequency drives, etc.). These systems shall be controlled, monitored and graphically programmed with the same Graphical Programming Language (GPL) used for all other control modules.

1. OEM Cooperation. Full cooperation by the Original Equipment Manufacturer (OEM) in this open protocol effort shall be a requirement for bidding this project.

2.03.6 FIELD HARDWARE/INSTRUMENTATION

A. Provide all remote sensing points and instrumentation as required for the systems. All sensors shall have accuracies as stated.

B. FIELD WIRING: For each digital device shall be two or three conductor No. 22 AWG, or larger twisted sets of copper conductors 300 volts, thermoplastic. When line voltage is present in conduits or wiring trays the insulation on all conductors shall be 600 volts. For multi-conductor wire having four or more conductors, wire size shall be not less than No. 20 AWG solid copper. Concealed accessible wiring may be installed as properly supported cable. Provide protective sleeves at wall and floor penetrations. Concealed inaccessible locations and mechanical rooms shall have wiring installed in properly sized, blue colored conduit.

C. SAFETY/STATUS SWITCHES

1. Snap action SPDT switches shall operate from a neoprene slack diaphragm, corrosion-resistant stainless steel diaphragm or copper diaphragm capable of being adjusted through the total pressure range. Switches shall withstand at least twice the working pressure of the system including any standing head, and have a temperature range exceeding the worst case liquid and ambient temperature range conditions. Provide a NEMA 4 enclosure for the switch assembly. For ease of service and maintenance, install the switch with a 3 valve manifold piped in copper to pressure taps in the liquid lines.

2. Current sensing relay shall be used for pump motor status. The current sensing relay shall be adjustable within three ranges; .1-6amps, 6-40amps and 40-200amps. Contact rating shall be .15amps at 30VDC.

3. Differential air pressure switches shall be piped in parallel across fans for positive indication of flow. Static pressure sensing tips shall be used for both high and low inputs. Pressure range shall be adjustable between .07 and 1.0" W.C. Snap acting contact shall be rated at 300 VA at 120 VAC.

D. TEMPERATURE SENSOR

1. Stem or tip sensitive types.

2. Sensing elements shall be hermetically sealed.

3. Stem and tip construction shall be 304 stainless steel.

4. All external trim material shall be corrosion resistant designed for the intended application.

5. Thermometer wells shall be stainless steel. Heat transfer compounds shall be compatible with the sensors. All piping system sensors shall be installed in thermowells.

E. SENSOR ACCURACY - Sensors are only one element in the overall system accuracy to which the CU can respond. That response includes alarm decision, value display, value calculation on which analog values must be multiplied, subtracted, square rooted, etc. As such, the system end-to-end accuracies are herein stated. The following range/ accuracies are required:

± .5 for the air temperatures.

± 1.0 for water temperatures.

± 0.5 for water temperatures in the range 40 - 55 F.

KWH and KW monitoring within 1.0% of full scale value.

± 2.0 psig for water or steam pressure in the range of 0 - 200 psig.

± 1.0% of full scale value for potential or current transducers.

± 3.0% for 0-100% RH.

Sensors for differential temperature readings to be used in BTU calculations shall be a matched pair with a differential accuracy of plus or minus 0.1 degrees F.

F. Temperature Devices:

1. Type & Accuracy. Temperature sensors shall be of the type and accuracy indicated for the application. Sensors shall have an accuracy rating within 1% of the intended use temperature range.

2. Mixed Air Application. Sensors used for mixed air applications shall be the averaging type and have an accuracy of +1°F. (0.5°C). Sensors shall be of adequate length to accurately measure average temperature of coil or plenum area.

3. Outside Air Temperature Sensors. Outside air temperature sensors accuracy shall be within +1°F. (0.5°C.). Minimum operating span shall -50°F. to 150°F. Outside Air Temperature and Humidity Sensors (separate devices) shall be mounted in the outdoors where natural air flow occurs, away from any artificial affect from mechanical sources. The humidity sensor span shall be 0 – 100% RH. The sensors shall be independent devices, designed for exterior application; provide all required shielding.

4. Duct Temperature Sensors shall have an insertion measuring probe 6 inches long with a temperature range of -40 to 250 degrees F. The sensor shall include a utility box and gasket to prevent air leakage and vibration noise. For all mixed air and coil discharge air applications, install bendable averaging duct sensors with a minimum 5 foot long sensor element. Element shall provide adequate coil coverage.

5. Liquid Immersion Temperature Sensors shall have a temperature range of -40 to 250 degrees F.

6. Room Temperature Sensors. Room temperature sensors shall have an accuracy of ±1.0°F. Minimum operating span shall 45°F. to 95°F.). Sensors in corridor areas, gym, and locker rooms shall have a temperature range of 45°F. to 95°F. The corridor, gym, and locker room sensor shall be stainless steel plate with a thermistor thermally bonded to back, with fully insulated gasket. The gym and locker room stainless steel plate sensor shall include a push button override. Room sensors shall have a digital display of room temperature and setpoint, setpoint adjustment, integrated occupancy sensor and push button override with status indicator.

7. Chilled Water and Condenser Water Sensors. Chilled water and condenser water sensors shall have an accuracy of ±1.0°F. in their range of application. Minimum operating span shall be 0°F. to 125°F. Sensors shall be installed in stainless steel sensor wells.

8. Hot Water Temperature Sensors. Hot water temperature sensors shall have an accuracy of 1.0°F. Minimum operating span shall 0°F to 250°F. Sensors shall be installed in stainless steel sensor wells.

9. Kitchen Cooler and Freezer Sensors: Cooler and freezer sensors shall be thermobuffer style sensor. The probe shall be a minimum of 2 inches long constructed of stainless steel. The wiring connections shall be completed using sealant filled connectors to protect from moisture and oxidation. The operating span shall be from -40°F to 185°F.

G. Pressure Instruments:

1. Differential Pressure and Pressure Sensors: Air pressure transmitter shall universally measure very low static or differential pressure using a variable capacitance technique. Static pressure shall measure in ranges from 0 to 10 inches water column. Operating pressure span and either unidirectional or bidirectional measurement shall be field selectable. Transmitter accuracy, including non-linearity, hysteresis and non-repeatability shall be within 1% of full scale. Pressure transducers shall have LCD display.

2. Pressure Switches: Snap action SPDT switches shall operate from a neoprene slack diaphragm, corrosion resistant stainless steel diaphragm or copper diaphragm capable of being adjusted through the total pressure range. Switches shall withstand at least twice the working pressure of the system including any standing head, and have a temperature range exceeding the worst case liquid and ambient temperature range conditions.

3. Air pressure transmitter shall universally measure very low static or differential pressure using a variable capacitance technique. Static pressure shall measure in ranges from 0 to 10 inches water column. Operating pressure span and either unidirectional or bidirectional measurement shall be field selectable. Transmitter accuracy, including non-linearity, hysteresis and non-repeatability shall be within 1% of full scale. Pressure transducers shall have LCD display.

4. Flow Switches: Differential-pressure Venturi-type designed for installation in piping. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications. Flow switch shall not cause pressure drop exceeding 2 psid at maximum system flow rate.

5. Status Switches: Current sensing relay shall be used for pump motor status. The current sensing relay shall be adjustable within three ranges; 0.1 - 6 amps, 6 – 40 amps, and 40 – 200 amps. Contact rating shall be 0.15 amps at 30 VDC.

H. Humidity Instruments

1. Duct Relative Humidity Sensors shall be duct-mounted devices that produce a linear output over the complete range of 0-100% RH. A thin film polymer sensing element shall respond quickly to changes in humidity and shall be protected from contamination by a sintered filter. The sensor shall be factory calibrated with periodic field recalibration capability. The sensor shall be mounted in a duct probe assembly and be installed only after the construction or renovation area is free of contamination.

2. Space Relative Humidity Sensors: The sensor shall be an analog precision capacitance type relative humidity detector. Sensing element shall be rated for the relative humidity range 0-100%.

I. CO2 Instruments: CO2 sensor shall utilize Non-dispersive infrared technology (NDIR) repeatable. Sensor repeatability shall be +/- 20 ppm, 0-2000. Sensor accuracy shall be <= 75 ppm over 0-1500 ppm range. Field selectable 4-20MA/0-5V/0-10V output with LCD display equal to Veris CD series.

J. Air Flow Monitoring Stations: Unless otherwise noted, monitor outdoor air volumes from duct mounted thermal dispersion air flow measurement systems. System shall employ bead in glass thermistor technology. Sensors shall be installed using an equal area sensor distribution. Thermistor signals shall be process by a 12 bit microprocessor based transmitter. Transmitter shall be 24vac powered. System shall be capable or processing any air flow rate from 0 to 5000FPM. Sensor accuracy shall be +/- 2% of reading with a +/- .25% repeatability. Sensors shall operate in conditions of -20˚ F to 160˚ F and 0 to 90% RH, non-condensing. Where indicated provide Air Flow Monitoring Station equal to Ebtron with remote indicating readout panels. Install readout panels a maximum of 6’-0” above the finished floor in the closest Mechanical Room.

K. Water Flow Metering – Hydronic heating and cooling: Provide water flow meters equal to Onicon F-1210 Dual Turbine.

L. WATER DIFFERENTIAL PRESSURE SENSOR

1. Sensor shall have three switch selectable ranges: (5, 10, 25, 50).
2. Sensor shall have test mode to produce full-scale output automatically.
3. Sensor shall have provision for zeroing by pushbutton or digital input.
4. Sensor shall have field selectable outputs of 0-5v, 0-10v, and 4-20ma.
5. Sensor shall have two pressure sensors.
6. Sensor shall operate from 24vdc or 24vac. (AC power applies to operation in voltage mode only).
7. Sensor housing shall be powder-coated steel.
8. Sensor shall have NEMA 4 rating.
9. Sensor shall have a port swap feature.
10. Sensor accuracy shall be +/-1% FS combined linearity, hysteresis, and repeatability.
11. Sensor overpressure ratings shall be 2x max. FS range proof and 5x max. FS range burst.
12. Sensor shall be provided with LCD display.
13. Provide pressure differential transmitter equal to Veris PWL-N-04 with Kele BVA enclosure. Provide pressure gauge upstream and downstream of transmitter.

M. Output Devices:

1. Control Relays.
2. Solid State Relays (SSR).

N. Valve and Damper Actuators:

1. Basis of design: Belimo.
2. Electronic Direct-Coupled. Electronic direct-coupled actuation shall be provided.
3. Actuator Mounting. The actuator shall be direct-coupled over the shaft, enabling it to be mounted directly to the damper shaft. Where a shaft extension is required a manufactured option accessory shall be used. Field fabricated extensions and couplers will not be allowed. The actuator shall employ a V-bolt and toothed V-clamp fastening technique. Single point bolt or screw type fastener for circular valve and damper shafts is unacceptable.
4. Electronic Overload Sensing. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.

5. Power Failure/Safety Applications. For power failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

6. Spring Return Actuators. All spring return actuators shall be capable of both clockwise and counterclockwise spring return operation by simply changing the mounting orientation.

7. Proportional Actuators. Proportional actuators shall accept a 0 to 10VDC or 0 to 20mA control input and provide a 2 to 10VDC or 4 to 20mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is not acceptable.

8. 24 Volts (AC/DC) actuators. All 24VAC/DC actuators shall operate on Class 2 wiring and shall not require more than 20VA for AC or more than 8 watts for DC applications. Actuators operating on 120VAC power shall not require more than 20VA. Actuators operating on 230VAC shall not be acceptable.

9. Non-Spring Return Actuators. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators shall have a manual crank for this purpose.

10. Modulating Actuators. All modulating actuators shall have an external, built-in switch to allow reversing direction of rotation.

11. Conduit Fitting. Actuators shall be provided with a conduit fitting.

12. U.L. Listing. Actuators shall be Underwriters Laboratories Standard 873 listed.

13. Warranty. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a minimum 5-year manufacturer's warranty.

14. Actuators shall be selected utilizing no more than 80% of the cataloged torque rating.

15. Actuators shall be electronic, low voltage (24 VAC/VDC), NEMA 2 rated for all applications. Two- position may utilize 120 VAC actuators. Actuators shall have UL, CSA and ISO 9001 certification and approvals. Actuators shall have a minimum operating range of –22° to 122°F. Optional auxiliary switches shall be available if required by the sequence. Actuators shall be fully modulating/proportional, floating/tri-state, or two-position as required. Pulse width modulation is unacceptable. Actuators shall have visual position indicators. Proportional actuators shall be field programmable to operate in sequence with other devices without additional transducers. All actuators except two-position shall be capable of providing a constant rotation rate independent of the load. Actuators used on dampers or valves shall be designed to directly couple to a stem, shaft or ISO style-mounting pad. Damper actuators or damper actuators adapted for use with control valves shall utilize V-bolt toothed V-clamp shaft fastening technique. Single point, bolt, or single screw type shaft fastening techniques for circular or round damper or valve shafts is unacceptable.

O. Valves: Controls subcontractor shall be responsible for selection of the proper control valves including line size, pressure rating, flow-coefficient, shutoff rating and allowable leakage factor. Valves 2 1/2 inches and larger shall have minimum 125 psig cast-iron body and shall have stainless steel stems and Flanged connections with field replaceable packing. Valves smaller than 2 1/2 inches shall be constructed of brass with screwed connections, stainless steel stems and field replaceable packing. Ball Valves 2” and less shall have forged brass or

bronze bodies rated for a minimum 250 psi, bronze or reinforced Teflon®seats, equal percentage flow characteristics in 2-Way applications, liner or constant flow in 3-Way applications, a spring loaded Teflon®, EPDM or dual EPDM o-ring packing, and stainless steel or brass stems. Butterfly valves shall have a fully lugged, drilled and tapped, cast iron body. Flanges shall meet ANSI 125/150 standards. The one-piece body shall have an extended neck allowing clearance for flanges and piping insulation. The disc shall be stainless steel and provide bi-directional bubble-tight close off in either direction. The flow characteristic shall be modified equal percentage for 2-way and linear for 3-way valves. Furnish a cartridge type, non-collapsing, EPDM seat. The disk shall have full 360-degree concentric seating. The shaft shall be supported at multiple (minimum three) locations. No gaskets shall be required between the valve and flange faces. Three-way butterfly valves shall utilize independent actuators for each valve body; connecting linkage is not acceptable.

P. Dampers: Control dampers shall be opposed blade (except where two-position action is indicated) with interlocking gasketed edges, jamb seals and ball type oilite bearings. Blades and frames shall have galvanized finish. Frames shall not be less than 5" X 1/2" X 16 gauge channel steel and shall be reinforced to form a rigid assembly. Blades shall be 16 gauge with maximum blade width of 10". All outside air and relief/exhaust air dampers shall be spring return normally closed and have independent control.

Dampers over four feet high or wide, or over 16 sq. ft. shall be built in two or more sections with interconnections on every other blade. Gasket material shall be molded neoprene or approved equal. Damper leakage shall not exceed 6.0 CFM/SF at 1" SP, fully closed. Damper shall be install with damper shafts in horizontal plane, unless supplied with bearing rated for vertical thrust.

Q. VARIABLE VOLUME TERMINAL CONTROL UNIT: Provide PID control for damper and valve control. The Room Sensor for VAV terminal units shall have a digital display of room temperature and set-point, set-point adjustment and push button override with status indicator. The VAV terminal unit discharge sensor shall be an insertion type probe.

R. Mylar labels shall be provided to identify all control components and points of connection.

2.04 DDC SOFTWARE

2.04.1 OVERVIEW

The system shall continuously perform Direct Digital Control (DDC) functions at the local control module in a stand-alone mode. Using Graphical Programming, the operator shall be able to design and modify control sequence of operation and all tuning parameters.

A. Minimum Function: Each control module shall perform the following functions:

1. Identify, time/date stamp.

2. Execute all application programs specified.

3. Execute DDC algorithms.

4. Trend and store data.

B. Control Failure Mode: In the event of a control module failure, all points under its control shall be commanded to the failure mode. All DDC software shall reside in the respective control module.

1. Orderly Shutdown. Power failures shall cause the control module to go into an orderly shutdown with no loss of program memory.

2. Automatic Restart. Upon resumption of power, the control module shall automatically restart and print out the time and date of the power failure and restoration at the respective Workstation system.

3. Automatic Restart. The restart program shall automatically restart affected field equipment. The operator shall be able to define an automatic power up time delay for each piece of equipment under control.

2.05 APPLICATIONS SOFTWARE

2.05.1 GENERAL

All software application algorithms described below MUST reside at the local Building/Area level, Multi-Application, Single-Application, or Unitary Controller level. Systems that rely on a workstation PC, server or router to perform these functions are NOT acceptable. The following applications software shall be provided for the purpose of optimizing energy consumption while maintaining occupant comfort:

A. Time of Day Scheduling (TOD):The system shall be capable of the following scheduling features:

1. Schedule by Type. Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times (hours: minutes). A weekly repeating schedule, i.e. between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule.

2. Schedule in Advance. Dated schedules shall be entered up to 9 (nine) years in advance.

3. Self-Deleting. Schedules shall be self-deleting when effective dates have passed.

4. Leap Year. Leap years shall be adjusted automatically without operator intervention.

B. Optimum Start/Stop (OSS)/Optimum Enable/Disable (OED): This application provides software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in °F. /hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.

1. Optimum Stop: Optimum Stop shall not be enabled on equipment more than one (1) hour prior to previously scheduled stop.

C. Demand Limiting (DL) - Temperature Compensated: The DL application shall be capable of four separate times of day KW demand billing rate periods. The system shall be capable of measuring electrical usage from multiple meters serving one building and each piece of equipment being controlled on the LAN shall be programmable to respond to the peak demand information from its respective meter.

1. Sliding Window. The demand control function shall utilize a sliding window method. The sliding window interval and increment shall be operator selectable in increments of one minute, up to 60 minutes.

2. Set-points for Defined Demand Level. The operator shall have the capability to set a initial set-point and a maximum set-point for each demand period. The initial set-point shall automatically increase by a user defined increment if the electrical demand is above set-point and all loads have been shed. The set-point shall only increase to the maximum set-point value.

3. Information Archiving. The system shall archive demand and usage information for use at a later time. System shall permit the operator access to this information on a current day, month to date and a year to date basis.

D. Unoccupied High/Low limit: The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the High/low limit range and shall remain activated until the space temperature returns to the High/low limit range.

1. Outside & Exhaust Air. The system shall close all outside air and exhaust air dampers and stop all exhaust fans during the unoccupied period

2. Unoccupied Space Temperature. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room.

3. Parameter Changes. Operator shall be able to define, modify or delete the following parameters.

a. Unoccupied High/Low limit set-point temperature(s).

b. Temperature band for Unoccupied operation.

E. Timed Local Override (TLO): The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button (momentary contact). Equipment on Time: If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse. The system shall maintain a trend log of override usage. The log shall include, date, time and area of override.

F. Space Temperature Control (STC): There shall be two space temperature set-points, one for cooling and one for heating, separated by a dead band. Only one of the two set-points shall be operative at any time. The cooling set-point is operative if the actual space temperature has more recently been equal to or greater than the cooling set-point. The heating set-point is operative if the actual space temperature has more recently been equal to or less than the heating set-point. There are three modes of operation for the set-points, one for the occupied mode (example: heating = 72°F. or 22°C., cooling = 74°F. or 23.3°C.), one for the unoccupied mode (example: heating = 55°F. or 12.7°C., cooling = 90°F. or 32°C.), and one for the standby mode (example: heating = 68°F. or 22°C., cooling = 76°F. or 24.4°C.). Where occupancy sensors are integrated with the space temperature sensor, the occupancy control shall override based on the occupancy sensor output.

G. Schedule. The occupied/unoccupied modes may be scheduled by time, date, or day of week.

H. Color Code. Colors shall be generated to represent the comfort conditions in the space, and shall be displayed graphically at the operator station. (Discuss colors)

1. If the actual space temperature is in the dead band between the heating setpoint and the cooling set-point, the color displayed shall be white for the occupied mode, representing ideal comfort conditions.

2. If the space temperature rises above the cooling set-point, the color shall change to light red. Upon further rise beyond the cooling set-point plus an offset, the color shall change to red. When space temperature falls below the heating setpoint, the color shall change to light blue. Upon further temperature decrease below the heating setpoint minus an offset, the color shall change to dark blue.

I. Operator Definable. All set points and offsets shall be operator definable. When in the occupied mode, start-up mode, standby mode, or when heating or cooling during the unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.

J. Optimum Start. An optimum start-up program transitions from the unoccupied set points to the occupied set points. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope (AI: Space Temperature).

2.06.1 UTILITY METERING

A. Electrical demand shall be from pulsing dry contacts provided by Owner and installed by the Utility Company at the power meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the Utility Company.

B. Gas usage in cubic feet per hour shall be from pulsing dry contacts provided by the Utility Company at the gas meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the utility company.

C. Water usage in gallons per hour shall be monitored from pulsing dry contacts provided by installation of a contractor provided water meter. The DDC system shall be capable of measuring and scaling any pulse rate provided by the water meter. Provide meter with all installation hardware necessary to enable insertion and removal of meter without system shutdown. The flow meter shall be hand insertable up to 400 psi. Turbine rotation shall be detected by electronic impedance base sensing (non-magnetic). The water meter shall be equal to Onicon F-1130 series, with scaled output (1 gallon per pulse). Meter to be supplied by controls contractor installed by Plumbing contractor.

D. VFD sub-metering shall be monitored and measured by way of the LON communication or BACnet output of the VFD.

E. For buildings that have multiple meters such as electrical sub meters, VFD meters, etc., the graphics shall show a list of building areas and equipment on each meter. Coordinate naming of equipment with Owner.

2.06.2 SURGE AND LIGHTNING PROTECTION

A. Line voltage protection: The JACE panels, Central Station Air Handling Units and Central Plant equipment shall be powered by 120 VAC circuits provided with surge protection. These

circuits shall be provided and installed by controls subcontractor. This protection is in addition to any internal protection provided by the manufacturer. A grounding conductor, (minimum 12 awg), shall be brought to each control panel from either a system grounding point or the ground bus in a breaker panel. Conduit grounds will not be acceptable. The surge protection device should be mounted so the LEDs are readily visible.

1. Surge protector requirements:
    a. Diagnostic LED indicates ground presence, system power and SPD function
    b. UL listed
    c. IEEE Cat A and Cat B
    d. Parallel configuration, external mount
    e. 22,500 amp peak surge current
    f. Operating Frequency: 0 Hz – 400 Hz
    g. Protective Modes: L-G, L-N, N-G
    h. Warranty: Ten Year Warranty
    i. Housing NEMA 4 ABS

B. Inter-unit Communications: All panel to panel data networks that are routed outside or between buildings shall be protected with proper surge protection. The protection device shall match the voltage levels of the inter-unit communications network.

1. Communications trunk wiring shall be protected with a transient surge protection device providing the minimal protection specifications of the General semiconductor, Model #422E device.

2. Power and Communication Wiring Transient Protection: The control manufacturers shall submit catalog data sheets providing evidence that all BAS products offered by the manufacturer are tested and comply with the standard for Transient Surge withstand capabilities for electrical devices ANSI C62.41, IEEE-587-1980, Categories A and B. Such testing shall have included power and communication trunk wiring. Compliance with IEEE-587 shall imply conformance with IEEE-472 transient standards based on the stated position of ANSI and IEEE regarding applicability of the rated standards.

3. The communications circuitry, input/output circuitry, and CU’s, shall provide protection against a 1,000 volt, 3 amp transient signal, directly applied to the communication or input/output terminations. The manufacturer’s catalog data sheet shall provide evidence of conformance with this requirement. Systems not complying with this requirement shall provide equivalent protection external to the BAS controller. Protection shall be provided for the individual communications and input/output terminations for each BAS controller. Submittal documentation shall clearly define how this requirement will be met and how the external protection will not affect the performance of the controllers.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Work schedule shall be in accordance with Division 1.

B. Wiring: The term wiring is construed to include furnishing of wire, conduit, miscellaneous material and labor to install a working system. Outdoor installations shall be of weatherproof construction or in new NEMA 3R or 4 enclosures. Wiring shall be yellow jacketed No. 22 TSP for inputs and outputs. Wiring shall be purple jacketed No. 22 TSP for communication bus. ~~Cat 5 wiring shall not be utilized.~~

1. Concealed accessible wiring may be installed as properly supported cable using bridal rings a minimum of 2" in diameter and located a maximum of 10'-0" on center so as to prevent excess sagging from occurring. Wire-ties or cable straps shall not be used for cable support. Provide protective sleeves at wall and floor penetrations. Low voltage wire (ie: control, signal, communication) shall be installed and supported independently from other equipment or devices. Do not use terminal unit supports to fasten or otherwise support low-voltage wire.
2. Concealed inaccessible locations and mechanical rooms shall have wiring installed in properly sized, blue colored conduit.
3. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
4. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
5. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables, example, blue conduit shall be used for communication and equipment wiring.
6. Install wire and cable with sufficient slack or service loops and flexible connections to allow for vibration of piping and equipment.
7. An example of the required colored wiring is below:

Purpose	Function	Color
Primary Communications LON	Field Device Communication	Purple
Analog Points	I/O Wiring	Yellow
Digital Points	I/O Wiring	Yellow
24VAC	Control power	White/Black tracer

C. Routing: Except for short apparatus connections, run conduit parallel to or at right angles to the building structure. Conceal conduit in finished spaces. Do not run conduit concealed under insulation or inside ducts. Mount control devices, and conduit located on ducts or apparatus with external insulation on stand-off support to avoid interference with insulation.

Run wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing. Rack connections bridging a cabinet door along the hinge side and protect from damage.

D. Field Materials:

1. Sensors and Controls: Permanently mark terminal blocks and sensors for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity. Label or code each field wire at each end. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
   a. Temperature sensors:
      i. Temperature sensors shall be readily accessible and adaptable to each type of application in such a manner as to permit for quick, easy replacement and servicing without special tools or skills.
      ii. Mount duct sensors in locations to sense the correct temperature of the air only, within the vibration and velocity limits of the sensing element.
         a) VAV Terminal Units: Supply temperature sensors shall be located a minimum of 36 inches to 48 inches downstream of the reheat coil, and upstream of all low pressure branch ductwork runouts to diffusers.
      iii. Mount extended surface element, when used, securely within the duct and position to measure the best average temperature. Thermally isolate elements from brackets and supports to respond to air temperature only. Securely seal duct penetrations.
      iv. Install pipe sensors in top of pipe for horizontal runs and at a positive slope on vertical runs to prevent condensation from flowing to sensor head.
   b. Temperature sensing elements installed in liquid systems shall be installed in thermowells.
   c. Relative humidity sensors shall have air guards when installed in air flows of more than 15 meters per minute across the sensor element.
   d. Pressure Instruments:
      Pressure sensors (all types) installed on liquid lines shall have drains. Pressure sensors installed on steam lines shall have drains and siphons. All pressure sensors shall have valves for isolation, venting, and taps for calibration. Pressure sensors shall be verified by calibration. Differential pressure sensors shall have nulling valves. Pressure switches (all types) installed on liquid lines shall have drains. Pressure switches installed on steam lines shall have drains and siphons. All pressure switches shall have valves for isolation, and taps for calibration. Pressure switches shall be adjusted to proper setpoint, and shall be verified by calibration. Differential pressure switches shall have nulling valves. Switch contact ratings and duty shall be selected for the application. The duct static-pressure sensing element, (tap or pitot tube), shall be located approximately two-thirds of the distance from the supply fan to the end of the duct with the greatest pressure drop. Do not locate adjacent to branches, transitions, elbows, etc. Provide taps for transmitter calibration.
   e. Install potential and current transformers in new NEMA enclosures. Current transformer leads shall be shorted when they are not connected to the measurement circuits.
   f. Install relays and contactors in new NEMA enclosures. H-O-A switches and override switches shall be installed so that controls function through the automatic position. Safety and fire or life safety interlocks shall function through both hand and automatic switch positions.
   g. Damper Actuators:
      Outside air, return air, and relief dampers shall have individual actuators unless installed on factory assembled mixing boxes.
      Actuators shall be installed so that their action shall seal the damper to the extent required to maintain leakage at or below the specified rate and shall move the blades smoothly.

h. Variable Frequency Drives (VFDs):

Point Name	Hardwired	Interface Com Card	GUI Display
VFD Command Start/Stop	X	X	Hardwired
VFD Speed Command (%)	X	X	Hardwired
Fan Status (via VFD)	X	X	Hardwired
VFD Speed Feedback (Hz)		X	Com
Fan Alarm (Command/Status mismatch)		X	Com
VFD Fault Status		X	Com
VFD Fault Reset		X	Com
VFD Power (kW)		X	Com
Timestamp		X	Com

E. Signal Transmission System Equipment:

1. General: Install all system components in accordance with the National Electrical Code and the manufacturer's recommendations; fuse and ground them properly.

   a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.

   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 12 inches long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.

   c. Cable Runs: Keep cable runs as short as possible. Connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter. Use vinyl tape, sleeves, or grommets to protect cables from abrasion or damage. Allow extra length for vibration at points where they pass around sharp corners, through walls, and panel cabinets.

   d. Grounding: Ground system per manufacturer's requirements for proper and safe operation.

F. Field Test and Inspections:

1. System Equipment: Upon completion of installation of each piece of equipment, field-inspect and mechanically and electrically test equipment for proper function.

2. Field Materials: Upon completion of installation of each piece of equipment, field-inspect and mechanically and electrically test equipment for proper function.

3. Acceptance Testing. Upon completion of the installation, the Contractor shall start up the system and perform all necessary trending, scheduling calibration, testing, and debugging operations. The Contractor in the presence of the Owners's representative shall perform an acceptance test. Acceptance test procedure to be submitted, for approval no later than 4 weeks prior to testing. Submission of test procedure shall imply that systems are complete, functional and that contractor has verified performance.

Successful completion of acceptance testing shall be required prior to substantial completion.

4. Perform the following field tests and inspections and prepare test reports:

   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.

   b. Test and adjust controls and safeties.

   c. Test calibration of controllers inputs, outputs, and sensors.

   d. Test each point through its full operating range to verify that safety and operating control set points are as required.

   e. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.

   f. Test each system for compliance with sequence of operation.

   g. Test software and hardware interlocks.

5. DDC Verification:

   a. Verify that instruments are installed before calibration, testing, and loop or leak checks.

   b. Check instruments for proper location and accessibility.

   c. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

   d. Check instrument tubing for proper fittings, slope, material, and support.

   e. Check installation of air supply for each instrument.

   f. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.

   g. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.

   h. Check temperature instruments and material and length of sensing elements.

   i. Check control valves. Verify that they are in correct direction.

   j. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.

   k. Check DDC system as follows:

      1) Verify that DDC controller power supply is from emergency power supply, if applicable.

      2) Verify that wires at control panels are tagged with their service designation and approved tagging system.

3) Verify that spare I/O capacity has been provided.

4) Verify that DDC controllers are protected from power supply surges.

l. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

6. Calibrating and Adjusting:

a. Calibrate instruments.

b. Make three-point calibration test for both linearity and accuracy for each analog instrument.

c. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

d. Control System Inputs and Outputs:

1) Check analog inputs at 0, 50, and 100 percent of span.

2) Check analog outputs using milliampere meter at 0, 50, and 100 percent output.

3) Check digital inputs using jumper wire.

4) Check digital outputs using ohmmeter to test for contact making or breaking.

5) Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

e. Flow:

1) Calibrate the input sensors to the specified accuracy.

2) Manually operate flow switches to verify that they make or break contact.

f. Pressure:

1) Calibrate pressure transmitters at 0, 50, and 100 percent of span.

2) Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

g. Temperature:

1) Calibrate the input sensors to the specified accuracy.

2) Calibrate temperature switches to make or break contacts.

h. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.

i. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.

j. Provide diagnostic and test instruments for calibration and adjustment of system.

k. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures. Document all tests and provide to WCPSS.

G. Adjust initial temperature and humidity set points.

H. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project during other than normal occupancy hours for this purpose.

I. System Graphics and Navigational Format:

1. General Notes

a. Show the following on each graphic screen: OAT, OAH, OA Enthalpy, CHW sup temp, HW sup temp, current time, Alarm portal link, Raleigh weather service (in AX or N4 web supervisor), Master schedule link, Building calendar link, and trend link.

b. Alarm background red and blinking.

c. Valves show modulating from 0% in closed to coil position to 100% in open to coil position.

d. Dampers show modulating from 0% in closed position to 100% in open position.

e. With multiple central plants, show what zones are served on each central plant screen. On each AHU screen, indicate which Central Plant serves the AHU.

f. Service screens for each major system.

g. Sequence of operation folder shown in Nav Bar tree.

h. Gas usage should be “CCF”.

i. Provide service screens for exhaust fans and lighting contactors. Containing area served, tagging and override.

j. In the navigational bar, parent folder “Home” shall contain at a minimum the following subfolders: Overview (entire building floor plan), FloorPlans (zoned floor plans), CentralPlant (Chillers, Boilers, etc), AirHandlers, ServiceScreens (described below), Sequence of operations, Control drawings, WCPSS Home Page.

k. In the navigational bar, parent folder “Config\Drivers\”controller”network” shall contain at a minimum the following subfolders: CentralPlant, AirHandlers,

VavBoxes, Global, Schedules, Exhaust Fans, Lights,Overrides, AverageTemps, FloorPlans, ServiceScreens.

l. All digital and analog points shall be able to be overridden from either the graphic or service screen (ie- dampers, actuators, fans, VFDs, pumps)

2. Service Screen

a. Global space cooling and heating set-points override.

b. Master start/stop override.

c. Interior lights SS & O/R.

d. Exterior lights SS & O/R.

e. Tab HW valves.

f. Tab CHW valves.

g. Tab OA dampers.

h. Fire alarm status.

i. Security panel armed status (this should cancel all pushbutton occupancy overrides when armed).

j. Overall site layout with zone status/override (link from status to schedule).

k. Admin zone in red, Media zone in yellow, Multipurpose or Gym zone in purple, Auditorium in a lighter shade of purple, Café/Kitchen zone in green, classroom zones in various colors. Show average space temp for each zone.

l. Electrical demand, demand limit set-point, 3 shed level set-points.

m. Cooler & freezer temp. Red and blinking when in alarm.

n. Domestic hot water temp, status/override (link to schedule), and pump status/override.

o. Global heat mode (VAV reverse acting) set-point.

p. Unoccupied low limit and high limit set-points.

q. Economizer low limit, high limit, and enthalpy set-points. Status.

r. OA dampers enable/override with link to schedule.

s. Electrical, gas and water usage today.

t. Link to Utilities Usage screen.

3. Zone screen

a. Room numbers.

b. Zone status override.

c. Cause of status (“Master Override”, “Zone Override”, ”Master Building Schedule”, Timed Override”, “Optimal Start”, “Optimal Stop”, “Zone Schedule”)

d. Link to zone schedule.

e. Temperature range spectrum.

f. Show zones with links in small inset on lower right area of screen.

g. Zone timestamp.

h. Link to temp control equipment (VAV, AHU).

4. VAV box screen

a. AHU supply temp at inlet of VAV box.

b. Link back to AHU from inlet temp.

c. Link back to zone screen.

d. Box flow setpoint.

e. Box flow.

f. Cooling demand (%).

g. Hot water valve position.

h. Occupancy status (Unoccupied, Standby, Occupied).

i. Box supply air temp.

j. Space temp.

k. Set-point control status/override (Local control/Remote control).

l. Effective space cooling set-point.

m. Remote cooling set-point with override.

n. Heat mode direct/reverse acting control status.

o. Maximum space temp set-point.

p. Minimum space temp set-point.

5. VAV AHU screen

a. Link to service screen.

b. Unit override.

c. AHU command status.

d. Cause of status (“Unit Override”, “Night Low Limit”, “Night High Limit”, “Zone Schedule”).

e. VAV reverse acting control set-point and status.

f. AHU duct layout.

g. Hardware sensors graphically shown with values.

h. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.

i. Dampers and valves with actuator command position.

j. OA minimum flow set-point.

k. Freeze protection status.

l. Supply air temp set-point with override.

m. Supply static pressure set-point.

n. Timestamp for each fan.

o. Economizer status.

p. OA damper enable status.

q. Damper control cause (“Fan Status Off”, “OA Damper Enable Off”,“Mixed air low limit”, “High CO2”, “Outside Air Flow”, “Economizer”).

r. Indicate which zones are served by this AHU.

6. VAV AHU service screen

a. All sensor values, set-points with override, and actuator command position values with override.

b. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h

c. Economizer command.

d. Unit start/stop with override.

e. Test and Balance HW Valves command with override.

f. Test and Balance CHW Valve command with override.

g. Test and Balance OA Dampers command with override.

h. Force all VAV’s to minimum/maximum flow, full open/full closed command with override.

i. All VAV boxes with the following information: occupancy, set-point control/override (Local control/Remote control), effective set-point, space temp, supply air temp, hw valve position with override, flow set-point, air flow, cooling demand (%), force damper open/force damper closed, total air flow of all boxes.

j. Supply air temp outside air reset parameters (adjustable).

k. VAV reverse acting control status with override.

7. Single Zone AHU screen

a. Link to service screen.

b. Unit override.

c. Link back to zone screen.

d. AHU command status.

e. Cause of status (“Unit Override”, “Night Low Limit”, “Night High Limit”, “Zone Schedule”).

f. AHU duct layout.

g. Hardware sensors graphically shown with values.

h. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.

i. Dampers and valves with actuator command position.

j. OA minimum flow set-point.

k. Freeze protection status.

l. Space temp cooling set-point.

m. Space temp heating set-point.

n. Timestamp for each fan.

o. Economizer status.

p. OA damper enable status.

q. Damper control cause (“Fan Status Off”, “OA Damper Enable Off”, “Mixed air low limit”, “High CO2”, “Outside Air Flow”, “Economizer”).

r. Indicate which zones are served by this AHU.

8. Single zone AHU service screen

a. All sensor values, set-points with override, and actuator command position values with override.

b. Fan VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.

c. Economizer command.

d. Unit start/stop with override.

e. Test and Balance HW Valves command with override.

f. Test and Balance CHW Valve command with override.

g. Test and Balance OA Dampers command with override.

9. Chilled water system screen

a. System status with override.

b. Cooling outdoor temperature low limit set-point and cooling enable status.

c. Chiller(s) specific alarm (string text), not just Alarm/Normal (if available).

d. Pump VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.

e. Secondary loop differential pressure sensor values and set-point.

f. Timestamp for each pump and chiller.

g. Chilled water system piping layout.

h. Hardware sensors graphically shown with values.

i. Chilled water set-point with override.

j. Freeze protection status from AHU's.

k. Primary pump(s) command (if available), status, and alarm.

l. Chiller(s) command, status, and active set-point.

m. Link to service screen.

n. Cause of status ("Cooling outdoor temperature low limit", "Override", "AHU Call", "Dehum").

10. Hot water system screen

a. System status with override.

b. Heating outdoor temperature high limit set-point and heating enable status.

c. Boiler(s) specific alarm (string text), not just Alarm/Normal (if available).

d. Pump VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.

e. Secondary loop differential pressure sensor values and set-point.

f. Timestamp for each pump and boiler management panel.

g. Hot water system piping layout.

h. Hardware sensors graphically shown with values.

i. Hot water set-point with override.

j. Freeze protection status from AHU's.

k. Boiler management panel command and status.

l. Link to service screen.

m. Cause of status ("Heating outdoor temperature high limit", "Override", "AHU Call", "VAV Reheat", "Freeze").

11. Central Plant service screen

a. All sensor values and set-points with override.

b. Pump VFD graphical display points shall be as shown previously in section 3.01,D, 1, h.

c. Cooling enable status, Cooling outdoor temperature low limit set-point, and cooling system override.

d. Heating enable status, Heating outdoor temperature high limit set-point, and heating system override.

e. Chiller(s) command/override, status, alarm, timestamp, and temp set-point override.

f. Boiler management panel command/override, status, timestamp, temperature set-point override, and runtime with reset.

g. HW temp outside air reset parameters (adjustable).

h. CHW temp outside air reset parameters (adjustable).

i. Chiller pump(s) status.

j. Chiller circuit(s) runtime and current (amps).

k. Chiller voltage.

l. Domestic Hot Water system. Temperature, heater and pump command and override.

12. Utilities Usage screen

a. Current month KWH value.

b. Last month KWH value.

c. Last meter value reset time and date.

d. Current 15 minute KW demand value.

e. Current month peak demand.

f. Current month peak demand time and date.

g. Last month peak demand.

h. Last month peak demand time and date.

i. Load shed set-point.

j. 3 shed level set-points.

k. KWH this hour value.

l. KWH last hour value.

m. KWH today value.

n. KWH yesterday value.

o. Current gas demand (cf/hr).

p. Current month gas usage value (ccf).

q. Last month gas usage value (ccf).

r. Last meter value reset time and date.

s. Gas usage value this hour (ccf).

t. Gas usage value last hour (ccf).

u. Gas usage value today (ccf).

v. Gas usage value yesterday (ccf).

w. Current water demand (gal/hr).

x. Current month water usage value (gal).

y. Last month water usage value (gal).

z. Last meter value reset time.

aa. Water usage value this hour (gal).

bb. Water usage value last hour (gal).

cc. Water usage value today (gal).

dd. Water usage value yesterday (gal).

3.02 LIGHTING CONTROL

The Control Subcontractor shall provide the number of outputs for lighting control as indicated on the drawings. Lighting will be controlled by arming/disarming the security system. The Control Subcontractor shall provide all wiring between the DDC system and the lighting contactors. Lighting Contactors and all power wiring shall be by the Electrical Contractor.

3.03 SECURITY CONTROLS

The Control Subcontractor shall connect to a dry contact point in the each of the school's security systems. The Control Subcontractor shall provide all wiring between the DDC system and the security armed and alarmed contacts. Security contacts are supplied by others. For schools with

multiple security systems such as whole building and cafeteria, these systems shall remain separate to allow access by both parties without disarming the second system. The security armed and alarmed contacts shall be monitored by this system.

3.04 FIRE ALARM

Smoke detectors are supplied and wired by Electrical Contractor. Electrical Contractor shall supply and install a relay near each motor controller to shut down the unit. Central fire alarm panel shall be provided with one contact output to the DDC system to indicate system trouble or alarm. Wiring required for alarm points shall be provided by the Control Subcontractor.

3.05 MAINTENANCE MANAGEMENT

The DDC system shall measure and record run time for all start/stop points in the system. Based upon the accumulated run time provide maintenance messages on the interval recommended by the equipment manufacturers.

Any digital input point that is used for maintenance purposes (i.e. Fan Status) shall also generate a maintenance message.

3.06 TROUBLE ALARMS

The Control Subcontractor shall establish a trouble high and trouble low alarm limit for each analog input and annunciate a corresponding alarm message. Alarm and event messages shall be in plain English and not LON or any other code language.

3.07 MODIFICATION

All software set-points, limits, alarms, messages, schedules, sequences, etc., as specified herein are to provide an initial setup of the control system. The Control Subcontractor shall provide software customization that may be required to adapt the DDC system to accurately respond to actual building parameters and installed equipment. Further, these software functions shall be readily modifiable by WCPSS personnel as changes in building operation dictate.

3.08 COOLERS AND FREEZERS

Real-time temperatures for coolers and freezers shall be included on all graphical pages. The cooler and freezer locations shall be shown on graphical floor plan where the units are located.

3.09 MESSAGES AND ALARMS

The installer is required to submit a point summary to confirm point names as specified herein The installer shall submit this point summary with the addition of identifying all alarms which includes detail information on the alarm parameters to WCPSS for approval prior to the beginning of any Commissioning process of the integrated automation system. WCPSS will provide the format form to the installer upon request.

All alarms which have been identified by the Owner as a nuisance alarm due to numerous times in and out of alarm, shall be addressed and corrected by the System Integrator in a manner that the Owner has approved.

PART 4 APPENDIX - GRAPHIC STANDARDS

4.01 STANDARD COLORS

The following tables and legend lists all of the standard colors for Graphics:

Table 4.1.0.1: Standard Text Colors

Description	Text Color	Background Color
Normal	Black	White
Alarm	Black	Red
Warning	Black	Red
Trouble	Black	Yellow
Off-line	Black	Yellow
Override	Black	Magenta

State indication shall be determined by status indicating equipment such as current sensing switches, auxiliary contacts, or position switches. Commands to field devices shall be shown separately.

Table 4.1.0.2: Standard Object Colors

Description	Color
Graphic Background Color	Light Gray
Navigation Button Background Color	Med. Gray
Ductwork	Blue or Gray
Hot Water Supply Piping	Dark Red
Hot Water Return Piping	Light Red
Chilled Water Supply Piping	Dark Blue
Chilled Water Return Piping	Light Blue
Cond. Water Supply Piping	Grey
Cond. Water Return Piping	Grey

4.2.0 USING GxTEXT STANDARDS

All fonts shall be bold Trebuchet MS, Serif or Arial. The minimum font size for the display of values shall be 9 point.

Table 4.2.0.1: Standard Fonts

Description	Standard Font
Graphic Title Block	White 16 point Serif Bold with Gray shadow
Text on Buttons	Black 9 point Serif Bold
All other text	White Serif Bold, minimum of 9 point

4.3.0 PRINTER DRIVERS & VIDEO RESOLUTION

4.3.1 PRINTER DRIVERS

Printer drivers shall not affect Graphics.

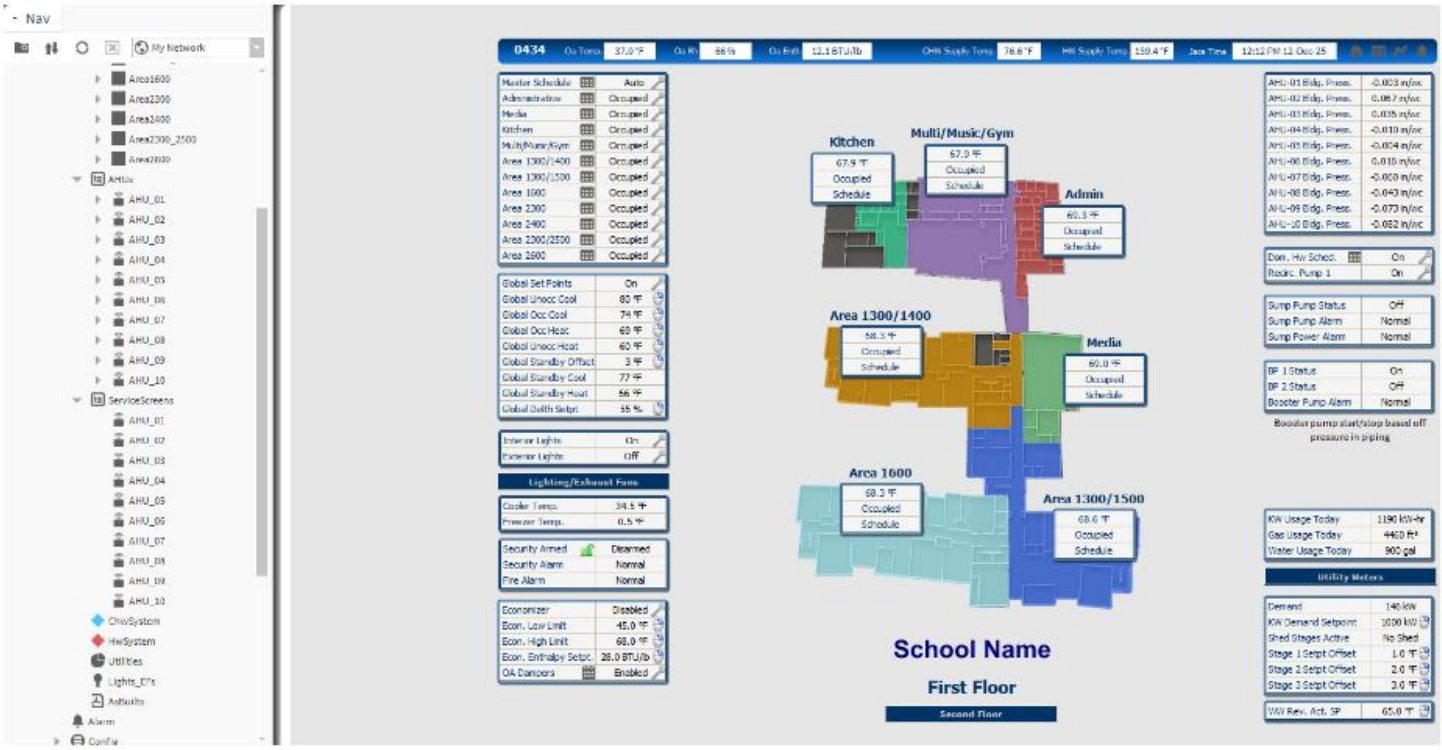
4.3.2 VIDEO RESOLUTION

Graphics shall be scaled to a minimum resolution of 1024x768. Graphics will display better at higher resolutions. A 19” monitor shall be the minimum size used to display Graphics.

4.4.0 GRAPHICS TEMPLATE

All Standard Graphics shall be based upon the template shown in Figure 4.4.0.1 below. All features of the Standard Graphics, such as title block, navigation buttons, etc., shall always be located in the same general area on each Graphic. For example, the navigation buttons shall always start at the left frame of the graphic. The Home, Charts and Alarm buttons shall always start in the upper right corner of the graphic.

Figure 4.4.0.1: Standard Graphic Template



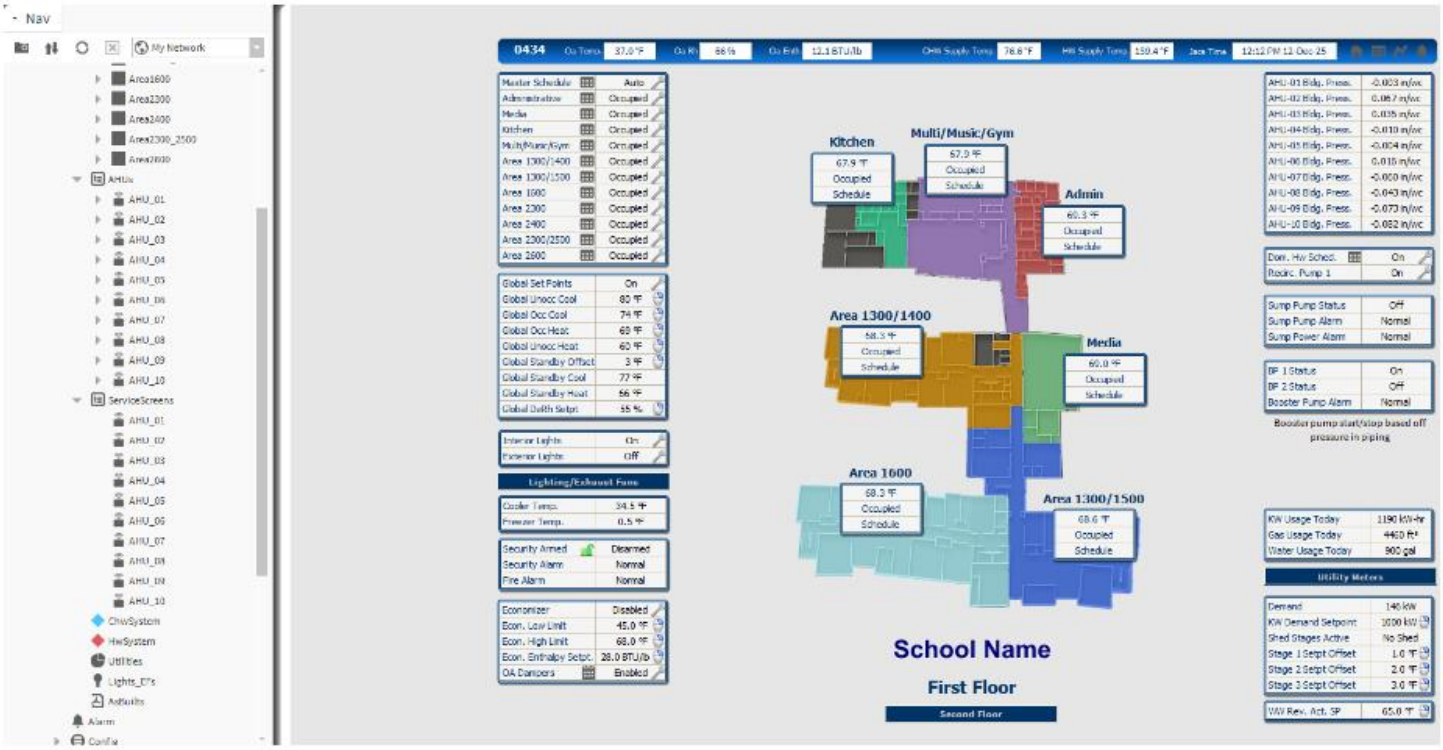
4.5.0 LABELING ON GRAPHICS

A description of a point shall be included on the Graphic next to the object's value whenever there is any ambiguity about the value's meaning. For example, when status and command points are both shown on a Graphic, they shall both be labeled with separate identifying descriptions. If a description of a point in a point block is not adequate, then a separate Note may be added to the Graphic Background near the point block clarifying function or purpose. This shall prevent any confusion about what a value represents.

4.6.1 NAVIGATION STANDARDS

Figure 4.6.1.1 below illustrates sample navigation.

Figure 4.6.1.1: Navigation Flow Example



4.7.0 STANDARD BUTTONS

All buttons shall be the same height to accommodate the 9 point font. All buttons on a specific graphic will be the same width to match the widest button on the graphic.

4.8.0 EXAMPLE GRAPHICS

4.8.1 EXAMPLE AHU GRAPHIC

Figure 4.8.1.1 below shows an example of a standard AHU Graphics. The data blocks shall follow the color legend in Tables 4.1.0.1 and 4.1.0.2.

Figure 4.8.1.1: Example Single Zone AHU Graphic

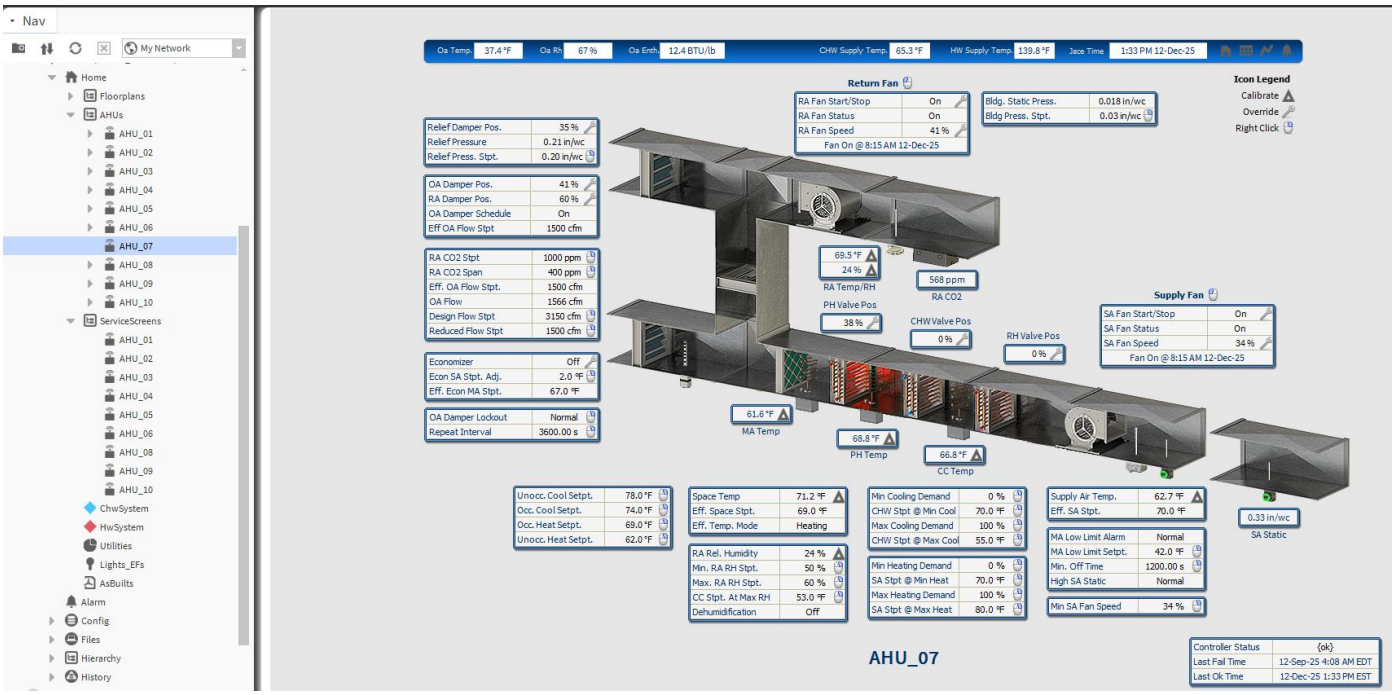
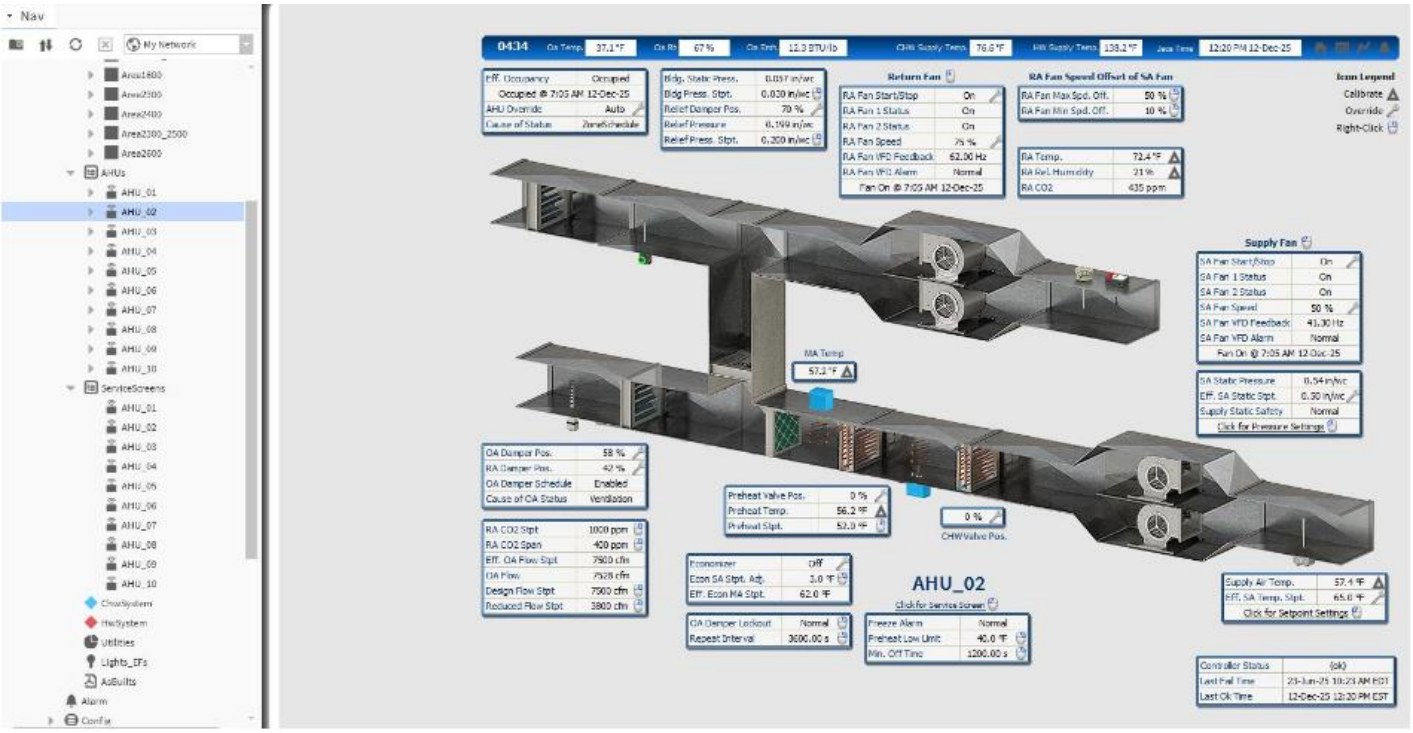


Figure 4.8.1.2: Example Multizone Zone AHU Graphic


Nav
My Network
Area1800
Area2300
Area2400
Area2300_2500
Area2600
AHUs
AHU_01
AHU_02
AHU_03
AHU_04
AHU_05
AHU_06
AHU_07
AHU_08
AHU_09
AHU_10
ServiceScreens
AHU_01
AHU_02
AHU_03
AHU_04
AHU_05
AHU_06
AHU_07
AHU_08
AHU_09
AHU_10
ChwSystem
HwSystem
Utilities
Lights_EFs
AsBuilts
Alarm
Config
04:14
Eff. Occupancy
Occupied
Occupied @ 7:05 AM 12-Dec-25
AHU Override
Auto
Cause of Status
ZoneSchedule
Bldg. Static Press.
Bldg Press. Stpt.
Relief Damper Pos.
Relief Pressure
Relief Press. Stpt.
Return Fan
RA Fan Start/Stop
On
RA Fan 1 Status
On
RA Fan 2 Status
On
RA Fan Speed
RA Fan VFD Feedback
62.00 Hz
RA Fan VFD Alarm
Normal
Fan On @ 7:05 AM 12-Dec-25
RA Fan Speed Offset of SA Fan
RA Fan Max Spd. Off.
50 %
RA Fan Min Spd. Off.
10 %
RA Temp.
72.4 °F
RA Rel.Humidity
21 %
RA CO2
435 ppm
Icon Legend
Calibrate
Override
Right-Click
Supply Fan
SA Fan Start/Stop
On
SA Fan 1 Status
On
SA Fan 2 Status
On
SA Fan Speed
50 %
SA Fan VFD Feedback
41.30 Hz
SA Fan VFD Alarm
Normal
Fan On @ 7:05 AM 12-Dec-25
SA Static Pressure
0.54 in/wc
Eff. SA Static Stpt.
0.50 in/wc
Supply Static Safety
Normal
Click for Pressure Settings
MA Temp
57.2 °F
OA Damper Pos.
58 %
RA Damper Pos.
42 %
OA Damper Schedule
Enabled
Cause of OA Status
Ventilation
RA CO2 Stpt
1000 ppm
RA CO2 Span
400 ppm
Eff. OA Flow Stpt
7500 cfm
OA Flow
7528 cfm
Design Flow Stpt
7500 cfm
Reduced Flow Stpt
3800 cfm
Preheat Valve Pos.
0 %
Preheat Temp.
56.2 °F
Preheat Stpt.
52.0 °F
0 %
CHWValve Pos.
Economizer
Off
Econ SA Stpt. Adj.
3.0 °F
Eff. Econ MA Stpt.
62.0 °F
OA Damper Lockout
Normal
Repeat Interval
3600.00 s
AHU_02
Click for Service Screen
Freeze Alarm
Normal
Preheat Low Limit
40.0 °F
Min. Off Time
1200.00 s
Supply Air Temp.
57.4 °F
Eff. SA Temp. Stpt.
65.0 °F
Click for Setpoint Settings
Controller Status
(ok)
Last Fail Time
23-Jun-25 10:23 AM EDT
Last Ok Time
12-Dec-25 12:20 PM EST

4.8.2 EXAMPLE PIU GRAPHIC

The figure below shows an example of a Graphic for a Variable Air Volume (VAV) box with reheat. The data blocks shall follow the color legend in Table 4.1.0.1.

Figure 4.8.2.1: Example VAV Box with Reheat Graphic

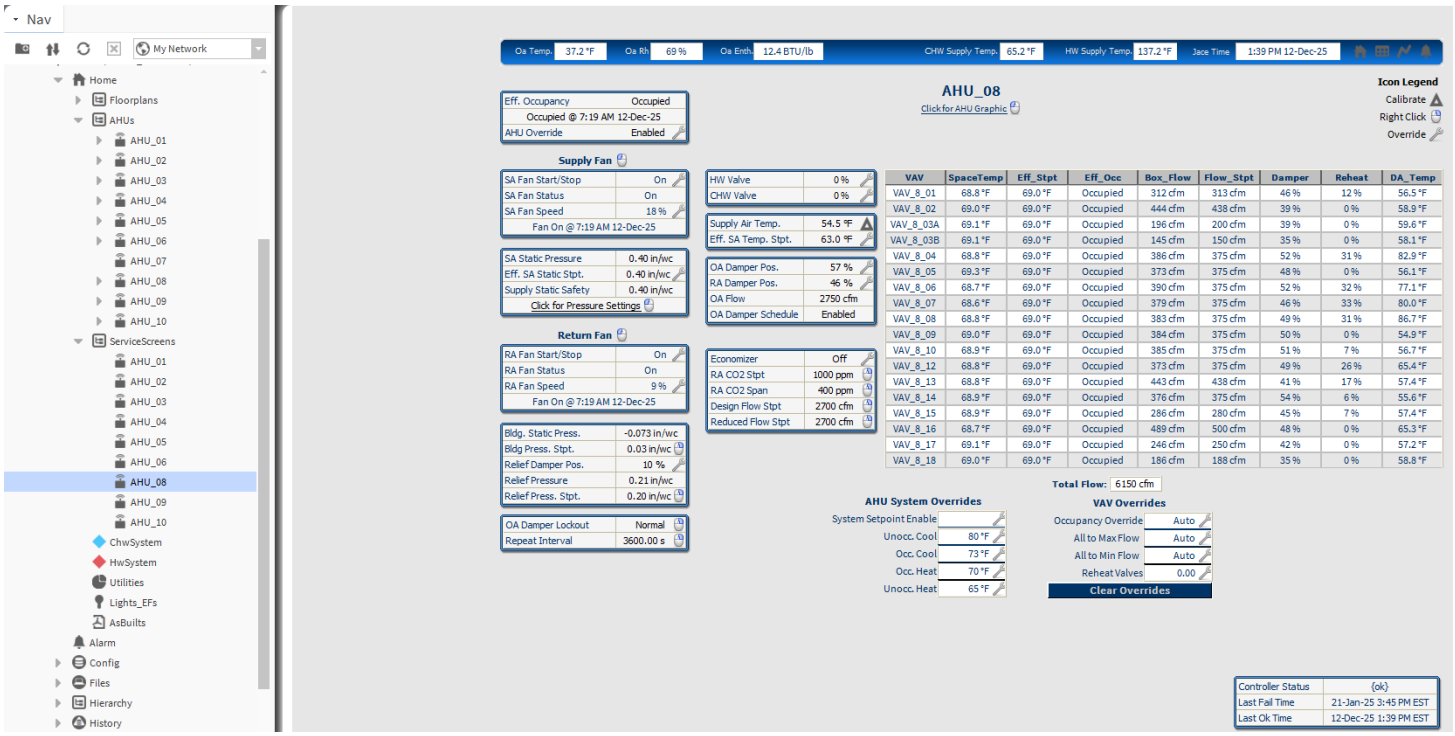


4.8.3 EXAMPLE SUMMARY GRAPHIC

In addition to each item as shown on Figures 4.8.1.1 & 2, 4.8.2.1, and 4.8.4.1 one summary Graphic showing multiple data parameters shall be provided. Figure 4.8.3.1 is an example of a summary Graphic. The data blocks shall follow the color legend in Table 4.1.0.1.

Navigation to the summary graphic shall be provided on the Nav Tree for all AHU's. A link is also provided on the device (picture) graphic for AHU's and Central plant screens.

Figure 4.8.3.1: Example Summary Graphic

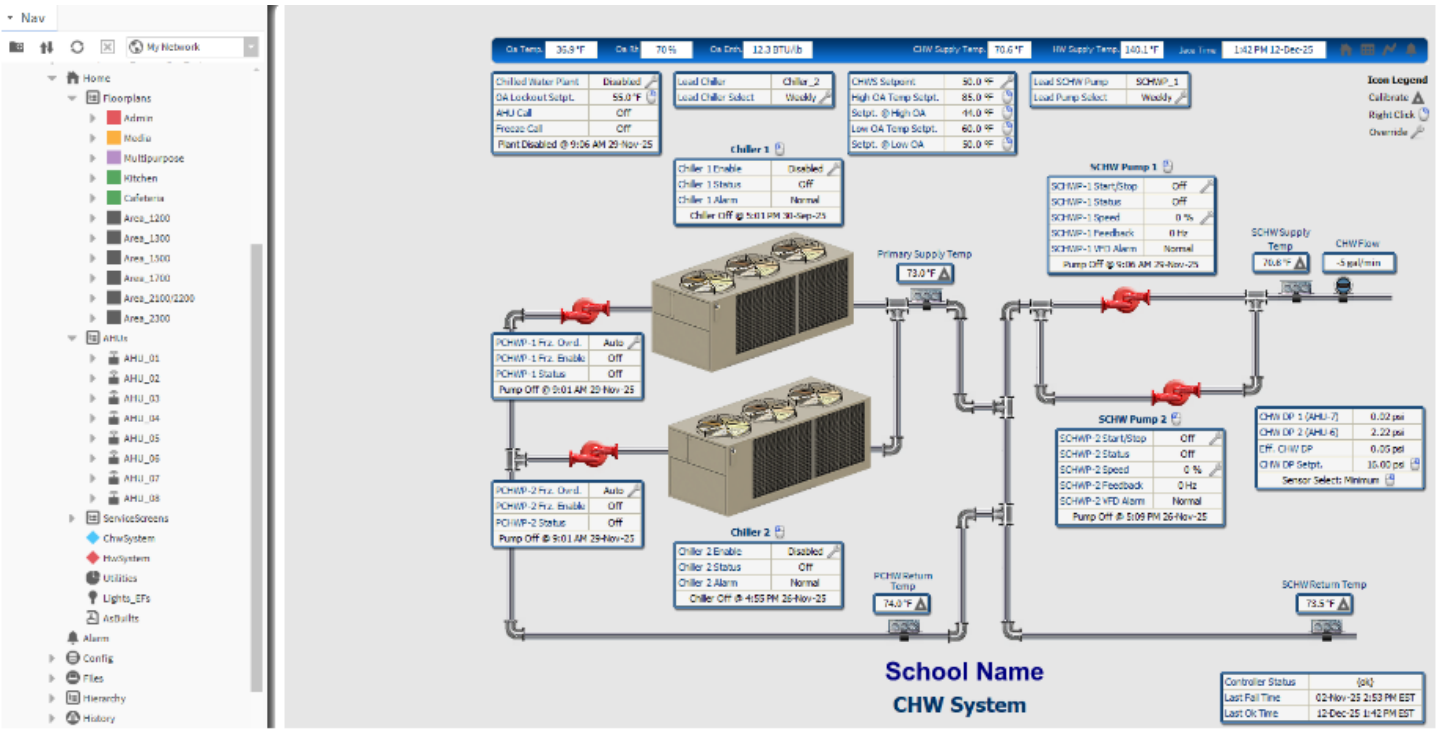


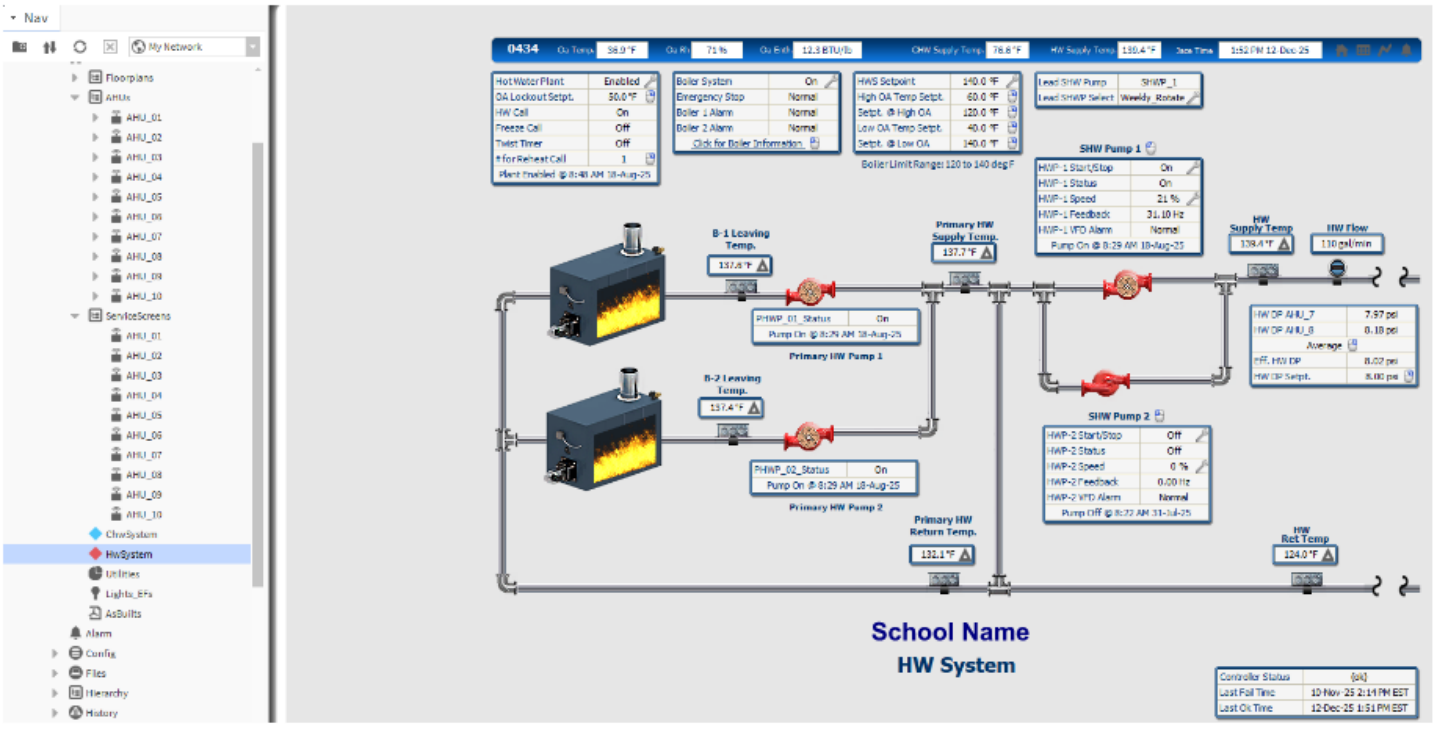
If an AHU serves many VAVs, PIUs, or other boxes and do not all fit neatly onto one summary Graphic, the summary shall be broken into multiple Graphics. Buttons shall be added to each summary Graphic to allow the user to easily go from one summary Graphic to another.

4.8.4 EXAMPLE CENTRAL PLANT GRAPHICS

Figure 4.8.4.1 show examples of some central plant Graphics. Note that the flow diagram shown in Figure 4.8.4.1 may not fit on a single Graphic for large or complex Central Plants. If this happens, the condenser water system and the chilled water system shall be broken out into separate Graphics. The data blocks shall follow the color legend in Table 4.1.0.1 and the graphic objects shall follow the color legend in Table 4.1.0.2.

Figure 4.8.4.1: Example Central Plant Flow Diagram

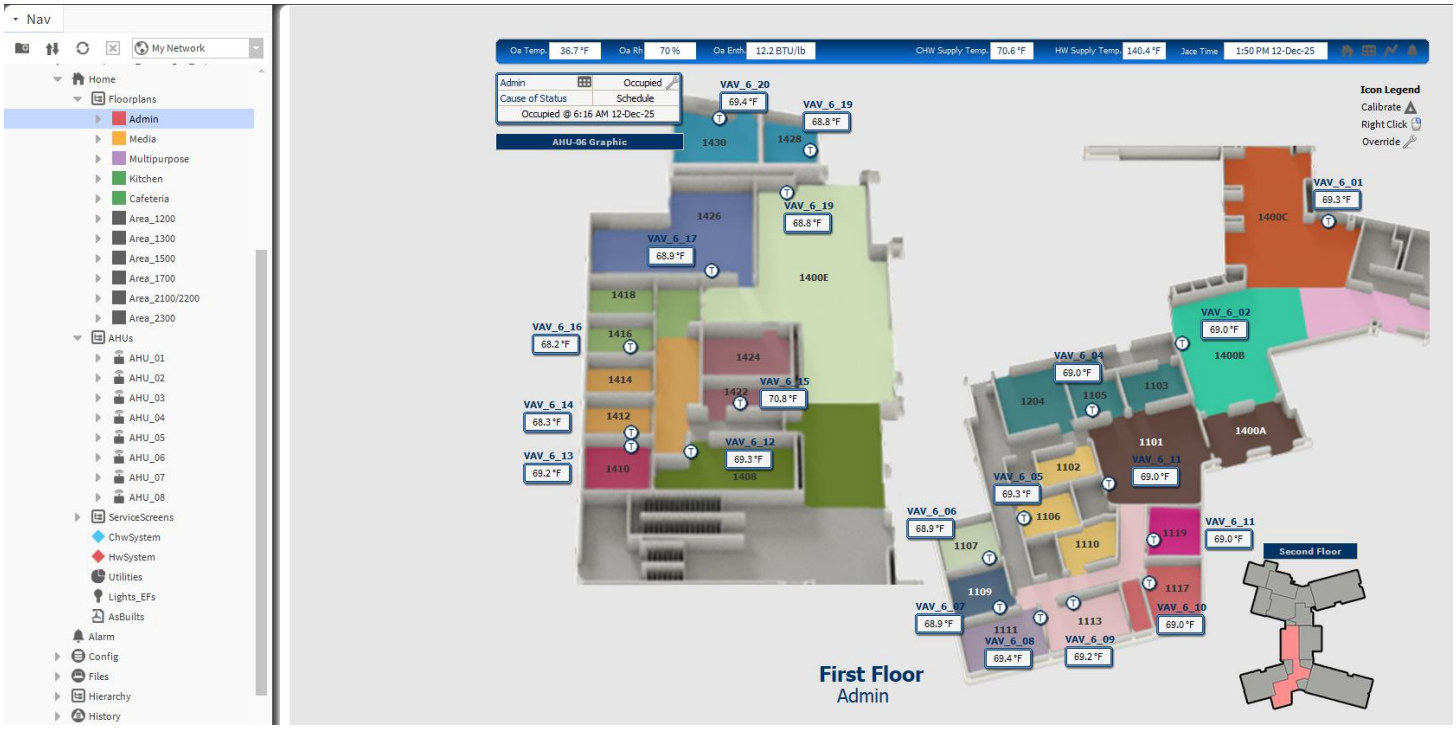




4.8.5 EXAMPLE FLOOR PLAN

Figure 4.8.5.1 below is an example of a Floor Plan. The WCPSS Project Manager for any given project shall provide the site building plans, as requested, in Adobe (.pdf) format. The room areas served by a single VAV box shall be color coded to be the same color. The data blocks shall follow the color legend in Table 4.1.0.1.

Figure 4.8.5.1 Example Floor Plan



END OF SECTION 23 09 00

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SEQUENCE OF OPERATION – Table of Contents

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SECTION 230993
SEQUENCE OF OPERATION

PART I. GENERAL

1.01 SECTION INCLUDES

A. Air Handling Units

B. Terminal Units

C. Chilled Water Systems

D. Heating HW Systems

E. Exhaust Fans

F. Lighting controls

G. Domestic Water System Controls/Monitoring

H. Miscellaneous Metering

I. Miscellaneous system monitoring & control

1.02 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including the General Conditions and Supplementary Conditions and other Division-1 Specification Sections, apply to this Section.

B. Section ***{Insert Section Number}*** - Basic Mechanical Requirements

C. Section 230900 - Building Automation System (BAS) General

D. Section 230901 - BAS Basic Materials, Interface Devices, and Sensors

E. Section 230903 - BAS Field Panels

F. Section 230904 - BAS Communications Devices

G. Section 230905 - BAS Software and Programming

H. Section 230801 – BAS Commissioning

1.03 SYSTEM DESCRIPTION

A. The systems to be controlled under work of this section basically comprise ***{describe the scope of the project}***. The HVAC systems being controlled are ***{describe the configuration of and the type of systems included in the project}***

B. This Section defines the manner and method by which controls function.

1.04 SUBMITTALS

A. Refer to Section 230900 and Division 1 for requirements for control shop drawings, product data, Users Manual, etc.

B. Programming Manual: Provide DDC system programming manual as well as documentation of site-specific programming prior to the start of Acceptance Phase.

PART II. PRODUCTS

Not Used

PART III. EXECUTION

3.01 GENERAL

A. Sequences specified herein indicate the functional intent of the systems operation and may not fully detail every aspect of the programming that may be required to obtain the indicated operation. Contractor shall provide all programming necessary to obtain the sequences/system operation indicated.

B. When an air handling unit is not in operation, control devices shall remain in their "off" positions. "Off" positions may differ from the "normal" (meaning failed) position. Except as specified otherwise, "off" and "normal" positions of control devices shall be as follows:

Device	"Off" Position	"Normal" Position
Heating coil valves	**controlling**	**open**
Cooling coil valves	**closed**	**closed**
Outside air damper	**closed**	**closed**
Return air damper	**open**	**open**
Exhaust/relief air damper	**closed**	**closed**

C. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials shall be centered on the associated setpoint. All modulating feedback control loops shall include the capability of having proportional, integral, and derivative action. Unless the loop is specified "proportional only" or "P+I", Contractor shall apply appropriate elements of integral and derivative gain to each control loop which shall result in stable operation, minimum settling time, and shall maintain the primary variable within the specified maximum allowable variance.

D. Provide a real time clock and schedule controller with sufficient scheduling capability to schedule all required controllers and sequences. Set up initial schedules in coordination with WCPSS.

E. Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:

1. **Occupied Period**: period of time when the building is in use and occupied. Generally systems will be fully operational throughout this period and ventilation air shall be continuously introduced. Space temperature setpoints will generally be in the "normal" range of 69°-77°F.
2. **Unoccupied period**: period of time when the building or zone is not in use and unoccupied. Ventilation air shall not be introduced.
3. **Preoccupancy Period**: Time prior to the Occupied period when the systems are returning the space temperatures from setback to "normal" or occupied setpoints (warm-up and cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling. Time period shall be determined by an optimum start strategy unless otherwise specified.
4. **Setback Period**: Setback will typically start with the end of the occupied period and end with the start of the preoccupancy period, however it shall be provided with its own schedule. Generally systems will be off except to

maintain a “setback” temperature, economization may be enabled to maintain “setback” cooling setpoint when applicable.

F. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the BAS start commands shall be staggered by 5-second (adj.) intervals to minimize inrush current.

G. Wherever a value is indicated as adjustable (adj.), it shall be modifiable, with the proper password level, from the Operator interface. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

H. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, one of the following methods shall be employed:

1. Contractor shall determine a fixed reset schedule which shall result in stable operation and shall maintain the primary variable within the specified maximum allowable variance.
2. A floating reset algorithm shall be used which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance.
3. Primary variable shall control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices shall still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term shall be selected to maintain the primary variable within the specified maximum allowable tolerance while minimizing overshoot and settling time. Contractor shall gain prior approval for implementing this method of reset.

I. Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. space temperature) setpoint. The reset increment shall be determined by the quantity of “need heat” or “need cool” requests from individual SCU’s. A SCU’s “need heat” virtual point shall activate whenever the zone’s space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A SCU’s “need cool” virtual point shall activate whenever the zone’s space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values shall limit the setpoint range.

J. Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. cooling valve, heating valve, damper position) setpoint of 85% open. The reset increment shall be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. The BAS analog output value shall be acceptable as indicating the position of the control device.
2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the "need heat" or "need cool" virtual point shall increment by one unit each time a zone's valve/damper position rises to greater than 95% (adj.). The quantity of "need heat" or "need cool" points shall then be the basis for reset.

K. Where "prove operation" of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS shall, after an adjustable time delay after the device is commanded to operate (feedback delay) , confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm shall be enunciated ~~audibly~~ visually. Upon failure, run command shall be removed and the device shall be locked out until the alarm is manually acknowledged unless specified otherwise.

L. BAS shall provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:

1. Speed control of variable speed drives
2. Control Reset Loop
3. Valve Travel Limit

M. Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus 5°F) BAS shall use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points shall be provided. One to store the parameter (5°F), one to store the setpoint, and one to store the value which is the result of the equation.

N. VSD Interface: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

O. **Demand Limiting:** The BAS shall broadcast the current demand level and adjust the current heating and cooling temperature setpoints as follows based on the current demand level:

1. Demand Level 0: The space temperature setpoints shall not be adjusted.
2. Demand Level 1: The heating setpoint shall be decreased by 1°F (adj.) & the cooling setpoint shall be increased by 1°F (adj.).
3. Demand Level 2: The heating setpoint shall be decreased by 2°F (adj.) & the cooling setpoint shall be increased by 2°F (adj.).
4. Demand Level 3: The heating setpoint shall be decreased by 3°F (adj.) & the cooling setpoint shall be increased by 3°F (adj.).

3.02 AIR HANDLING UNITS - GENERAL

A. **Logic Strategies**: The BAS shall fully control the air handlers. Generally the BAS shall energize the AH (start the fans and activate control loops) as dictated for each air handler. The following indicates when and how the BAS shall energize the AHs and control various common aspects of them. The following "logic strategies" shall be included by reference with each air handler with any specific clarifications required:

1. **Scheduled Occupancy:** BAS shall determine the occupancy periods (occupied, unoccupied, preoccupancy, and setback) as defined above. The following details the common control aspects related to the scheduled occupancy. The BAS shall display the applicable mode or "cause" for the unit operating. Reference the BAS control specifications (graphics) for more information on how this should be displayed.
   a) **Occupied Period**: BAS shall energize the AH during all occupied periods. Note that the beginning of the occupancy period shall be set sufficiently before the actual start of occupancy to obtain the required building component of ventilation per ASHREA 62. Specific times shall be as directed by the A/E. Minimum OA flow setpoint shall be as scheduled on the drawings. "Normal" setpoints shall apply.
   b) **Unoccupied Period**: Minimum OA flow shall be 0 CFM and the minimum OA damper position shall be 0%. If during the unoccupied period there is a request for occupancy override, the occupancy modeshall become active for an adjustable period. The unoccupied period and the preoccupancy period will typically overlap.
   c) **Setback Period**: the BAS shall deenergize the unit except as required to maintain a setback temperature as indicated in the individual sequences with a 5°F cycle differential. Generally, where setback temperatures apply in multiple zones, the average space temperature in the worst zone shall control the system. Setback setpoints generally apply except during preoccupancy. If during the unoccupied period there is a request for occupancy override, the occupancy mode shall become active for an adjustable period. Generally, during heating setback, cooling shall be disabled. During cooling setback, both heating and cooling shall be enabled.
   d) **Preoccupancy**: BAS shall energize the AH continuously during the preoccupancy period. Minimum OA flow shall be 0 CFM or the minimum OA damper position shall be 0%. "Normal" space setpoints shall apply for the connected terminal units. Preoccupancy duration shall be optimized so that the preset start time is minimized but all zones achieve setpoint at the start of the occupied period. The BAS shall continuously adjust to the preoccupancy period (up to a user

defined maximum amount of time) to optimize the preoccupancy start period. Generally, during warm-up mode, cooling shall be disabled. During morning cooldown, both heating and cooling shall be enabled.

2. **Sequenced Heating and Cooling:** BAS shall control the heating and cooling coils and air side economizer as detailed for the particular AH. Program logic shall directly prohibit the heating and cooling valves as well as the heating valve and economizer damper to be open (or above minimum) simultaneously. This does not apply to cooling and reheat valves that are used simultaneously for dehumidification.
3. **Airside Economizer:** BAS shall modulate the mixing dampers to provide "free cooling" when conditions merit. The free cooling shall generally be staged before any mechanical cooling. While cooling conditions merit, dampers shall be modulated in a DA PID loop to maintain mixed air temperature at a setpoint as specified for the individual unit. Economizer logic shall remain enabled during setback cooling, where applicable. Economizer mode shall be active in cooling mode (demand cooling) while:
   a) The unit is energized and status has been proven for at least 15 seconds (adj.).
   b) AND, when outside air temperature falls below the switching setpoint of 68°F (adj.), with 1°F (adj.) cycle differential.
   c) AND, when outside air temperatures are above 45°F (adj.), with 1°F (adj.) cycle differential.
   d) AND, when outside air enthalpy is less than 28 BTU/lb
4. **Mixed Air Low Limit Override**: BAS shall override the signal to the OA & RA dampers via a proportional only loop to maintain a minimum mixed air temperature. The maximum allowed output of the OA/RA dampers shall drop from 100% to 0% as the mixed air temperature drops from 45°F to 40°F (all values being adjustable).
5. **Freeze Safety**: Upon a drop in temperature below 40F (adj) at the heating coil discharge air temperature sensor, the supply air and return air fans shall stop, the OA & EA dampers will close, the RA damper will open, the secondary chilled water pump and the heating water pump shall start and the hot water plant shall be enabled, and the heating water and chilled water control valves at the air handling unit shall open fully. After a time delay of 10 minutes (adj.), if the heating coil discharge air temperature has risen above 40°F (adj.), the unit supply air and return air fans shall start again. If the heating coil discharge air temperature falls below 40°F a second time within one hour (adj.), initiate an alarm. Proceed through the freeze protection cycle again. The outside air damper shall remain closed until manually reset (via software).
6. **Smoke/Fire Safety**: Upon indication of smoke or fire by the Fire Alarm system (via a relay provided by the FAS contractor), all dampers shall revert to their normal "Off" positions unless specifically indicated otherwise. The BAS shall enunciate the appropriate alarm; then remove and lock out the unit start command until the alarm condition is cleared.
7. **High or Low Pressure Safety**: Upon activation of a high or low pressure safety switch, AH shall be deenergized via a hard wired interlock and an indication of the operation shall be indicated at the BAS. The BAS shall enunciate the appropriate alarm; then remove and lock out the unit start

command until the alarm condition is cleared.

8. **Demand Control Ventilation:** The OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer (per applicable code), damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 30 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 15 min. (adj.), the OA damper shall reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop.
9. **Supply Air Static Pressure Reset Control:** Reset duct static pressure set point(s) higher or lower between maximum and minimum set points based on BAS optimization logic that uses the terminal unit air damper positions. The set point(s) shall be increased to maintain all dampers at less than 95% open. The set points(s) shall be decreased to maintain minimum of one damper at no less than 90% open. Initial and minimum setpoints shall be recommended by the TAB Contractor and approved by the Engineer.

   Maximum set points shall be equal to the initial setpoints plus 0.50 inches. Reset set point in 15 minute increments.
10. **Humidity Control:** Upon a rise in humidity level above 65% (adjustable) and until relative humidity drops to 60%, as sensed by the return duct humidity sensor, the cooling coil control valve shall modulate to provide 53 deg F discharge air temperature. The unit fan speed, terminal box position, and reheat coil control valve shall be modulated to maintain space temperature 1 deg lower than the cooling setpoint.

B. The detailed “logic strategies” above shall be required by reference to them in each of the individual sequences specified below.

3.03 SINGLE DUCT VAV AH WITH PH & CHW COIL, RETURN FAN [DWG M4.01]

A. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Supply Duct Static Pressure Setpoint**:
   a) Setpoint shall be reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at approximately [4] with all values adjustable.
   b) BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the static setpoint.
   c) Reset values shall be adjusted for optimized building and energy performance.

B. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows:

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall be enabled to run whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General" and the supply fan status has been proven on for at least 5 seconds (adj.).
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized and the unit is operating in the Occupied mode, BAS shall control the speed of the VSD based on a tracking algorithm as defined below.
   a) TAB contractor shall determine the following 4 values:
      1) Supply Fan Max: The speed at which the supply fan will typically operate when all connected terminal units are at their maximum flow setpoints
      2) Supply Fan Min: The speed at which the supply fan will typically operate when all connected terminal units are at their minimum flow setpoints

3) Return Fan Max: The speed at which the return fan will typically need to operate when all connected terminal units are at their maximum flow setpoints

4) Return Fan Min: The speed at which the return fan will typically need to operate when all connected terminal units are at their minimum flow setpoints

b) The BAS shall modulate the return fan speed as follows:

1) When the speed of the supply fan is less than the Supply Fan Min value, the return fan speed shall be the output of a linear reset loop that is reset from 0% to the Return Fan Min value as the supply fan speed increases from 0% to the Supply Fan Min value

2) When the speed of the supply fan is greater than the Supply Fan Min value but not greater than the Supply Fan Max value, the return fan speed shall be the output of a linear reset loop that is reset from the Return Fan Min value to the Return Fan Max value as the supply fan speed increases from the Supply Fan Min value to the Supply Fan Max value

3) When the speed of the supply fan is greater than the Supply Fan Max value, the return fan speed shall be the output of a linear reset loop that is reset from the Return Fan Max value to 100% as the supply fan speed increases from the Supply Fan Max value to 100%. Note that this stage will not apply if Supply Fan Max value or the Return Fan Max value equals 100%.

4) The return fan speed shall be limited so that it is never commanded to a speed that is more than 20% (adj.) above or 20% (adj.) below the speed of the supply fan.

c) On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

d) During Unoccupied mode of operation, the Return Fan Speed shall be the same as the Supply Fan Speed.

4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic.

5. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

C. **Outside Air (OA)/ Return Air (RA)/ Relief (Rel) Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.

2. **Minimum OA Control**: OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall

have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 60 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 30 min. (adj.), the OA damper shall reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop."

3. **Relief Control**: BAS shall modulate the Rel damper to maintain the Relief plenum pressure at setpoint. Setpoint shall initially be set at 0.2"w.c. (adj.).
4. **Economizer**: BAS shall modulate the OA/RA & Rel dampers per the Airside economizer strategy to maintain the mixed air temperature at setpoint. The mixed air setpoint shall be equal to the discharge air temperature setpoint (specified herein) minus 3°F (adj.). The dampers shall modulate open per the higher of the economizer PID loop output and:
   a) The Minimum OA flow control output described above (for the OA & RA dampers only).
   b) The Relief Control output described above (for the Rel Damper).
5. **Mixed Air Low Limit**: Per the mixed air low limit logic strategy, the OA and RA dampers' position shall be limited to prevent the mixed air temperature from falling below the low limit setpoint. The limit shall override the output from the economizer and minimum OA flow control loop outputs.

D. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. The BAS shall utilize a Sample and Bump output strategy or other similar loop output/logic to calculate a resultant value based on the number of"need cooling" requests from associated VAV terminal units. The Upper and lower limits of this reset setpoint shall initially be set to 65°F and 55°F (both adjustable), respectively. The output of this loop shall input to a dehumidification loop as the high limit of its reset range (see below).
2. A dehumidification loop shall be A Proportional only loop output reset from the high limit output from the temperature reset loop (as described above) to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).
3. The resultant temperature output after passing through the two loops (as described above) shall be the effective discharge temperature setpoint. This value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic.

All reset values shall be adjusted for optimized building and energy performance.

F. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F (adj.), and
   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.
2. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve shall be commanded to 100% open (adj.)

G. **Cooling Section**:

1. **Cooling Coil Valve**: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the ChW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open.
4. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the ChW valve shall be commanded to 100% open (adj.)

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.04 SINGLE DUCT VAV AH WITH PH & CHW COIL, RETURN FAN CONTROLLED BY BLDG STATIC [DWG M4.02]

A. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Supply Duct Static Pressure Setpoint**:
   a) Setpoint shall be reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at approximately [4] with all values adjustable.
   b) BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the static setpoint.
   c) Reset values shall be adjusted for optimized building and energy performance.

B. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows:

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall be enabled to run whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General" and the supply fan status has been proven on for at least 5 seconds (adj.).
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized and the unit is operating in the Occupied mode, BAS shall control the speed of the VSD to maintain the building static pressure at setpoint.
   a) Setpoint shall initially be set at 0.03"w.c. (adj.).
   b) The return fan speed shall be limited so that it is never commanded to a speed that is more than 20% (adj.) above or 20% (adj.) below the speed of the supply fan.
   c) On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
   d) During Unoccupied mode of operation, the Return Fan Speed shall be the same as the Supply Fan Speed.

4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

C. **Outside Air (OA)/ Return Air (RA)/ Relief (Rel) Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 60 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 30 min. (adj.), the OA damper shall reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop."
3. **Relief Control**: BAS shall modulate the Rel damper to maintain the Relief plenum pressure at setpoint. Setpoint shall initially be set at 0.2"w.c. (adj.).
4. **Economizer**: BAS shall modulate the OA/RA & Rel dampers per the Airside economizer strategy to maintain the mixed air temperature at setpoint. The mixed air setpoint shall be equal to the discharge air temperature setpoint (specified herein) minus 3°F (adj.). The dampers shall modulate open per the higher of the economizer PID loop output and:

a) The Minimum OA flow control output described above (for the OA & RA dampers only).

b) The Relief Control output described above (for the Rel Damper).

5. **Mixed Air Low Limit**: Per the mixed air low limit logic strategy, the OA and RA dampers' position shall be limited to prevent the mixed air temperature from falling below the low limit setpoint. The limit shall override the output from the economizer and minimum OA flow control loop outputs.

D. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. The BAS shall utilize a Sample and Bump output strategy or other similar loop output/logic to calculate a resultant value based on the number of "need cooling" requests from associated VAV terminal units. The Upper and lower limits of this reset setpoint shall initially be set to 65°F and 55°F (both adjustable), respectively. The output of this loop shall input to a dehumidification loop as the high limit of its reset range (see below).
2. A dehumidification loop shall be A Proportional only loop output reset from the high limit output from the temperature reset loop (as described above) to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).
3. The resultant temperature output after passing through the two loops (as described above) shall be the effective discharge temperature setpoint. This value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic.

All reset values shall be adjusted for optimized building and energy performance.

F. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F (adj.), and
   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.
2. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve shall be commanded to 100% open (adj.)

G. **Cooling Section**:

1. **Cooling Coil Valve**: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the ChW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open.

4. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the ChW valve shall be commanded to 100% open (adj.)

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.05 SINGLE DUCT VAV AH WITH PH & CHW COIL, RELIEF FAN CONTROLLED BY BLDG STATIC [DWG M4.03]

A. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Supply Duct Static Pressure Setpoint**:
   a) Setpoint shall be reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at approximately [4] with all values adjustable.
   b) BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the static setpoint.
   c) Reset values shall be adjusted for optimized building and energy performance.

B. **Relief Fan**: BAS shall control the starting and stopping of the relief fan as follows:

1. **Start/Stop**: The BAS shall command the operation of the Relief fan to maintain building pressure at setpoint. An appropriate amount of derivative gain or a ramp function shall be employed to prevent overshoot of the building pressurization setpoint. The fan shall be controlled as follows:
   a) Fan Start: Via proof of relief damper end switch verification input, [AHU mounted Relief dampers] the fan shall be enabled whenever the building pressure exceeds 0.05"w.c. (adj.).for more than 2 minutes (adj.).

b) Fan Stop: The fan shall be disabled whenever the building pressure is below 0.01”w.c (adj.) AND the building pressurization loop output has been at 0% for 5 minutes (adj.).

c) The relief fan shall remain off whenever the supply fan status is not proven on.

2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

3. **VSD Control**: Whenever the fan is energized and the unit is operating in the Occupied mode, BAS shall control the speed of the VSD to maintain the building static pressure at setpoint.

a) Setpoint shall initially be set at 0.03”w.c. (adj.).

b) The relief fan speed shall be limited so that it is never commanded to a speed that is more than 20% (adj.) above or 20% (adj.) below the speed of the supply fan.

c) On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

d) During Unoccupied mode of operation, the Relief Fan Speed shall be the same as the Supply Fan Speed.

4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system’s graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

C. **Outside Air (OA)/ Return Air (RA)/ Relief (Rel) Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their “off” positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.

2. **Minimum OA Control**: OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 60 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 30 min. (adj.), the OA damper shall

reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop."

3. **Relief Control**: BAS shall modulate the Relief damper to maintain the building static pressure at setpoint.
4. **Economizer**: BAS shall modulate the OA/RA & Rel dampers per the Airside economizer strategy to maintain the mixed air temperature at setpoint. The mixed air setpoint shall be equal to the discharge air temperature setpoint (specified herein) minus 3°F (adj.). The dampers shall modulate open per the higher of the economizer PID loop output and:
   a) The Minimum OA flow control output described above (for the OA & RA dampers only).
   b) The Relief Control output described above (for the Relief Damper).
5. **Mixed Air Low Limit**: Per the mixed air low limit logic strategy, the OA and RA dampers' position shall be limited to prevent the mixed air temperature from falling below the low limit setpoint. The limit shall override the output from the economizer and minimum OA flow control loop outputs.

D. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. The BAS shall utilize a Sample and Bump output strategy or other similar loop output/logic to calculate a resultant value based on the number of"need cooling" requests from associated VAV terminal units. The Upper and lower limits of this reset setpoint shall initially be set to 65°F and 55°F (both adjustable), respectively. The output of this loop shall input to a dehumidification loop as the high limit of its reset range (se5 below).
2. A dehumidification loop shall be A Proportional only loop output reset from the high limit output from the temperature reset loop (as described above) to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).
3. The resultant temperature output after passing through the two loops (as described above) shall be the effective discharge temperature setpoint. This value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic.

All reset values shall be adjusted for optimized building and energy performance.

F. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F (adj.), and
   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.

2. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve shall be commanded to 100% open (adj.)

G. **Cooling Section**:

1. **Cooling Coil Valve**: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the ChW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open.
4. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the ChW valve shall be commanded to 100% open (adj.)

H. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.06 SINGLE DUCT VAV AH WITH ECONOMIZER - PREHEAT & CHW COIL [DWG M4.04]

A. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Supply Duct Static Pressure Setpoint**:
   a) Setpoint shall be reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at approximately [4] with all values adjustable.
   b) BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the static setpoint.

c) Reset values shall be adjusted for optimized building and energy performance.

B. **Outside Air (OA)/ Return Air (RA)/ Relief (Rel) Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 60 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 30 min. (adj.), the OA damper shall reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop."
3. **Economizer**: BAS shall modulate the OA, RA & Relief dampers per the Airside economizer strategy to maintain the mixed air temperature at setpoint. The mixed air setpoint shall be equal to the discharge air temperature setpoint (specified herein) minus 3°F (adj.). The dampers shall modulate open per the higher of the economizer PID loop output and the Minimum OA flow control output described above (for the OA & RA dampers only).
4. **Mixed Air Low Limit**: Per the mixed air low limit logic strategy, the OA, RA & Relief dampers' position shall be limited to prevent the mixed air temperature from falling below the low limit setpoint. The limit shall override the output from the economizer and minimum OA flow control loop outputs.

C. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

D. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. The BAS shall utilize a Sample and Bump output strategy or other similar loop output/logic to calculate a resultant value based on the number of "need cooling" requests from associated VAV terminal units. The Upper and lower limits of this reset setpoint shall initially be set to 65°F and 55°F (both

adjustable), respectively. The output of this loop shall input to a dehumidification loop as the high limit of its reset range (see below).

2. A dehumidification loop shall be A Proportional only loop output reset from the high limit output from the temperature reset loop (as described above) to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).
3. The resultant temperature output after passing through the two loops (as described above) shall be the effective discharge temperature setpoint. This value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic.

All reset values shall be adjusted for optimized building and energy performance.

E. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F (adj.), and
   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.
2. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve shall be commanded to 100% open (adj.)

F. **Cooling Section**:

1. **Cooling Coil Valve**: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the ChW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open.
4. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the ChW valve shall be commanded to 100% open (adj.)

G. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.07 SINGLE DUCT VAV AH WITHOUT ECONOMIZER - PREHEAT & CHW COIL [DWG M4.05]

A. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.

3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the supply duct static pressure setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Supply Duct Static Pressure Setpoint**:
    a) Setpoint shall be reset between the limits of .5" to 2" as to maintain pressure requests of the VAV boxes at approximately [4] with all values adjustable.
    b) BAS shall utilize a Sample and Bump output strategy or other similar loop output or logic to reset the static setpoint.
    c) Reset values shall be adjusted for optimized building and energy performance.

B. **Outside Air (OA)/ Return Air (RA) Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 60 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 30 min. (adj.), the OA damper shall reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop."
3. **Mixed Air Low Limit**: Per the mixed air low limit logic strategy, the OA & RA dampers' position shall be limited to prevent the mixed air temperature from falling below the low limit setpoint. The limit shall

override the output from the economizer and minimum OA flow control loop outputs.

C. **Space Temperature Control**: The space temperatures shall be controlled via individual VAV boxes.

D. **Discharge Temperature Control**: The discharge temperature setpoint shall be set to the lower of the following:

1. The BAS shall utilize a Sample and Bump output strategy or other similar loop output/logic to calculate a resultant value based on the number of "need cooling" requests from associated VAV terminal units. The Upper and lower limits of this reset setpoint shall initially be set to 65°F and 55°F (both adjustable), respectively. The output of this loop shall input to a dehumidification loop as the high limit of its reset range (see below).
2. A dehumidification loop shall be A Proportional only loop output reset from the high limit output from the temperature reset loop (as described above) to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).
3. The resultant temperature output after passing through the two loops (as described above) shall be the effective discharge temperature setpoint. This value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic.

All reset values shall be adjusted for optimized building and energy performance.

E. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at 52°F (adj.), and
   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.
2. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve shall be commanded to 100% open (adj.)

F. **Cooling Section**:

1. **Cooling Coil Valve**: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the ChW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open.
4. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the ChW valve shall be commanded to 100% open (adj.)

G. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.08 SINGLE ZONE VAV AH W/ PH, CHW COIL, RH COIL, RETURN FAN CONTROLLED BY BLDG STATIC [DWG M4.06]

A. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD to maintain the Space temperature at setpoint (see zone temperature control below). On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

B. **Return Fan**: BAS shall control the starting and stopping of the return fan as follows:

1. **Start/Stop**: BAS shall command the operation of the return fan and it shall be enabled to run whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General" and the supply fan status has been proven on for at least 5 seconds (adj.).
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall enunciate an alarm.
3. **VSD Control**: Whenever the fan is energized and the unit is operating in the Occupied mode, BAS shall control the speed of the VSD to maintain the building static pressure at setpoint.
   a) Setpoint shall initially be set at 0.03"w.c. (adj.).
   b) The return fan speed shall be limited so that it is never commanded to a speed that is more than 20% (adj.) above or 20% (adj.) below the speed of the supply fan.
   c) On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
   d) During Unoccupied mode of operation, the Return Fan Speed shall be the same as the Supply Fan Speed.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

C. **Outside Air (OA)/ Return Air (RA)/ Relief (Rel) Dampers**: BAS shall control the dampers as follows:

1. **Closed**: When AH is deenergized, dampers shall remain in their "off" positions. When AH is energized during unoccupied period the minimum OA flow setpoint will be 0 cfm which will close the OA damper unless economizer is available.
2. **Minimum OA Control**: OA damper shall modulate between minimum damper position and reduced minimum damper position based on RA CO2 when economizer mode is not enabled. When economizer is enabled, it shall have priority over the damper position and CO2 control shall not be active. The minimum OA and reduced OA ventilation (50% of min OA) requirements shall be specified by the engineer, damper positions established by the air balancer, and BAS programmed by the BAS contractor. Engineer shall ensure that specified minimum and reduced minimum damper position setpoints are adequate to maintain building pressure slightly positive at all times. The initial CO2 setpoint shall be 1000 ppm with a 400 ppm operating span. When the CO2 value is below the CO2 PPM setpoint as measured by the RA CO2 sensor for 60 min. (adj), the OA damper shall reset from "Minimum" position to the "Reduced Minimum" position. When the CO2 value is above the CO2 PPM setpoint (adj.) as measured by the RA CO2 sensor for 30 min. (adj.), the OA damper shall reset from "Reduced Minimum" to the "Minimum" position. This is typically a "proportional only" control loop as the OA damper should not modulate until it's above or below setpoint. Economizer mode shall remain typical as a PI or PID Loop."
3. **Relief Control**: BAS shall modulate the Relief damper to maintain the Relief plenum pressure at setpoint. Setpoint shall initially be set at 0.2"w.c. (adj.).
4. **Economizer**: BAS shall modulate the OA/RA & Rel dampers per the Airside economizer strategy to maintain the mixed air temperature at setpoint. The mixed air setpoint shall be equal to the discharge air temperature setpoint (specified herein) minus 2°F (adj.). The dampers shall modulate open per the higher of the economizer PID loop output and:

    a) The Minimum OA flow control output described above (for the OA & RA dampers only).

    b) The Relief Control output described above (for the Rel Damper).

5. **Mixed Air Low Limit**: Per the mixed air low limit logic strategy, the OA and RA dampers' position shall be limited to prevent the mixed air temperature from falling below the low limit setpoint. The limit shall override the output from the economizer and minimum OA flow control loop outputs.

D. **Space Temperature Control**: The BAS shall reset the discharge temperature setpoint and modulate the speed of the supply fan to maintain the space temperature at setpoint as described below.

E. **Discharge Temperature Control**: The discharge temperature setpoint shall be reset as follows:

1. The unit shall enter cooling mode whenever the space temperature is greater

than the space temperature cooling setpoint (with a 2°F hyst).

2. In the cooling mode, the BAS shall utilize a DA PID loop output that controls to maintain the space temperature at the space temperature cooling setpoint. The output of this loop shall be the Cooling PID Loop output.
   a) As the cooling PID loop output increases from 0% to 60%, the DAT setpoint shall be reset from 70°F to 55°F, with all values being adjustable.
   b) As the cooling PID loop output increases from 40% to 100%, the Supply Fan Speed shall be reset from Minimum to 100%, with all values being adjustable.
3. The unit shall enter heating mode whenever the unit not in the cooling mode.
4. In the heating mode, the BAS shall utilize a RA PID loop output that controls to maintain the space temperature at the space temperature heating setpoint. The output of this loop shall be the Heating PID Loop output.
   a) As the heating PID loop output increases from 0% to 60%, the DAT setpoint shall be reset from 70°F to 100°F, with all values being adjustable.
   b) As the heating PID loop output increases from 40% to 100%, the Supply Fan Speed shall be reset from Minimum to 100%, with all values being adjustable.
5. All reset values shall be adjusted for optimized building and energy performance.

F. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of
   a) a PID loop to maintain a leaving coil temperature at setpoint, and
   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).
2. Preheat leaving coil temperature setpoint shall be equal to the Discharge air temperature setpoint – 1°F (adj).
3. Heating Loops shall remain active even when the AHU is not enabled.
4. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve shall be commanded to 100% open (adj.)

G. **Cooling Section**:

1. **Cooling Coil Valve**: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain coil discharge temperature at setpoint.
2. The coil discharge temperature setpoint shall be determined as follows:
   a) The Mixed Air temperature Setpoint shall be equal to the current DAT setpoint + 1°F (adj.).
   b) A dehumidification loop shall enabled whenever
      1) The return air humidity is above setpoint
      2) The unit is not in morning warmup or night setback mode

3) The outside air temperature is greater than 55°F (adj.)

4) AND, unit fan status is proven ON.

c) The dehumidification loop shall be a Proportional only loop output that is reset reset from the Mixed Air Temperature Setpoint (as described above) down to 55°F (adj.) as the return air humidity rises from 55% to 65% (both adjustable).

d) This value shall be trended, alarmed (vs actual temperature) and shown on the BAS graphic.

3. During setback or morning warm-up modes, the ChW valve shall remain closed.
4. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed unless the economizer dampers have been commanded to full open or the unit is in the dehumidification mode.
5. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the ChW valve shall be commanded to 100% open (adj.)

H. **Reheating Section**:

1. **HW ReHeating Valve**: N.O. valve shall modulate via a PID loop to maintain the unit discharge air temperature at setpoint.
2. The Reheat PID loop shall only be active when the unit is in the dehumidification mode. Otherwise, the output from this loop shall remain at 0%.
3. **Freeze Condition**: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the RH valve shall be commanded to 100% open (adj.)

I. **Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

3.09 VAV AH WITH HT RECOVERY, PH COIL & CHW COIL, REHEAT COIL, EF CONTROLLED BY BUILDING STATIC [DWG 4.07]

A. **General**: The air handler shall be fully controlled by the BAS. For details on the referenced logic strategies refer to item "Air Handling Units - General". Air handler control logic strategies shall include

1. scheduled occupancy
2. sequenced heating and cooling coil valve control
3. freeze safety.
4. supply high pressure safety
5. exhaust low pressure safety
6. smoke/ fire safety

B. **Supply Fan**: BAS shall control the starting and stopping of the supply fan as follows:

1. **Start/Stop**: BAS shall command the operation of the supply fan and it shall run continuously whenever the AH is "energized" as specified for the applicable logic strategies specified in item "Air Handling Units - General".
2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall lock out the unit and enunciate an alarm. A remote fan reset can be utilized up to 3 times, upon 3 failures within 30 min, a manual reset shall be required before the unit is allowed to restart.
3. **VSD Control**: On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

C. **OA Damper**: The OA Damper shall be controlled as follows:

1. **Open/Closed**: The OA damper shall be hardwire interlocked to open whenever the supply fan is requested to run at the VSD (in HAND or AUTO).
2. **Proof**: Damper operation shall be proven via a damper end switch. Damper status shall be hard wire interlocked to the VSD to prevent operation if the damper status is not proven open. BAS shall also prove damper operation. Upon failure of the damper, BAS shall lock out the unit and enunciate an alarm. A manual reset via the BAS shall be required before the unit is allowed to restart.

D. **Exhaust Fan**: BAS shall control the starting and stopping of the exhaust fan as follows:

1. **Start/Stop**: BAS shall command the operation of the exhaust fan and it shall run continuously whenever the AH is "energized" as specified for the

applicable logic strategies specified in item "Air Handling Units - General" and the supply fan status has been proven on for at least 5 seconds (adj.).

2. **Proof**: BAS shall prove fan operation and use the status indication to accumulate runtime. Upon failure of the fan, BAS shall lock out the unit and enunciate an alarm. A remote fan reset can be utilized up to 3 times, upon 3 failures within 30 min, a manual reset shall be required before the unit is allowed to restart.
3. **VSD Control**: Whenever the fan is energized, BAS shall control the speed of the VSD as follows:
   a) Initial Test & Balance shall set the Exhaust Fan airflow CFM offset as shown in the air handling unit schedule.
   b) The exhaust fan speed shall be limited so that it is never commanded to a speed that is more than 20% (adj.) above or 20% (adj.) below the speed of the supply fan.
   c) On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.

E. **EA Damper**: The EA Damper shall be controlled as follows:

1. **Open/Closed**: The EA damper shall be hardwire interlocked to open whenever the exhaust fan is requested to run at the VSD (in HAND or AUTO).
2. **Proof**: Damper operation shall be proven via a damper end switch. Damper status shall be hard wire interlocked to the VSD to prevent operation if the damper status is not proven open. BAS shall also prove damper operation. Upon failure of the damper, BAS shall lock out the unit and enunciate an alarm. A manual reset via the BAS shall be required before the unit is allowed to restart.

F. **Heat Recovery Bypass Damper**: BAS shall control the damper(s) as follows:

1. **Closed**: When AH is deenergized, damper(s) shall remain in their "off" positions (full open to the flat plate enthalpic chamber).
2. **Open**: During Pre-Occupancy Mode, or when OA Economizer conditions permit.

G. **Economizer Mode**:

1. Economizer mode shall be enabled whenever OA conditions permit:
   a. The unit has been energized and status has been proven for at least 15 seconds (adj.).
   b. And, when OA temperature falls below the switching point of 68 deg F (adj.)
   c. And, when OA temperature is above 45 deg F (adj.)
   d. And, when OA enthalpy is less than 28 BTH/lb.

2. Upon Economizer Mode enable, OA and EA dampers shall open and flat plate enthalpic chamber bypass damper shall close to the chamber and open to bypass OA.

H. **Discharge Temperature Control**: The discharge temperature setpoint shall be reset as follows:

1. The unit shall enter cooling mode whenever the space temperature is greater than the space temperature cooling setpoint, 74F (adj).

2. In the cooling mode, the BAS shall utilize a DA PID loop output that controls to maintain the space temperature at the space temperature cooling setpoint.

   a) As the cooling space temperature PID loop output increases from 0% to 60%, the DAT setpoint shall be reset from 70°F to 55°F, with all values being adjustable.

   b) As the cooling space temperature PID loop output increases from 60% to 100%, the Supply Fan Speed shall be reset from Minimum to 100%, with all values being adjustable.

3. The unit shall enter heating mode whenever the unit is not in the cooling mode.

4. In the heating mode, the BAS shall utilize a DA PID loop output that controls to maintain the space temperature at the space temperature heating setpoint, 69F (adj).

   a) As the heating space temperature PID loop output increases from 0% to 60%, the DAT setpoint shall be reset from 70°F to 100°F, with all values being adjustable.

   b) As the heating space temperature PID loop output increases from 60% to 100%, the Supply Fan Speed shall be reset from Minimum to 100%, with all values being adjustable.

All reset values shall be adjusted for optimized building and energy performance.

I. **Preheating Section**:

1. **HW Heating Valve**: N.O. valve shall modulate per the higher of

   a) a DA PID loop to maintain discharge temperature at setpoint, and

   b) a proportional only loop that is reset from 0 to 100% as the preheat air temperature drops from 48°F (adj.) to 40°F (adj.).

   Heating Loops shall remain active even when the AHU is not enabled.

J**. Reheating section:** shall be active when dehumidification loop is active:

1. Dehumidification: loop shall be enabled whenever:
   a) RA humidity is above setpoint, 65% (adj).
   b) Unit is not in morning warmup or night setback mode.
   c) Unit fan status is proven on.

2. Upon a rise in RA humidity level above 65% RH (adj.) as sensed by the RA humidity sensor, the cooling coil control valve shall modulate to provide 52 deg F (adj.) leaving air temperature. The reheat coil control valve shall be modulated to maintain space temperature 1 deg F lower than the cooling setpoint.

3. Freeze Condition: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the HW valve(s) shall be commanded to 100% open (adj.)

K**. Cooling Section**:

1. Cooling Coil Valve: Whenever the AHU is energized and status is proven ON, N.C. cooling coil valve shall modulate via a DA PID loop to maintain discharge temperature at setpoint.
2. During setback or morning warm-up modes, the CHW valve shall remain closed.
3. Whenever the unit is energized and the economizer mode is active, the chilled water valve shall remain closed, unless the space temp exceeds

setpoint by 2 deg F for more than 10 min.

4. Freeze Condition: Whenever a freeze condition is initiated (as described in item "Air Handling Units – General – Freeze Safety", the CHW valve shall be commanded to 100% open (adj.)

L**. Occupancy Override**: When the Occupancy Override button on any of the room sensors is depressed momentarily, the unit shall be indexed to the Occupied period for 60 min. (adj.)

M**. Pre-occupancy Mode:**

During morning warm up/cool down, the AHU shall follow the Preoccupancy sequence as noted in "Air Handling units – General". The OA and EA dampers will open via fan/damper interlock as noted above. The unit recirculation damper shall be open to bypass the enthalpic core, and the damper(s) to the flat plate enthalpic chamber shall be closed.

3.10 SINGLE DUCT VAV BOX WITH REHEAT CONTROL [DWG M4.22]

A. **General**: Control shall be pressure independent with minimum, maximum and heating maximum flow setpoints, scheduled occupancy with optimum preoccupancy.

B. **Space Temperature Control:** Four setpoints shall apply. Normal Heating (69°F adj.)), Normal Cooling (74°F adj.)), Setback Heating (55°F (adj.)), and setback cooling (80°F (adj)). These four values shall be the only values changed by the operator to adjust space temperature setpoint. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input).

C. **Occupancy Sensor / Standby mode:** For classrooms (only), the BAS shall monitor the occupancy sensor(s) that serve the room(s) served by the terminal unit. If the (any) zone indicates occupancy the terminal unit shall control to the normal space heating and cooling setpoint as described above. If occupancy is not indicated in the (all) zone(s) served by the terminal unit for a period of 2 mins (adj.). the zone shall enter standby mode. During the standby mode, separate standby heating and cooling setpoints shall be calculated and utilized for control.

1. **Standby space cooling setpoint**: shall be the normal space cooling setpoint plus 3°F (adj.)
2. **Standby space heating setpoint**: shall be the normal space heating setpoint minus 3°F (adj.)

D. **Zone Damper**: Zone damper shall modulate in a PI loop to maintain zone volume setpoint. Zone volume setpoint shall be reset as follows based on the parent AHU Discharge Air Temperature:

1. Whenever the parent AHU DAT is < 65°F (adj.), the following sequence shall apply:

   a) Cooling: The zone volume setpoint shall be reset between the cooling minimum and the cooling maximum volume settings to maintain the space temperature at the cooling space temperature setpoint via a PID loop output. The zone volume setpoint shall be reset linearly between the minimum and cooling maximum volume setpoints as the loop output increases from 0 to 100%.

   b) Heating: The zone volume setpoint shall be reset between the heating minimum and the heating maximum volume settings to maintain the space temperature at the heating space temperature setpoint via a PID loop output. Note that a common space heating PID loop output will be used to reset the zone volume setpoint (in the heating mode) and the HW reheat valve (see below). The zone volume setpoint shall be reset linearly between the minimum and heating maximum volume setpoints as the loop output increases from 25 to 100% (adj.).

   c) Dead band: When the space temperature is between the effective space temperature heating and cooling setpoints (heating and cooling PID outputs are both at 0%), the zone volume setpoint shall remain at the cooling minimum flow setpoint.

2. Whenever the parent AHU DAT is > 65°F (adj.), the following sequence shall apply:
   a) Cooling: The zone volume setpoint shall remain at minimum whenever the space temperature is above the cooling setpoint as no cooling is available in this mode.
   b) Heating: The zone volume setpoint shall be reset between the minimum and the COOLING maximum volume settings to maintain the space temperature at the heating space temperature setpoint via a PID loop output. Note that a common space heating PID loop output will be used to reset the zone volume setpoint (in the heating mode) and the HW reheat valve (see below). The zone volume setpoint shall be reset linearly between the minimum and COOLING maximum volume setpoints as the loop output increases from 0 to 100% (adj.).
   c) Dead band: When the space temperature is between the effective space temperature heating and cooling setpoints (heating and cooling PID outputs are both at 0%), the zone volume setpoint shall remain at the cooling minimum flow setpoint.

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3. Zone Volume flow setpoints shall be as scheduled on the drawings.

E. **Hydronic Reheat**: Zone reheat coil valve shall modulate in a PID loop output (same loop output that resets the volume setpoint in the heating mode) to maintain the space temperature at the heating setpoint as defined above. The valve shall modulate from 0 to 100% on a PID loop output of 0-75% (adj.). The valve shall be closed whenever ALL the parent air handling units are off.

F. **Static Pressure Request**: The terminal unit shall issue a "pressure request" as follows:

1. Whenever the damper output is > 95%, a pressure request shall be issued

2. Whenever the damper output falls below 85%, the pressure request shall stop.

G. Unoccupied Mode:

1. When the AHU shuts down, all terminal unit box controllers are indexed to unoccupied mode, terminal unit volume dampers shall index to last position or minimum position. Space temperature setpoints shall index to the unoccupied setback heating (55°F (adj.)), and setback cooling (80°F (adj)) setpoints. When the zone temperature is between the unoccupied heating and cooling setpoints, the primary air damper will be at minimum or last position CFM, and the reheat valve will be fully closed. On a rise in zone temperature above the unoccupied cooling setpoint, the associated AHU is indexed on and the terminal unit primary air damper will modulate the CFM as needed to bring the space temperature below the unoccupied cooling setpoint, the reheat valve remains fully closed. On a drop in zone temperature below the unoccupied heating setpoint, the associated AHU is indexed on, the reheat valve modulates open and the primary air damper is modulated as needed to bring the space temperature above the unoccupied heating setpoint.
2. When the zone temperature is between the unoccupied heating and cooling setpoints, the primary air damper will be at minimum CFM (or last position), the reheat valve will be fully closed, and the AHU is indexed off.

H. **Trending**:

1. Configure a trend using real-time data with the following column headings: VAV TERMINAL DESCRIPTION, ZONE TEMPERATURE, ZONE TEMPERATURE SETPOINT, PRIMARY AIR FLOW, PRIMARY AIR FLOW SETPOINT, DAMPER POSITION (0 to 100% open), REHEAT OUTPUT (0 to 100% heating), DISCHARGE AIR TEMPERATURE.
2. Reference the requirements for summary service screens in the Controls (graphics section) specification for additional information.

3.11 FAN COIL UNIT [DWG M4.24]

A. **Space Temperature Control:** Four setpoints shall apply. Normal Heating (69°F adj.)), Normal Cooling (74°F adj.)), Setback Heating (55°F (adj.)), and setback cooling (80°F). These four values shall be the only values changed by the operator to adjust space temperature setpoint. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input).

B. **Heating Valve**: heating control valve shall modulate via PID loop as required to maintain space temperature at the heating setpoint.

C. **Cooling Valve**: cooling control valve shall modulate via PID loop as required to maintain space temperature at the cooling setpoint.

1. **Heating Request**: This terminal shall issue a “heating request” Whenever the heating PID output is at 100% (full heating)
2. **Cooling Request**: This terminal shall issue a “cooling request” whenever the cooling PID output is at 100% (full cooling)

D. **Humidity Control:** Upon a rise in humidity level above 65% (adjustable) and until relative humidity drops to 60%, as sensed by the space humidity sensor, the cooling coil control valve shall modulate to provide 55 deg F discharge air temperature. The reheat coil control valve shall be modulated to maintain space temperature 1 deg lower than the cooling setpoint.

E. **Fan**: Fan shall be enabled during occupied mode. During unoccupied mode, fan shall be deenergized except as required to maintain setback temperature setpoints for both heating and cooling with a cycle differential of 3°F (adj.).

F. **Fan Proof**: BAS shall monitor fan status, report status to graphic screen, and use to accumulate runtime. Upon a detection of fan failure, BAS shall enunciate an alarm.

3.12 VERTICAL UNIT VENTILATOR [DWG M4.23]

A. **Space Temperature Control:** Four setpoints shall apply. Normal Heating (69°F adj.)), Normal Cooling (74°F adj.)), Setback Heating (55°F (adj.)), and setback cooling (80°F). These four values shall be the only values changed by the operator to adjust space temperature setpoint. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input).

B. **Heating Valve**: heating control valve shall modulate via PID loop as required to maintain space temperature at the heating setpoint.

C. **Cooling Valve**: cooling control valve shall modulate via PID loop as required to maintain space temperature at the cooling setpoint.

1. **Heating Request**: This terminal shall issue a "heating request" Whenever the heating PID output is at 100% (full heating)

2. **Cooling Request**: This terminal shall issue a "cooling request" whenever the cooling PID output is at 100% (full cooling)

D. **Humidity Control:** Upon a rise in humidity level above 65% (adjustable) and until relative humidity drops to 60%, as senses by the space humidity sensor, the cooling coil control valve shall modulate to provide 55 deg F discharge air temperature. The reheat coil control valve shall be modulated to maintain space temperature 1 deg lower than the cooling setpoint.

E. **Fan**: Fan shall be enabled during occupied mode. During unoccupied mode, fan shall be deenergized except as required to maintain setback temperature setpoints for both heating and cooling with a cycle differential of 3°F (adj.).

F. **Fan Proof**: BAS shall monitor fan status and use to accumulate runtime. Upon a detection of fan failure, BAS shall enunciate an alarm.

3.13 WATER SOURCE HEAT PUMP [DWG M4.21]

A. **Space Temperature Control:** Four setpoints shall apply. Normal Heating (69°F adj.)), Normal Cooling (74°F adj.)), Setback Heating (55°F (adj.)), and setback cooling (80°F). These three values shall be the only values changed by the operator to adjust space temperature setpoint. All other deadbands, differentials, etc. shall be calculated in the program logic (unless another means is provided to prohibit overlap of the heating and cooling loops and ensure a dead band such as function block templates that restrict the setpoint input).

B. **Fan**: Fan shall be enabled during occupied mode. During unoccupied mode, fan shall be deenergized except as required to maintain setback temperature setpoints for both heating and cooling with a cycle differential of 3°F (adj.).

C. **Fan Proof**: BAS shall monitor fan status and use to accumulate runtime. Upon a detection of fan failure, BAS shall enunciate an alarm.

D. **Heating Request**: Heating shall be requested whenever the space temperature is below the heating setpoint (with a 2°F Hysterisis (adj.)). A minimum ON time of 3 minutes (adj.) and a minimum OFF time of 3 minutes (adj.) shall apply.

E. **Cooling Request**: Cooling shall be requested whenever the space temperature is above the cooling setpoint (with a 2°F Hysterisis (adj.)). A minimum ON time of 3 minutes (adj.) and a minimum OFF time of 3 minutes (adj.) shall apply.

F. **Humidity Control:** Upon a rise in humidity level above 65% (adjustable) and until relative humidity drops to 60%, as senses by the space humidity sensor, the unit compressors shall modulate to provide 55 deg F discharge air temperature. The hot gas reheat coil shall modulate to maintain space temperature 1 deg lower than the cooling setpoint.

G. **Heat Pump Loop Request:** The Heat Pump Loop shall be requested to run whenever any Heat Pump is requesting Heating or Cooling.

H. **Heat Pump Loop System Status:** The Heat Pump Loop status shall be proven ON before the compressor is enabled.

I. **Heat Pump Compressor:** The WSHP compressor shall be enabled whenever:

1. the fan is command ON and status is proven.
2. And, Heating or Cooling is being requested
3. And, the status of the Heat Pump Loop is proven (see Water Source Heat Pump Loop Sequence).

J. **Heat Pump Reversing Valve:** The WSHP compressor shall be enabled whenever the compressor is enabled and the unit is in the Heating Mode (note that if the unit requires the reversing valve to be enabled in the Cooling Mode, the reverse shall occur).

3.14 AIR COOLED CHILLER WITH PRIMARY AND SECONDARY PUMPS [DWG M4.14]

A. **General**: BAS shall fully control the chilled water systems and equipment and provide monitoring and diagnostic information for management purposes. BAS shall interface directly with the chiller and all available points shall be monitored and displayed via the operator interface. Refer to the control diagram for additional information.

1. **Cooling Enable**: Cooling shall be enabled when any chilled water valve opens more than 20% continuously for 5 min. (adj.) and the outside air temperature is above 60°F (adj.). Once enabled, the chilled water system will operate for a minimum of 30 minutes. The chilled water system shall also be enabled whenever manually enabled by the operator at the operator interface.
2. **Cooling Disable**: Cooling shall be disabled when all chilled water valves are less than 5% open continuously for 10 min. (adj.) or the outside air temperature is below 60°F. The chilled water system shall also be disabled whenever manually disabled by the operator at the operator interface.

B. Secondary Pump Control

1. **Start/Stop**: Whenever the system is enabled, at least one secondary chilled water pump shall be enabled to run continuously. Whenever the system is disabled, the secondary pumps shall be disabled after a 1 minute delay.
2. **Freeze Mode:** The secondary chilled water system shall be enabled for freeze protection whenever:
   a) The OAT falls below 25°F (adj.)
   b) OR, any AHU (or other unit) is tripped off due to a freeze condition (auto or manual reset).

   This mode shall not cause the primary system to operate (i.e. chiller(s) are not enabled).
3. **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. Upon failure of the lead pump, the BAS shall enable the standby/lag pump and enunciate an alarm. The BAS shall rotate the lead pump on a regular basis (every 7 days – adj.) to equalize runtime.
4. **VSD Control**: Whenever a pump is energized and status is proven for at least one of the pumps, the BAS shall control the speed of the VSD to maintain the (lowest) differential pressure reading at setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.

5. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
6. **Differential Pressure Setpoint**:
   a) Setpoint shall be initially set at 15psi (adj.).
   b) Setpoint shall be adjusted by the TAB contractor for optimized building and energy performance.
7. **Lead/Lag**: The BAS shall stage the Lag pump on/off as follows: *{Delete this section if Lead/Lag does not apply (system operates in Lead/Standby mode or Lead/Lag/Standby mode)}*
   a) Enable Lag Pump: The BAS shall enable the lag pump whenever the speed signal to the Lead pump is > 95% (adj.) for 10 minutes.
   b) Disable Lag Pump: The BAS shall disable the lag pump whenever the Lag pump is enabled and the speed signal is < 40% (adj.) for 10 minutes (adj).
8. **Lead/Standby**: The BAS shall start the Standby pump as follows: *{Delete this section if Lead/Standby does not apply (system operates in Lead/Lag mode or Lead/Lag/Standby mode)}*
   a) Enable Standby Pump: Upon failure of the lead pump, the BAS shall enable the standby and enunciate an alarm. Pump rotation shall be advanced when standby pump is called to run.
9. **Lead/Lag/Standby**: The BAS shall stage the Lag pump on/off as follows: *{Delete this section if Lead/Lag/Standby does not apply (system operates in Lead/Standby or Lead/Lag mode)}*
   a) Enable Lag Pump: The BAS shall enable the lag pump whenever the speed signal to the Lead pump is > 95% (adj.) for 10 minutes.
   b) Disable Lag Pump: The BAS shall disable the lag pump whenever the Lag pump is enabled and the speed signal is < 40% (adj.) for 10 minutes (adj).
   c) Enable Standby Pump: Upon failure of the lead or lag pump, the BAS shall enable the standby and enunciate an alarm. Pump rotation shall be advanced when standby pump is called to run.

C. Primary CHW Pump

1. The primary pump shall be started via an output from the chiller controller whenever the associated chiller is enabled.
2. BAS shall monitor the pump status.
3. The primary chilled water system shall be enabled for backup freeze protection if the chiller should fail to enable the primary pumps -
   a) The BAS shall monitor the Chiller low-temp condition point.
   b) The BAS shall monitor the primary pump status. After a time delay (10 min adj.) if Chiller fails to enable the primary pumps for freeze protection:
      1. AND the OAT is below 35F
      2. AND primary chilled water pump is not enabled (via pump status input

above)

3. BAS shall enable the primary chilled water pump

4. When OAT rises above 35F, BAS shall release enable of the chiller primary pump and return primary pump control to the chiller on-board control.

D. Chiller Control

1. **Enable/Disable**: Whenever the Chilled Water System is enabled, AND Either Secondary pump is proven the Chiller shall be enabled after a 1 minute delay (adj.).
2. **Proof/ Failure assessment**: Whenever the chiller is in alarm, the BAS shall enunciate an alarm. BAS shall assess the chiller to be in alarm if:
   a) chiller status is not proven ON in the first 10 minutes after the chiller is initially enabled.
   b) OR, any time the chiller alarm point is ON.

3.15 DUAL AIR COOLED CHILLERS WITH PRIMARY AND SECONDARY PUMPS [DWG M4.15]

A. **General**: BAS shall fully control the chilled water systems and equipment and provide monitoring and diagnostic information for management purposes. BAS shall interface directly with the chiller and all available points shall be monitored and displayed via the operator interface. Refer to the control diagram for additional information.

1. **Cooling Enable**: Cooling shall be enabled when any chilled water valve opens more than 20% continuously for 5 min. (adj.) and the outside air temperature is above 60°F (adj.). Once enabled, the chilled water system will operate for a minimum of 30 minutes. The chilled water system shall also be enabled whenever manually enabled by the operator at the operator interface.
2. **Cooling Disable**: Cooling shall be disabled when all chilled water valves are less than 5% open continuously for 10 min. (adj.) or the outside air temperature is below 60°F. The chilled water system shall also be disabled whenever manually disabled by the operator at the operator interface.

B. Secondary Pump Control

1. **Start/Stop**: Whenever the system is enabled, at least one secondary chilled water pump shall be enabled to run continuously. Whenever the system is disabled, the secondary pumps shall be disabled after a 1 minute delay.
2. **Freeze Mode:** The secondary chilled water system shall be enabled for freeze protection whenever:
   a) The OAT falls below 25°F (adj.)
   b) OR, any AHU (or other unit) is tripped off due to a freeze condition (auto or manual reset).

   This mode shall not cause the primary system to operate (i.e. chiller(s) are not enabled).
3. **Proof**: BAS shall prove pump operation and use the status indication to

accumulate runtime. Upon failure of the lead pump, the BAS shall enable the standby/lag pump and enunciate an alarm. The BAS shall rotate the lead pump on a regular basis (every 7 days – adj.) to equalize runtime.

4. **VSD Control**: Whenever a pump is energized and status is proven for at least one of the pumps, the BAS shall control the speed of the VSD to maintain the (lowest) differential pressure reading at setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
5. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
6. **Differential Pressure Setpoint**:
   a) Setpoint shall be initially set at 15psi (adj.).
   b) Setpoint shall be adjusted by the TAB contractor for optimized building and energy performance.
7. **Lead/Lag**: The BAS shall stage the Lag pump on/off as follows: *{Delete this section if Lead/Lag does not apply (system operates in Lead/Standby mode or Lead/Lag/Standby mode)}*
   a) Enable Lag Pump: The BAS shall enable the lag pump whenever the speed signal to the Lead pump is > 95% (adj.) for 10 minutes.
   b) Disable Lag Pump: The BAS shall disable the lag pump whenever the Lag pump is enabled and the speed signal is < 40% (adj.) for 10 minutes (adj).
8. **Lead/Standby**: The BAS shall start the Standby pump as follows: *{Delete this section if Lead/Standby does not apply (system operates in Lead/Lag mode or Lead/Lag/Standby mode)}*
   a) Enable Standby Pump: Upon failure of the lead pump, the BAS shall enable the standby and enunciate an alarm. Pump rotation shall be advanced when standby pump is called to run.
9. **Lead/Lag/Standby**: The BAS shall stage the Lag pump on/off as follows: *{Delete this section if Lead/Lag/Standby does not apply (system operates in Lead/Standby or Lead/Lag mode)}*
   a) Enable Lag Pump: The BAS shall enable the lag pump whenever the speed signal to the Lead pump is > 95% (adj.) for 10 minutes.
   b) Disable Lag Pump: The BAS shall disable the lag pump whenever the Lag pump is enabled and the speed signal is < 40% (adj.) for 10 minutes (adj).
   c) Enable Standby Pump: Upon failure of the lead or lag pump, the BAS shall enable the standby and enunciate an alarm. Pump rotation shall be advanced when standby pump is called to run.

C. Primary CHW Pump

1. The primary pump shall be started via an output from the chiller controller whenever the associated chiller is enabled.
2. BAS shall monitor the pump status.
3. The primary chilled water system shall be enabled for backup freeze protection if the chiller should fail to enable the primary pumps -
   a) The BAS shall monitor the Chiller low-temp condition point.
   b) The BAS shall monitor the primary pump status. After a time delay (10 min adj.) if Chiller fails to enable the primary pumps for freeze protection:
      1. AND the OAT is below 35F
      2. AND primary chilled water pump is not enabled (via pump status input above)
      3. BAS shall enable the primary chilled water pump
4. When OAT rises above 35F, BAS shall release enable of the chiller primary pump and return primary pump control to the chiller on-board control.

D. Chiller Control

1. **Enable/Disable**: Whenever the Chilled Water System is enabled, AND a Secondary pump is proven, at least 1Chiller shall be enabled after a 1 minute delay (adj.).
2. **Proof/ Failure assessment**: Whenever a chiller is in alarm, the BAS shall enunciate an alarm. Upon assessing a chiller as failed, the BAS shall immediately enable the Lag/Standby chiller (if not already enabled). The BAS shall assess a chiller as failed if:
   a) chiller status is not proven ON in the first 10 minutes after the chiller is initially enabled.
   b) OR, any time the chiller alarm point is ON.

E. **Chiller Lead/Lag Staging**: The BAS shall stage the Lag Chiller on/off as follows: {Delete this section if Lead/Lag does not apply (system operates in Lead/Standby mode only)}

1. Enable: The BAS shall enable the lag chiller whenever:
   a) The primary system is being requested
   b) AND, the secondary chilled water supply temperature is greater than 4°F above the chiller supply setpoint for more than 5 minutes (all values adjustable) continuously
   c) AND, more than 30 minutes has elapsed since the start of the last chiller.
2. Disable: The BAS shall disable the lag chiller whenever
   a) the Lag chiller has been enabled for at least 30 minutes (adj.)
   b) AND, the secondary chilled water supply temperature is NOT greater than 4°F above the chiller supply setpoint
   c) AND, the chiller RLA% is less than 70% for 2 minutes continuously (all values adjustable) for all active chillers
   d) OR, the primary Chilled Water System is no longer being requested (all chillers commanded off).
3. Chiller lead/lag shall be rotated on a weekly basis.

3.16 ~~CONDENSING~~ BOILER HW SYSTEM –PRIMARY / SECONDARY [DWG M4.12]

A. **General**: BAS shall control the heating hot water system and equipment and provide monitoring and diagnostic information for management purposes.

B. **System Enable**: System shall be enabled whenever

1. manually selected to run by a manual command on the BAS
2. OR, the System Override Timer (local twist timer switch) is enabled
3. OR, the Outside Air Temperature is less than 50°F
4. OR, there is a call for the Heating System to run from any AHU or terminal unit for 10 minutes
5. OR, any AHU (or other unit) is tripped due to a freeze condition (auto or manual reset).
6. AND, the Emergency Stop Button is not enabled
7. AND, the system is not manually disabled by a command on the BAS.

C. **System Disable**: System shall be disabled whenever

1. the system is manually disabled by a command on the BAS
2. OR, the Emergency Stop Button is enabled
3. OR, the Outside Air Temperature is less than 50°F AND there is no call for the Heating System to run from any AHU or terminal unit for 5 minutes

D. Secondary Pump Control

1. **Start/Stop**: Whenever the system is enabled, at least one secondary hot water pump shall be enabled to run continuously.
2. **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. Upon failure of the lead pump, the BAS shall enable the standby pump and enunciate an alarm. The BAS shall rotate the lead pump on a weekly basis (adjustable) to equalize runtime.
3. **VSD Control**: Whenever a pump is energized and status is proven for at least one of the pumps, the BAS shall control the speed of the VSD to maintain the differential pressure at setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Differential Pressure Setpoint**:
   a) Setpoint shall be initially set at 15psi (adj.).
   b) Setpoint shall be adjusted by the TAB contractor for optimized building and energy performance.
6. **Lead/Lag**: The BAS shall stage the Lag pump on/off as follows: *{Delete this section if Lead/Lag does not apply (system operates in Lead/Standby mode or Lead/Lag/Standby mode)}*

a) *Enable Lag Pump: The BAS shall* enable the lag pump whenever the speed signal to the Lead pump is > 95% (adj.) for 10 minutes.

b) Disable Lag Pump: The BAS shall disable the lag pump whenever the Lag pump is enabled and the speed signal is < 50% (adj.) for 2 minutes'

7. **Lead/Standby**: The BAS shall start the Standby pump as follows: *{Delete this section if Lead/Standby does not apply (system operates in Lead/Lag mode or Lead/Lag/Standby mode)}*

   a) Enable Standby Pump: Upon failure of the lead pump, the BAS shall enable the standby and enunciate an alarm. Pump rotation shall be advanced when standby pump is called to run.

8. **Lead/Lag/Standby**: The BAS shall stage the Lag pump on/off as follows: *{Delete this section if Lead/Lag/Standby does not apply (system operates in Lead/Standby or Lead/Lag mode)}*

   a) Enable Lag Pump: The BAS shall enable the lag pump whenever the speed signal to the Lead pump is > 95% (adj.) for 10 minutes.

   b) Disable Lag Pump: The BAS shall disable the lag pump whenever the Lag pump is enabled and the speed signal is < 50% (adj.) for 2 minutes'

   c) Enable Standby Pump: Upon failure of the lead or lag pump, the BAS shall enable the standby and enunciate an alarm. Pump rotation shall be advanced when standby pump is called to run.

E. Primary System Control

1. **Enable/Disable**: Whenever a primary system is requested by the BAS, the associated primary pump shall be enabled. When a primary system is disabled, the associated primary pump shall continue to run (for boiler pump down) for 2 minutes (adj).
2. Proof: BAS shall prove pump operation. Upon failure of the pump, the BAS shall enunciate an alarm and asses the pump as failed. The boiler controller shall then swap the lead primary system (as described above.)
   Alarm Management
   Proof/Failure Assessment: BAS shall assess the boiler as failed, any time the boiler alarm contacts are ON. Upon failure of the Boiler, the BAS shall enunciate an alarm at the BAS.
3. **Secondary Hot Water Supply Temperature Setpoint:** The BAS shall reset the secondary hot water supply temperature setpoint. The HW Supply Temperature setpoint shall be reset from 120°F to 140°F as the outside air temperature drops from 60°F to 40°F (all values being adjustable)
4. **Lead/Lag**: The onboard boiler controls shall stage the boilers ON/OFF and modulate the firing rate as necessary to maintain the secondary hot water supply temperature at setpoint.

3.17 WATER SOURCE HEAT PUMP LOOP W/CT & CONDENSING BOILER [DWG M4.25]

A. **General**: BAS shall fully control the loop pump system and equipment and provide monitoring and diagnostic information for management purposes.

1. **System Enable**: The System shall be enabled when more than 2 (adj.) units requests the system to run OR, the system is manually enabled via the BAS.
2. **Cooling Disable**: The System shall be disabled when no units request the system to run continuously for 5 min. (adj.) OR, the system is manually disabled via the BAS.
3. Once enabled (in auto mode), the system shall run for a minimum of 30 minutes.

B. Loop Pump Control

1. **Start/Stop**: Whenever the system is enabled, at one loop water pump shall be enabled to run continuously. Whenever the system is disabled, the secondary pumps shall be disabled after a 1 minute delay.
2. **Proof**: BAS shall prove pump operation and use the status indication to accumulate runtime. Upon failure of the lead pump, the BAS shall enable the standby pump, swap the lead designation, and enunciate an alarm. The BAS shall rotate the lead pump on a regular basis (every 7 days – adj.) to equalize runtime.
3. **VSD Control**: Whenever a pump is energized and status is proven for at least one of the pumps, the BAS shall control the speed of the VSD to maintain the differential pressure at setpoint. On start and stop, the VSD shall ramp to speed and slow down within adjustable acceleration and deceleration limits.
4. **VSD Interface**: BAS shall monitor the VSD via a direct interface. All available information shall be accessible via the interface for display on the VFD graphic. The VFD Alarm point shall be displayed on the main graphic and shall be alarmed via the BAS. All other points may be displayed on a separate graphic that is selected from this system's graphic. Reference the VFD chart on the project plans for additional information on points that should be hardwired versus integrated through a direct interface.
5. **Differential Pressure Setpoint**:
   a) Setpoint shall be initially set at 15psi (adj.).
   b) Setpoint shall be adjusted by the TAB contractor for optimized building and energy performance.

C. **Loop Temperature Control**:

1. The system shall utilize the Condensing Boiler and Cooling Tower to maintain the loop at the respective Heating and Cooling temperature setpoints.
2. The Loop Water Supply Temperature Heating Setpoint shall be 60°F (adj.).
3. The Loop Water Supply Temperature Cooling Setpoint shall be 90°F (adj.).
4. The System shall operate in the Heating Mode whenever:

a) Either Loop pumps is enabled and proven ON

b) AND, the Loop Water Supply Temperature is less than the Loop Water Supply Temperature Heating Setpoint for 1 minute (adj.).

5. The Heating Mode shall be disabled whenever:
   a) Neither Loop pumps is enabled and proven ON
   b) OR, the Loop Water Supply Temperature is greater than the Loop Water Supply Temperature Heating Setpoint plus 5°F (adj.).
6. The System shall operate in the Cooling Mode whenever:
   a) Either Loop pumps is enabled and proven ON
   b) AND, the Loop Water Supply Temperature is greater than the Loop Water Supply Temperature cooling Setpoint for 1 minute (adj.).
7. The cooling Mode shall be disabled whenever:
   a) Neither Loop pumps is enabled and proven ON
   b) OR, the Loop Water Supply Temperature is less than the Loop Water Supply Temperature cooling Setpoint minus 5°F (adj.).

D. Primary Pump Control

1. **Enable/Disable**: Whenever loop system is operating in the heating mode, the individual boilers shall control their primary pumps.
2. **Proof**: Individual boilers shall prove their primary pump operation. Upon failure of the pump, the BAS shall receive and enunciate an alarm.

E. Boiler Control

1. **Enable/Disable**: Whenever loop system is operating in the heating mode, the boiler shall be enabled.
2. **Proof/ Failure assessment**: BAS shall assess the boiler as failed, any time the boiler alarm contacts are ON. Upon failure of the Boiler, the BAS shall enunciate an alarm at the BAS.
3. **Firing Rate:** The onboard boiler controls shall control the firing rate of the boiler to maintain the Loop Water Supply Temperature at setpoint.

F. Condenser Water Pump Control

1. **Enable/Disable**: Whenever loop system is operating in the cooling mode, the condenser water pump shall be enabled. .
2. **Proof**: BAS shall prove pump operation. Upon failure of the pump, the BAS shall enunciate an alarm.

G. Cooling Tower Control:

1. **Enable/Disable**: Whenever loop system is operating in the cooling mode and the condenser water pump status is proven ON, the BAS shall enable the Cooling Tower Control Loop.
   a) The BAS shall use the loop to control the loop water supply temperature at the cooling setpoint. The output of this loop shall control the starting, stopping, and modulation of the fan.
   b) On a PID output of greater than 20% (adj.), the BAS shall start the fan. Once enabled, the fan shall remain enabled for a minimum of 1 min. (adj.).
   c) On a PID output of less than 5%, the BAS shall stop the fan.

d) The output of the PID loop shall control the Fan speed via the Variable Speed Drive.

H. **System OK:** The BAS shall send a signal to all associated water source heat pump units notifying them that the system is operating in an acceptable state (compressors are allowed to run) whenever:

1. The loop system is enabled
2. AND, At least 1 loop pump is proven ON
3. AND, the remote differential pressure is > 4 psi (adj.)
4. AND, the Loop Water Supply Temperature is > 50°F (adj.)
5. AND, the Loop Water Supply Temperature is < 100°F (adj.)

3.18 ELECTRIC METER MONITORING

A. The BAS shall monitor individual building electrical power meter(s) as indicated on the drawings.

B. MANAGEMENT REPORTING: The BAS shall record the following and have the ability to report it at daily, monthly and yearly intervals:

1. Instantaneous kW demand with time and date (trended).
2. kWh with time and date totalized for:
   a) Day to Date
   b) Previous Day
   c) Month to Date
   d) Previous Month
   e) Year to Date
   f) Previous Year

3.19 GAS METER MONITORING

A. The BAS shall monitor individual Gas Consumption meter(s) as indicated on the drawings.

B. MANAGEMENT REPORTING: The BAS shall record the following and have the ability to report it at daily, monthly and yearly intervals:

1. Cubic Feet used with time and date totalized for:
   a) Day to Date
   b) Previous Day
   c) Month to Date
   d) Previous Month
   e) Year to Date
   f) Previous Year

3.20 LIGHTING SEQUENCE OF OPERATION

A. Security System Interface

1. The security alarm panel needs to provide contacts for Alarm/Normal and Armed/Disarmed to the BAS system. The HVAC Space Sensor override button will serve to operate the lighting override during Unoccupied conditions.

B. Interior

1. The interior lights will be energized when the security system is disarmed.
2. The interior lights will be de-energized 10 minutes after the security system is armed.
3. This will be the same for weekdays as well as weekends.
4. These lights will be energized when the security system alarms and will remain on until the system is reset, at which time the lights will follow the armed/disarmed sequence.
5. Unoccupied Schedule: When the override button on the space sensor is activated, the lights serving the area where the button was pressed shall turn on for two (2) hours (adj). When override time period has 15 minutes remaining, the lights will blink 3 times in 3 second intervals.

C. Exterior

1. The exterior lights (those that are attached to the building – ie: wall pack downlight-type located above entranceways) will be energized at sundown.
2. The lights will be de-energized at sunrise.
3. These lights will be energized when the security system alarms and will remain on until the system is reset, at which time the lights will follow the armed/disarmed sequence.

3.21 DOMESTIC METER MONITORING

A. The BAS shall monitor individual Domestic Water Consumption meter(s) as indicated on the drawings.

B. MANAGEMENT REPORTING: The BAS shall record the following and have the ability to report it at daily, monthly and yearly intervals:

1. Gallons used with time and date totalized for:
   a) Day to Date
   b) Previous Day
   c) Month to Date
   d) Previous Month
   e) Year to Date
   f) Previous Year

END OF SECTION 230993

SECTION 26 0800
ELECTRICAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning

Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:

1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.

2. Verify and document proper functional performance of equipment and systems.

3. Verify that O&M documentation is complete.

4. Verify that the Owner's operating personnel are adequately trained.

1.2 RELATED WORK

A. Section 01 1000 – Summary of Work

B. Section 01 3300 – Submittal Procedures

C. Section 01 7700 – Closeout Procedures

D. Section 01 7823 – Operation and Maintenance Data

E. Section 01 7839 – Project Record Document

F. Section 01 7900 – Demonstration and Training

G. Section 01 9113 – General Commissioning Requirements

1.3 REFERENCE STANDARDS

A. National Electric Code (NEC)

B. American Society for Testing and Materials (ASTM)

C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)

D. Illuminating Engineering Society (IES)

E. Institute of Electrical and Electronics Engineers (IEEE)

F. International Electrical Testing Association (NETA)

G. National Electrical Manufacturers Associates (NEMA)

H. National Fire Protection Association (NFPA)

I. Underwriters Laboratory, Inc. (UL)

J. Refer to Section 019100 for additional Reference Standards.

1.4 ABBREVIATIONS AND DEFINITIONS

A. A/E: Architect, Architect/Engineer, and/or Engineer

B. ASI: Architectural Supplemental Instruction

C. BAS: Building Automation System

D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR

E. CxA: Commissioning Authority

F. Controls Contractor

G. CM: Construction Manager

H. Cx: Commissioning

I. Cx Plan: Commissioning Plan

J. Cx RFI: Commissioning Request for Information

K. DDC: Direct Digital Control System

L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.

M. EC: Electrical Contractor

N. FBO: Furnished By Others

O. FT: Functional Performance Test

P. IAW: In Accordance With

Q. MC: Mechanical Contractor

R. O&M: Operation and Maintenance

S. OPM: Owner Project Manager

T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.

U. PC: Prefunctional Checklist

V. RFI: Request for Information

W. Sub(s): Subcontractors or Prime Contractor

X. TC: Testing Contractor

Y. TBD: To Be Determined

[DESIGNER NOTE: The below list in section 1.5 to be edited on a per project basis]

1.5 ELECTRICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

The following electrical equipment and systems shall be commissioned in this project.

A. Controls and occupancy sensors for lighting

B. Grounding and bonding for electrical systems ≥600v, from the building entrance through the main switchboard, switchgear, to the distribution panels.

C. Metering equipment.

D. Motor Control Centers, Variable Speed Drives, Motor Starters, protective devices.

E. Emergency power system including generator set, Uninterruptible Power Supply (UPS), transfer switch, fire pump controller interface, associated equipment and testing.

1.6 SUBMITTALS

A. Refer also to Specification Section 01 9113, Subsection 1.6.

B. Provide the CxA a copy of the following items, for the systems to be commissioned:

1. Equipment and System Submittals to include, at minimum, the following:
    a. Cut Sheets
    b. Performance data
2. Manufacturer's pre-startup checklists
    a. Manufacturer's start-up checklists
    b. Installation Instructions
3. Shop drawings (including any resubmittals required by the A/E)

4. Short-circuit analysis and coordination study

5. Protective device settings

6. Testing plan

7. Completed field test report, including all completed forms and checklist; and list of all outstanding deficiencies and uncompleted items

8. Operational and maintenance documentation

9. Training plan and training materials

10. As-built documentation

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Refer to Specification Section 01 9113, Subsection 2.1.

B. Instrumentation required to verify readings and test system and equipment performance shall be provided by Contractor and made available to Commissioning Authority. Infrared scanning equipment shall be a FLIR (or approved equal) thermal imaging camera set capable of viewing an entire bus or equipment assembly at one time. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified.

2.2 Cx WEB-BASED COMMISSIONING TOOL

A. Refer to Specification Section 01 9113, Subsection 2.1.

PART 3 - EXECUTION

3.1 MEETINGS

A. Refer to Specification Section 01 9113, Subsection 3.3.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment to be commissioned, according to Section 1.5 above.

B. General

Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

Independent Testing Agencies: For systems where independent testing agencies (TA) are specified, the cost of this testing is borne by the contractor. Much of the testing performed by these independent agencies will cover aspects required in the commissioning start ups and functional performance tests requirements. Contractor and testing agencies shall coordinate with the CxA so that they can witness the testing and approve the applicable aspects of the FPTs. CxA may in some cases independently spot check work of the testing agencies if the tests were not witnessed. However it is not the intent for the TA to re-accomplish testing that is specified in the construction specifications. For instance, much of the testing requirements for the Electrical Testing will be performed by the independent electrical testing agency provided under the contract. The CxA will witness the indicated sample of the TA testing and record the results in the record of functional performance testing.

C. Start-up and Initial Checkout Documentation

1. The CxA will provide prefunctional checklists (PCs). PCs indicate the required procedures to be executed as part of startup and initial checkout of equipment and systems.

2. The subcontractor responsible for providing and installing the equipment develops the full start-up plan by combining (or adding to) the CxA's prefunctional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checkout and inspection of each piece of equipment and a summary statement with a signature block at the end of the checklist.

3. The full start-up document shall consist of:

   a. The CxA's prefunctional checklists.

   b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block at the end.

   c. The manufacturer's normally used field checkout sheets.

4. The contractor submits the full startup document to the CxA for review and approval.

5. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

D. Execution of Prefunctional Checklists and Startup

1. Two weeks prior to startup, the Subs and vendors shall schedule startup and checkout with the OPM, CM and CxA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.

2. The CxA and possibly the A/E will observe the procedures and tests for selected pieces of primary equipment. It is the intent that the CxA will observe the tests during contractor testing. If the contractor does not inform the CxA of testing, the CxA may request the contractor to repeat the test.

3. The CxA will observe the physical start-up of the first major system or equipment. Additional observations of related or duplicate equipment or systems may be observed at the discretion of the CxA.

4. The Subs and vendors shall execute startup and provide the CM with a signed and dated copy of the completed start-up and prefunctional tests and checklists. The CM reviews for completion and accuracy, then submits to the CxA and A/E.

5. Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

6. Completed startup testing report must be provided to CxA prior to functional testing.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Sub(s) shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully. The procedures form and any outstanding deficiencies shall be provided to the CxA within two days of test completion.

2. The CxA will work with the Sub(s) and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party. Refer to Section 01 9113, 3.7 – Documentation, Non-Conformance and Approval of Tests.

3.3 FUNCTIONAL PERFORMANCE TESTING - DEMONSTRATION

A. This sub-section applies to functional testing for equipment and system in this division.

B. The general list of equipment and systems to be commissioned is found in Paragraph 1.5.

C. Objectives and Scope

1. The objective of functional performance testing is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and contract documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.

2. In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, failures, interlocks, warm-up, safety, etc.) where there is a specified system response. Verifying each sequence in the sequence of operation is required.

3. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

4. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems, and automation hardware and software. All training documentation, O&Ms, and submittals shall be at the job site before functional testing commences.

D. Development of Test Procedures

1. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment and warranty protection.

E. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule functional tests after written notification from the CM and affected Subs. The CxA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

2. In general, functional testing shall not be scheduled until all hardware and software submittals are approved, Prefunctional checklists are approved, and start-up has been satisfactorily completed. Scheduling of functional testing shall be done with a minimum of two weeks notice prior to testing. Functional testing of the equipment and systems listed in section 1.5 of this specification section shall not be conducted out of the presence of the CxA and OPM, unless specifically approved to do so in writing by the CxA or OPM. Any functional testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

F. Demonstration, Verification and Validation

The electrical systems demonstration shall include, at minimum, the following (as applicable):

1. Lighting Control Systems
2. Metering
3. Panelboards
4. Circuit Breakers
5. Disconnect Switches
6. Switchboards/Motor Control Centers
7. Emergency power systems

G. Problem Solving

The CxA will recommend solutions to problems found; however, the burden of responsibility to solve, correct, and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

A. Refer to Specification Section 01 9113, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

A. In addition to installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 01 9113, subsection 3.8 for further detail.

3.6 TRAINING OF OWNER PERSONNEL

A. See Specification Section 01 9113, Subsection 3.9.

B. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of electronic detection and alarm equipment or system.

C. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, normal power, emergency power, etc.

D. Training sessions shall not exceed 4 hours per period (unless prior approval provided by Owner). Provide minimum Level I, II and III instructional training hours per following table. Two separate scheduled sessions of Level I and Level II training shall be provided. One scheduled session of Level III training shall be provided where applicable.

3.7 DEFERRED TESTING

A. See Specification Section 01 9113, Subsection 3.10.

END OF SECTION

SECTION 27 00 01 - TECHNOLOGY INSTALLATION GUIDELINES

PART 1 - GENERAL Gray blocks apply to renovation projects.

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. The Contractor shall provide the required protection in accordance with the requirements of these specifications and NEC Refer to Current Release Available, Article 800. The protection shall be provided on both ends of all inter-building cables where required by code or otherwise indicated in the contract documents (i.e., building-to-building, building-to-modular classroom, or building-to-modular complex).

1.2 SUMMARY

A. This Section includes a Telecommunications Distribution System which is ready for the installation of active electronic equipment such as hubs, routers, bridges, switches, repeaters, adapters, etc. The system shall incorporate all requirements of this specification.

B. Renovation Projects Only: The Contractor shall bid job as if all communications cable to be installed is plenum-rated unless otherwise stated on the plans. The Contractor will be responsible during construction to identify any additional plenum areas not noted on the plans. The contract will be adjusted by using the unit pricing below, if required. The following “Unit Prices” shall be submitted as a part of the proposal. The Contractor shall provide a material and labor unit price for: (1) Plenum- rated Cat6 4-pair cable, (2) Plenum-rated inner duct, (3) Plenum-rated 2-strand fiber optic cable, and (4) Plenum-rated 6-strand fiber optic cable. Unit price difference in material cost as labor cost should remain the same. Provide price in cost per 100 feet (100’).

1.3 PRELIMINARY MEETING

A. An initial planning meeting will be held with the Contractor to clarify all requirements (systems, services, distribution methods, etc.), identify responsibilities, and schedule the events that will transpire during the implementation of the project. **This meeting should be held within ninety (90) days of the NTP (Notice to Proceed).**

B. Contractor shall prepare and provide two (2) copies of the following documentation for review and approval by WCPSS Technology Department.

I. MDF and FDE Diagrams - Include cable routing, position of all components and apparatus, detailed layout of the wall field, and a labeled cable plant drawing.

II. Work Area Floor Plans - Include detailed cable routes and labeling plan for all work areas. The Contractor may obtain floor plans from the Architect in AutoCAD format, if so desired, to aid in preparing the submittal.

III. Schedule Documentation - Provide cross-connect records for all voice and data devices. (See Attachments 27 00 00 “A through D”)

IV. Backbone Distribution Plan

V. **Schedule of work: See Construction Schedules and Reports Section**

VI. The Contractor shall provide a list of its project management staff and technical support staff to be assigned to this project together with their resumes and working experience.

C. Upon completion of the project, the Contractor shall prepare "As-Built” documentation showing actual site conditions and installation as constructed and provide copies of such documentation as per paragraph 1.3

for inspection purposes by WCPSS Technology Department. This will include a record of field test results and copies of the schedules for each IDF electronically in .dwg and .pdf file format. All test results must be subdivided, by TCOs. Test results must be in cable ID sequence.

I. **The Technology Department must receive the documentation needed for the acceptance inspection thirty (30) days prior to substantial completion to insure the network wiring system is functional at substantial completion.**

II. **As built cable ID numbers should be color-coded as follows:**

a. **Blue for data**

b. **Orange for fiber**

III. **The cable numbers on the "As-builts" should also be color coded as noted above.**

D. In addition to the engineering diagrams, the following items shall be provided by the Contractor at substantial completion after the wiring system has been inspected and accepted by WCPSS Technology Department:

I. Laminated cable schedules sized eight and one-half inch (8-1/2") by eleven inches (11"), **to be hung in the appropriate rooms in an approved manner (see Attachments 27 00 00 "A through D").** Cable schedules should also be submitted electronically in .dwg and .pdf file formats.

II. One size "E" laminated drawing of "As-Builts" and one "E" size laminated drawing of riser diagrams and outlet schedules shall be attached to the wall **with approved fasteners** in the MDF. Color key, copper data cabling blue, and fiber optic data cabling orange. **Highlight, in some manner, the MDF/IDF/FDE rooms. Drawings shall also be submitted electronically in .dwg and .pdf file format.**

E. Technical Support Staff and Experience

I. The Contractor shall utilize certified cable installers and technicians with approved vendor specific certification. The Contractor shall supply certification documentation for cable installers.

II. The Contractor shall state their nearest branch office and dealer's office in relation to the proposed site of the cabling system. If none, the location of the main office shall be stated.

III. The Contractor shall state their nearest location of their principal support center. This center shall have permanently stationed support staff that is capable of providing technical support, if required.

F. System Warranty

I. The Contractor shall provide a five (5) year warranty for both products and labor and also provide a fifteen (15) year manufacturers' warranty on all parts installed.

II. Service must be provided within twenty-four (24) hours of notification for emergency situations and within seventy-two (72) hours for routine service.

1.4 PRODUCT SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.

I. Product data for system components to WCPSS Technology Department for verification of compliance to specifications.

1.5 QUALITY ASSURANCE

A. Comply as applicable with ANSI/TIA/EIA-568-B.1, ANSI/TIA/EIA-568-B.2, and ANSI/TIA/EIA-568-B.3 "Commercial Building Telecommunications Cabling Standard," Refer to Current Release Available.

B. Comply as applicable with ANSI/TIA/EIA-569-A, "Commercial Building Standards for Telecommunications Pathways and Spaces," Refer to Current Release Available.

C. Comply as applicable with ANSI/TIA/EIA-606, "The Administration Standard for Telecommunications Infrastructure of Commercial Buildings," Refer to Current Release Available.

D. Comply as applicable with J-STD-607, "Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications," Refer to Current Release Available

E. Comply with NFPA 70, "National Electrical Code," Refer to Current Release Available.

F. "Nationally Recognized Testing Laboratory" (NRTL) Listing: Provide materials that are listed and labeled.

I. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

II. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

III. FCC Regulations: Comply with FCC Part 68, Chapter 1, "US Code of Federal Regulations," Title 47 for all telephone system wire and cable connection components.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLE: Contractor shall provide all horizontal cables.

A. COPPER (Cat6) CABLE

I. All cables shall conform to or exceed the ANSI TIA/EIA-568-B.2 “Commercial Building Telecommunications Cabling Standard” - Part 2: Balanced Twisted Pair Cabling Components.

II. Other standards supported include IEEE 802.3, 1,000 BASE-T, 100 BASETX and ANSI X3T9.5 TP-PMD requirements for UTP at 250 MHz.

III. Cables shall be capable of supporting evolving high-end applications such as 155 Mbps ATM. All cables shall be composed of 4-pair 24 AWG solid copper conductors.

IV. The cable shall be Underwriter’s Laboratories Inc. (UL) and/or (ETL) listed type CMR and CMP.

B. FIBER OPTIC CABLE

I. All cables shall conform to or exceed the TIA/EIA-568-B.3 Commercial Building Telecommunications Cabling Standard - Part 3: Optical Fiber Cabling Components Standard.

II. The Single-mode fiber shall comply with ANSI/TIA/EIA-492CAAA-1998, Detail Specification for Class IVa Dispersion-Unshifted Single-mode optical fibers.

III. Each fiber shall be tight buffered with color-coded PVC.

IV. The fiber cable shall meet the NEC requirements for OFN, OFNR or OFNP and comply with Bellcore, FDDI, TIA/EIA-568-B.3 and ICEA standards.

V. Connectors shall be crimp-on type, pre-polished SC connectors or hot melt with a maximum loss of 3**.0**dB.

2.2 TELECOMMUNICATIONS OUTLET (TCO)

A. COPPER (Cat6) CABLE

I. Shall be modular, RJ45 type/8-position/8 conductor.

II. Shall be universal application/multi-vendor supportive accepting most phone and data plugs.

III. Modular connectors shall be flush with outlet faceplate.

IV. Cover shall be “office-white” (or approved equivalent) in color and must contain a covered label id window slot on the faceplate.

V. For wall telephone units, provide straight in type connection and include provision for support of unit.

VI. All cables shall be routed and supported around the exterior walls of the room in a consistent pattern, with all break-outs being 90-degree angled turns without any corners being cut.

VII. Outlets shall be wired in a TIA/EIA-568B configuration.

a. All outlets shall utilize cross-over lead technology to address data circuit applications up to 500 MHz and conform to or exceed the TIA/EIA-568-B.2 Commercial Building Telecommunications Cabling Standard and the following:

i. Electrical specifications:

a) TIA/EIA Category (Cat6).

b) Data Rate: Compatible with 1000 Mbps Institute of Electrical and Electronics Engineers Inc, (IEEE) 802.3, 10BASE-T applications. Fully supports 1000 Mbps TP-PMD at 328-ft (100m) over UTP per ANSI X3T9.5.

c) Insulation resistance: 500-MΩ minimum.

d) Dielectric withstands voltage 1,000 VAC RMS, 60 Hz minimum, contact-to-contact and 1,500 VAC RMS, 60 Hz minimum to exposed conductive surface.

e) Contact resistance: 20 mΩ maximum.

f) Current rating: 1.5 A at 68° F (20°C) per IEC Publication 512-3, Test 5b.

g) UL or ETL certified/tested and must be stamped on the outer sheathing of the cable along with being listed on the submittal specification sheets.

h) CSA Certified.

i) Comply with FCC Part 68.

j) All copper and fiber cables must be manufactured in the United States of America.

ii. Mechanical Performance:

a) Plug Insertion Life: 750 insertions.

b) Contact Force: 3.5-oz (99.2 g) minimum using FCC-approved modular plug.

c) Plug Retention Force: 30-LB (133 N) minimum between modular plug and jack.

d) Temperature Range: -40° to 150°F (-40° to 66°C).

2.3 PATCH PANEL

A. CATEGORY COPPER (Cat6)

I. The panel shall support the Cat6 applications and facilitate cross-connection and inter-connection using patch cords.

II. The patch panels shall be fire-retardant, molded plastic consisting of horizontal index strips for terminating conductors. These index strips shall be marked with four colors on the high teeth, separating the tip and ring of each pair, to establish pair location.

III. The panel shall be able to accommodate over five hundred (500) repeated insertions without incurring permanent deformation and it shall pass the reliability test of no more than one (1) contact failure in ten thousand (10,000) connections.

IV. Nineteen-inch (19") rack mountable patch panels shall be used. Patch panel installations shall contain a retaining trough between every one hundred (100) pair termination block.

V. The panel shall be able to accommodate 24 AWG cable conductors.

VI. The panel shall be Underwriter's Laboratories Inc. (UL) listed.

VII. Shall be wired in a TIA/EIA 568B configuration.

VIII. Separate labeled patch panels shall be installed for each different type of cable installed in each floor rack in all Technology Closets. This refers to all Data Station Cables, Wireless Access Point Cables, and IP Security Camera Cables. Each Panel shall be labeled per current guidelines for the type of cabling terminated on that panel.

2.4 110 COPPER PATCH PANELS TO-T568B JACK (VOICE ONLY)

A. COPPER (Cat6) CABLE

I. The patch panel shall support the Cat6 applications and facilitate cross-connection and inter-connection using patch cords.

II. The patch panels shall be fire-retardant, molded plastic consisting of horizontal index strips for terminating twenty-five (25) or fifty (50) pairs of conductors each. These index strips shall be marked with four (4) colors on the high teeth, separating the tip and ring of each pair, to establish pair location.

III. The patch panels shall be able to accommodate over five hundred (500) repeated insertions without incurring permanent deformation and it shall pass the reliability test of no more than one (1) contact failure in ten thousand (10,000) connections.

IV. Shall be wired in a TIA/EIA-568-B configuration. Patch panels shall have six (6) or twelve (12) jacks, as required.

V. The patch panels shall be able to accommodate 24 AWG cable conductors.

VI. The patch panels shall be Underwriter's Laboratories (UL) listed.

2.5 FIBER OPTIC DISTRIBUTION ENCLOSURE (FDE) / FIBER OPTIC TERMINATION ENCLOSURE (FTE) / FIBER OPTIC TERMINATION SHELF (RACK MOUNT)

A. Shall provide cross-connect, inter-connect, splicing capabilities, and contain the proper troughs for supporting and routing the fiber cables/jumpers.

B. Shall consist of a modular enclosure with retainer rings in the slack storage section to limit the bend radius of fibers.

C. Shall have a "window" section to insert fiber optic adapter panels for mounting of SC adapters.

D. Connectors shall meet or exceed the following specifications:

I. Operating Temperature: -40 °to 185°F (-40° to 85°C)

II. Maximum Loss: 3**.0** dB

E. Shall provide terminating capability of six (6), twelve (12), twenty-four (24), forty-eight (48), or seventy-two (72) connectors as indicated on plans or as required for number of fibers.

F. All enclosure housing shall be metal. All terminations shall be enclosed in housing with access door.

G. **FDEs SHALL CONTAIN NO PATCH CABLES**. Contractor shall use **SC FIBER BULK HEAD** connectors to achieve the pass-through.

H. No pull out fiber trays are to be used.

2.6 BACKBONE DISTRIBUTION FEEDER CABLE

A. FIBER OPTIC

I. Fiber optic cables shall be Optical Cable Corporation DX-Series Distribution Cables, Riser and Plenum-Rated as required. Equivalent cables from other vendors will be allowed.

II. The Single-mode fiber shall comply with ANSI/TIA/EIA-492CAAA-1998, Detail Specification for Class IVa Dispersion-Unshifted Single-mode optical fibers.

III. Each fiber shall be tight-buffered with color-coded PVC.

IV. All fiber must be armored or installed in innerduct.

V. The fiber cable shall meet the NEC requirements for OFN, OFNR or OFNP and comply with Bellcore, FDDI, TIA/EIA-568-B.2 and ICEA standards.

VI. All fiber must conform to:

i. ANSI/TIA/EIA-568-B3

ii. Telcordia GR-20, Telcordia GR-409

iii. ANSI/ICEA S-87-640

iv. ANSI/ICEA S-83-596

VII. The fiber must support:

i. 1000BASE-SX/1000BASE-LX

ii. Fiber channel 1.062/2.125

iii. 10GBASE-SR/SW

iv. 10GBASE-LX4

VIII. Features of armored fiber must include:

i. Jacketed armor that remains flexible due to the spiral wrap armoring process.

ii. The armored design allows for an easy one-pull installation into any environment.

iii. Aluminum of steel interlock armor is available.

iv. Aluminum interlock offers ten (10) to thirteen (13) times the impact resistance over all-dielectric optical cable.

v. Compact outside diameters when compared to plenum inner duct or conduit.

vi. Interlocking armor available without an over jacket.

2.7 MISCELLANEOUS

A. SURFACE AND MULTI-COMPARTMENT RACEWAY

I. Types, sizes and channels as indicated and required for each application, with fittings that match and mate with raceway. Raceway mounting clips to provide concealed mechanical attachment to mounting surface.

II. Surface Metal Raceway: Shall be equal to Wire Mold 700 Series, with fittings that match and mate with raceway.

III. Multi-compartment surface raceway: Shall be equal to Wire Mold 4000 Series, with fittings that match and mate with raceway. Wiring device plates shall overlap raceway cover.

B. POWER/DATA POLES

I. Types, sizes and channels as required for each application, with fittings that match and mate with pole. Provide dual channel type as required for multi-service applications. Provide pole appropriate for type of ceiling - accessible/inaccessible.

C. PRECAST HAND HOLE STRUCTURES

I. Hand holes shall be equal to Quazite PG2436BA30. Hand holes are twenty-four inches (24”) by thirty-six (36”) by thirty (30”) deep. Provide heavy-duty two (2) bolt cover with “Communications” logo.

D. TERMINATION LABELS

I. Shall conform to ANSI/TIA/EIA-606. Labels will have pressure sensitive, permanent acrylic type adhesive, P-Touch type weather proof or equal, black letters/numbers on white back ground. All TCO labels shall be installed under the clear id window slot cover of face plate.

E. SURGE/TRANSIENT PROTECTOR PANEL

I. Porta PN-1525GT Multi-pair Protector Panels or approved equal for each twenty-five (25) pair cable on both ends where the cable enters the building. Use multiple units for higher pair count cables or multiple cables. The protector units to be provided and installed by the Contractor and the protector units must be with fuses.

F. OPTICAL FIBER RACEWAY

I. Flexible telecommunication raceway (inner duct) designed and listed specifically for use with fiber optic cables. All inner duct installed shall be UL-listed Riser-rated minimum or Plenum-rated. General-rated will NOT be allowed. Use Plenum-rated as required for plenums. UL label must be stamped or printed on product. Use Riser-rated in all other locations. Only fiber optic cable shall be installed in this raceway.

II. Armored fiber may be used as an alternative to inner duct.

G. OPTICAL FIBER RACEWAY FITTINGS

I. Fittings shall be specifically designed to match raceway type and material.

H. FOUR (4) POST RACKS: To be furnished and installed by Contractor.

I. Shall be equivalent to Panduit's seven (7) foot 4-post rack system with dual sided horizontal and vertical wire management designed for proposed 4 post rack equivalent to Panduit's "Net Runner" cable manager system. Cable management units shall be installed in between all installed patch panels in floor racks and on the outside of both end floor racks.

I. SWITCH ENCLOSURE (SE) (Mobile Unit Use Only)

I. Enclosure shall be twenty-four inches (24") by twenty-four inches (24") by four inches (4") as per 27 00 00 Guidelines.

II. Enclosure shall be constructed from 16-gauge cold rolled steel. Hinges shall be formed steel type or equivalent and swing from side. Front panels to have louvers mounted horizontally to aid in heat dissipation. Mount enclosure to ensure the louvers run horizontally. Hinge must allow door to open side to side only. Unit shall have thumb latch device. Unit shall have a polyester powder, enamel or equivalent type finish. Enclosure should be beige in color. Use a Hoffman or equal – wall mounted part number 511-NU.

III. Enclosure shall have one-half inch (½") plywood backboard to mount equipment. Enclosure shall have sealed rubber cable entry grommets where required. Owner to supply and install electronics only. Do not use wing nuts to fasten board to the rear of switch enclosure.

IV. Contractor to install a communication circuit assembly in the top right or top left corner of the SE. This unit must be Wiremold Uniduct PN-CM-MMB-293 multi-media box or equivalent. The fibers must be terminated in the enclosure with SC connector adapters. The adapters must be Pass and Seymour Activate PN-2A-2SC (2-strand duplex SC) or equivalent. If an equal is going to be submitted for approval from WCPSS, a sample must accompany the specification submittal process. The Contractor shall ensure that there is at least six feet (6') of repair margin fiber in the enclosure.

V. Enclosure shall be mounted to wall with four (4) one-quarter inch (¼") bolts into wall anchors. Use toggle bolts for hollow partitions. Bolt shall pass through the one-half inch (½") plywood backboard, the enclosure and into the wall anchor.

VI. Cable shall be routed to enclosure as follows:

a. New Construction: Two (2) one inch (1") EMT minimum roughed in wall to a single gang box. Enclosure shall have a four inch (4") by four inch (4") diameter opening in back and be mounted directly over outlet box. Conduits to be sized based on number of fiber and copper cables.

b. Existing Wall - Hollow Partition - Enclosure shall have a four inch (4") by four inch (4") diameter opening in back and be mounted directly over a four inch (4") by four inch (4") diameter opening in wall. Cable to be routed in wall as stated in specifications.

c. Existing Wall-Surface Mount - Route cable down wall in surface metal raceway mechanically fastened to wall in top of enclosure. Use a surface metal raceway type connector.

VII. The cable count cannot exceed twelve (12) copper cables for any single SE. If the cable count exceeds twelve (12), a Re4 Rebox must be installed.

J. REBOX (RE4 Type only)

I. Rebox shall be thirty-two inches (32") high by twenty-four point two inches (24.2") wide by ten inches (10") deep. See 27 00 00 Guidelines. Front door shall have two (2) locks, one (1) set of nineteen inch (19") extension brackets and one (1) set nineteen inch (19") bottom hinge brackets for patch panels. Color should be light gray. Rebox must be a RE4 pre-configured as above or equal.

II. Rebox shall be constructed from sixteen (16) gauge cold rolled steel. Hinges shall be formed steel type or equivalent and swing from side. Front panel shall have louvers mounted horizontally to aid in heat dissipation.

III. Contractor to install a communication circuit assembly in the top right or top left corner of the Rebox. This unit must be Wiremold Uniduct PN-CM-MMB-293 multi-media box or equivalent. The fibers must be terminated in the enclosure with SC connector adapters. The adapters must be Pass and Seymour Activate PN-2A-2SC (2-strand duplex SC) or equivalent. If an equal is going to be submitted for approval from WCPSS, a sample must accompany the specification submittal process. The Contractor shall ensure that there is at least six feet (6') of repair margin fiber in the enclosure.

IV. Rebox shall be mounted to wall with four (4) one-quarter inch (¼") bolts into wall anchors. Use toggle bolts for hollow partitions and lead anchors for solid masonry walls. Bolt shall pass through the one-half inch (½") plywood backboard, the enclosure and into the wall anchor. Rebox shall be mounted approximately thirty six (36") inches AFF to the bottom of the cabinet.

V. Cable shall be routed to Rebox as follows:

d. New Construction: Two (2) one inch (1") EMT minimum roughed in wall to a single gang box. Rebox shall have a four inch (4") by four inch (4") diameter opening in back and be mounted directly over outlet box. Conduits to be sized based on number of fiber and copper cables.

e. Existing Wall - Hollow Partition - Rebox shall have a four inch (4") by four inch (4") diameter opening in back and be mounted directly over a four inch (4") by four inch (4") diameter opening in wall. Cable to be routed in wall as stated in specifications.

f. Existing Wall-Surface Mount - Route cable down wall in surface metal raceway mechanically fastened to wall in top of enclosure. Use a surface metal raceway type connector.

g. A maximum of seventy two (72) cables may be terminated in each Rebox. If cable count exceeds this quantity, a second Rebox or floor rack must be installed.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The contractor shall maintain conductor polarity (tip and ring) identification at the MDF, the Telecommunications sub closets, risers, and station connecting blocks in accordance with industry practices.

B. The Contractor shall provide all cables. All communication cable installed by the Contractor shall be fully tested in accordance with TIA/EIA-568-B.2 (for UTP) and TIA/EIA 526-14-A-B.14 prior to acceptance.

C. The Contractor shall test all fiber optic cable prior to the installation of the cable. The Contractor shall assume all liability for the replacement of the cable should it be found defective at a later date**. Fiber test must be bi-directional after installation through all FDEs and show footage in feet.**

D. The Contractor shall provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wiring duct (MDF & FDE locations), miscellaneous grounding and support hardware, etc., necessary to facilitate the installation of the system in a neat and orderly fashion as approved by the Architect.

E. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the system. This may include, but is not limited to, tools for terminating cables, testing and splicing equipment for copper/fiber cables, communication devices, jack stands for cable reels, or cable winches.

F. The Contractor shall be responsible for printed labels for all cables and cords, distribution frames, and outlet locations, according to the specifications. No labels are to be written by hand **including numbers on boots**. **Approval must be obtained from WCPSS for labeling devices used.**

G. The Contractor shall not place or attach any telecommunications cabling alongside power lines, or share the same conduit, “J” type hook, channel or sleeve with electrical apparatus or other low voltage system installed cabling.

H. The Contractor shall ensure that the maximum pulling tensions of the specified distribution cables are not exceeded and cable bends maintain the proper radius during the placement of the facilities. Failure to follow the appropriate guidelines will require the Contractor to provide in a timely fashion the additional material and labor necessary to properly rectify the situation. This shall also apply to any and all damages sustained to the cables by the Contractor during the implementation.

I. The Contractor shall be responsible for providing an approved ground at all newly installed distribution frames, and insuring proper bonding to any existing facilities. The Contractor shall also be responsible for ensuring ground continuity by properly bonding all appropriate cabling, enclosures, cabinets, service boxes and framework. All grounds and bonding shall consist of green #6 AWG **solid** copper wire and shall be supplied from an approved building ground and bonded to the main electrical ground in compliance with J-STD-607 “Commercial Building Ground (Earthing) and Bonding Requirements for Telecommunications, Sections 2.1 and 5.3

J. The Contractor shall furnish a chart (cable schedule) indicating cable termination locations from end to end. This document shall be page-numbered, laminated and attached to each distribution frame **(**see 27 00 00 a**ttachments** 27 00 00 “A **through D”)**. **Documents shall also be submitted electronically in .dwg and .pdf file format.**

K. The Contractor shall furnish to the Owner all closeout documentation electronically and on some form of media storage device in .dwg and .pdf file format. The documentation (schedules, test results) must be subdivided with tabs indicating cable type and in numerical sequence. See 27 00 00 Guidelines, section 1.3.

L. **Any data cable that is not located in the same room as the Rebox, or IDF must have a full label on the cable at both ends.**

The Contractor shall install the necessary biscuit jacks for all installed Life Safety System on-site per 27 00 00 Guidelines, 27 00 00 exhibit “E2.05”. The Contractor shall install a home room Cat6 cable from the biscuit jack to the appropriate service equipment. If the service equipment is located in a separate building from the DEMARC room, this cable will then have to pass through an IDF. This cable shall have to be lightning protected. The Owner will install the patch cord to the phone service. The Contractor is to install the Cat6 cable in the biscuit jacks only. Each separate biscuit jack shall be labeled as to the Life Safety System it corresponds to.

M. **The contractor shall provide the correct colored (Blue for Data Station and WAP cables and Green for Security Camera cables) patch cords for all cables terminated in any installed Rebox. Patch Cords shall be three feet (3’) in length.**

3.2 INSTALLATION, GENERAL

A. Telephone Service: Comply with telephone utility organization requirements as to details of the telephone service.

B. Distribution System: Complete installation required. The system will be fully operational when instruments and electronic equipment are connected.

C. Raceway: Install service and distribution raceway for all cabling as indicated.

D. Existing telecommunication outlets and wiring are to remain fully operational until the new system has been tested and accepted.

E. Conduit sleeves for Computer Network Infrastructure shall be installed not more than four inches (4") from wall and shall be stubbed at a maximum of four inches (4") above or below finished floor. Plastic bushings and pull wires shall be provided. All installed conduits to a location not contained within the main building

complex must have a minimum of two (2) separate pathways provided for WCPSS use. One (1) pathway will be for current use and one (1) pathway will be for future use. This can be achieved with multiple conduit runs, internally installed corrugated plastic innerduct, or a “max-cell” type innerduct material.

F. Where the protector panels are installed in a room with a plywood backboard, mount directly on backboard. Where the protector panels are installed on the exterior of the building, mount in a NEMA 3R enclosure (Hoffman Screw Cover Type 3R Enclosures - Bulletin A-3 or equal). Where the protector panels are installed indoors in a room without a backboard, mount in a NEMA 1 enclosure (Hoffman Small Type I Enclosures Bulletin A-2). Size as required to accommodate all devices and wiring with adequate clearance. Contractor will provide protector units.

G. The Contractor shall remove accessible abandoned communications cable per the current edition of the National Electric Code, Section 800.52(B) or Current Release Available.

3.3 HORIZONTAL CABLE INSTALLATION

A. Obtain approval of all raceway system installation from engineer prior to installing any cable. Install cable without damaging conductors or jacket. Do not bend cable to a smaller radius than minimum recommended by manufacturer. Do not exceed manufacturers recommended pulling tensions. Pull cables simultaneously where more than one is being installed in the same raceway or at the same location. Use pulling compound or lubricant where necessary. Compound used must not damage conductor or insulation. Use pulling methods that will not damage cable or raceway, including fish tape, cable, rope, and wire-cable grips.

B. Wiring Method

I. New Construction: Install outlet boxes with jack assemblies at outlets. Install cable in raceway in wall. Terminate raceway with a bushing in ceiling space above outlet except as otherwise indicated. Run cable concealed in accessible ceiling space except as otherwise indicated.

II. Existing Construction: If the interior of existing walls are not obstructed, the Contractor shall conceal horizontal distribution wiring internally within the walls without the use of raceway. If such obstructions exist, Contractor shall use surface metal raceway.

III. Do not penetrate any ceiling or floor tile suspected of being asbestos without coordinating work with the Owner. Consult plans for known asbestos areas.

IV. Fiber optic cable shall be installed in raceway from Rebox to MDF. All fiber optic cable shall be installed in optical fiber raceway (inner duct) minimum one inch (1”) in diameter or other raceway (i.e., conduit). There shall be no exposed conduit or fiber optic cabling. Utilize fittings and boxes specifically designed for use with the associated raceway. Each end of the fiber shall contain a slack storage box with approximately 6 feet (6’) of cable slack. Provide pull boxes for inner duct at a maximum of one hundred feet (100’). Armored fiber may be used in lieu of inner duct. No splicing of fiber cable is acceptable.

V. Provide bushings on all conduit stubbed to ceiling void.

VI. Copper Cable above finished ceilings: Install parallel or perpendicular to surfaces or exposed structural members and follow surface contours where possible. Install cables in approved supports on walls, not diagonally across ceiling void. All cables shall be routed and supported around the exterior walls of the room in a consistent pattern, with all break-outs being 90-degree angled turns without any corners being cut.

a. Cable Support: Secure cable to independent supports at intervals as required by current industry standards, that prevents sagging between supports. Use metallic supports with corrosion-resistant finish. Please provide separate cable pathways for all Technology related cabling and all other low voltage cabling.

b. Splices: Do not splice any cable between the normal terminations of runs.

c. No Dropped Ceiling: Route in conduit along structure.

d. Attach cable to building structure only as per NEC-800 Refer to Current Release Available.

e. Technology related cables installed in cable tray shall be separated from all other low voltage cabling by dividing the tray into two distinct sections.

f. Technology related cabling installed in “J” type hooks” shall be separated from all other installed low voltage cabling. This means a separate installed “J” type hook pathway should be provided for all non-technology related low voltage cabling.

VII. In suspended ceiling and raised floor areas where walker duct, cable trays or conduit are not available, the Contractor shall bundle horizontal Cat6 wiring with wire ties at appropriate distances. The cable bundling shall be supported via Cat6 "J" type hooks or Cat6 bridle rings with saddles attached to the existing building structure and framework. Adhering to industry standards concerning cable fill capacity for cable type being utilized. Use of Velcro straps is prohibited.

C. The 4-pair UTP cables shall be installed using a star topology format from the administration subsystem on each floor to every individual TCO.

D. The length of any horizontal Cat6 cable shall not exceed two hundred ninety-five feet (295’) (90 m).

E. In the event the Contractor is required to remove ceiling tiles, such work shall not break or disturb grid and must be coordinated with the construction site superintendent. Any damaged tiles after the ceiling is installed shall be replaced under this contract by the contractor that damaged said tiles.

F. Conduit installed by the Contractor should not exceed one hundred feet (100’) or contain more than two (2) ninety degree (90°) degree bends without utilizing appropriately sized pull boxes.

G. No Condulets may be used.

H. Cabling in Telecommunications Sub closets and Cabinets: Install conductors parallel to and at right angles to walls. Bundle, lace and train the conductors to terminal points with no excess. Use wire distribution spools at points where cables are fanned or conductors turned. Connect conductors that are terminated, spliced or interrupted to terminal blocks.

I. Conductor Terminations: Terminate conductors of cables on terminal block using tools recommended by terminal block manufacturer.

3.4 TELECOMMUNICATION OUTLET (TCO)

A. Unless otherwise noted on the floor plans, the TCO shall be flush mounted.

B. Outlet jacks shall be color keyed blue for data.

C. Wireless Access Point and Camera drops shall be installed in the center of the room at a maximum height of ten (10’) feet AFF with a minimum twenty (20’) service loop in ceiling areas containing acoustical ceiling tiles and terminated on an RJ45 keystone style jack enclosed in a surface mount style box installed in and extended to the patch panel in the nearest designated IDF closet. Each biscuit jack installed shall be labeled with the complete label designation for that individual cable drop on the outside cover of biscuit jack and on adjacent ceiling grid. Wireless Access Point drops located in the mechanical rooms with a solid or no ceiling apparatus should be mounted on the wall at a maximum height of ten (10’) feet AFF. Each outlet should be labeled with the complete label designation for that individual cable drop on the front of the faceplate.

3.5 **FEEDER** CABLE

A. Contractor shall obtain approval of all raceway systems installation from the engineer prior to installing any cable.

B. Contractor shall install the **feeder** cables in a star topology, terminated in the MDF at one end and in the IDF in a Telecommunications sub closet at the other end.

C. All fibers shall be installed in raceway (inner duct or armored fiber) and terminated with approved pre-polished, crimp-on SC-style connectors or hot melts at termination or distribution enclosures or at termination shelves equipped with sufficient panels, adapters and jumper storage to terminate and secure all fibers.

D. The fiber cable shall be protected by optical fiber raceway or appropriate apparatus at all times. Each end of the fiber cable shall contain a slack storage box with approximately six feet (6') of cable slack.

3.6 OUTSIDE CABLE

A. All buried cable shall be contained in a raceway system. When using PVC, a metallic locating tape shall be installed twelve inches (12") below grade.

B. Contractor shall obtain approval of all raceway system installation from the engineer prior to installing any cable.

C. Provide hand holes on all underground inner building (between buildings) conduit runs that change direction.

D. Contractor shall provide electrical lightning/surge protection panels and protector units on copper cables that will prevent electrical surges on the cable from entering buildings.

E. It shall be the responsibility of the Contractor to stake all areas along the cable route forty-eight (48) hours prior to any trenching or digging.

F. The Contractor shall be responsible for restoring any disturbed earth to its original condition. A reasonable effort shall include any landscaping, seeding, or replacement of shrubbery that may be required to properly restore the excavated area. If settling should occur, the installation Contractor shall be responsible for any secondary restoration.

G. All aerial cabling shall be installed with an environment suitable guide wire and supported by a CAB product #1070 (3 inch diameter Galvanized Standard Style with 3/8" lock) cable ring or equivalent product.

3.7 GROUNDING

A. Communications Systems - In compliance with NEC Refer to Current Release Available, Article 800, J-STD-607-A-2.1, J-STD-607-A-5.1, J-STD-607-Annex B

I. Install a #6 AWG green insulated **solid** copper ground wire from the main building service entrance grounding system to the MDF Telecommunications Main Grounding Busbar (TMGB).

II. Install a #6 AWG green insulated **solid** copper ground wire from the TMGB to each Telecommunications cabinet in the MDF.

III. DO NOT GROUND OR BOND TO THE BUILDING STRUCTURE

B. **Contractor shall install a copper busbar for grounding of communication systems.**

3.8 IDENTIFICATION

A. Provide identification in accordance with the recommendations of ANSI/TIA/EIA-606, "Administration Standard for Telecommunications Infrastructure." Refer to labeling descriptions below.

B. New labeling shall be a fully integrated extension of the existing network labeling system. No duplication of the existing network number may be used in the new labeling system or existing system.

3.9 TELECOMMUNICATIONS LABELING LEGEND

A. Copper Telecommunications Outlet (TCO) - *"X-RM**NNN**-B**NN**":*

I. Where *"X"* equals "MDF" (Main Distribution Frame), "**IDF**" (**Intermediate Distribution Facility**), or "RB" (Rebox) indicating where the cable is terminated at the other end.

II. Where ***"NNN"*** equals the room number where the MDF, **IDF**, SE, or RB is located.

III. Where *"B"* equals the outlet, designation symbolized by "D" for data, "F" for fiber, "WAP" for wireless access point, or "CAM" for camera.

IV. Where ***"NN"*** equals the unique outlet/fiber number. This number shall be consecutive for each MDF, **IDF**, or RB and shall be numbered 01, 02, 03, etc.

B. Wireless Access Points and Camera drops – "X-RMNNN-BNN" :

I. Where *"X"* equals "MDF" (Main Distribution Frame), "**IDF**" (**Intermediate Distribution Facility**), or "RB" (Rebox) indicating where the cable is terminated at the other end.

II. Where ***"NNN"*** equals the room number where the MDF, **IDF**, or RB is located.

III. Where *"B"* equals the cable type designation symbolized by "D" for data, "F" for fiber, "WAP" for wireless access point, or "CAM" for camera.

IV. Where ***"NN"*** equals the unique outlet/fiber number. This number shall be consecutive for each MDF, **IDF**, or RB and shall be numbered 01, 02, 03, etc.

V. A complete cable id label is to be applied to the biscuit jack attached to each individual cable and to the ceiling grid in general area where any WAP or Camera drop is located. A round 3/4" orange sticker should also be applied in same spot as label for all WAP drops. A round 3/4" green sticker should also be applied in same spot as label for all Camera drops.

C. Copper Patch Panels - Label each outlet at the MDF, **IDF**, or RB patch panels with a corresponding outlet number. Numbering shall be from left to right, top to bottom and with consecutive numbers. *Note: All labels shall be uniform in size using the same font size on letters and numbers (block style) throughout. The schedule sheet and labels on patch panels must match. The patch panel cable numbers should only reflect the cables that are terminated.

D. **If the data cables are all contained within the same room, the data labels may read D1, D2, D3, etc. if not, they must have a full label at both ends.**

E. Fiber **Station Cables** and Fiber **Distribution Enclosure (FDE)** - label as follows:

I. Fiber **Station Cables** - *"X-RM**NNN**-B-**NN**":*

a. Where *"X"* equals "MDF" or "FDE" (located in an **IDF**) indicating where the cable is terminated at the other end.

i. Where ***"NNN"*** is the room number where the MDF or FDE is located.

ii. Where *"B"* equals the outlet designation symbolized by "F" for fiber

iii. Where ***"NN"*** is the fiber outlet number. This number shall be consecutive for each outlet. The numbers shall be unique for each outlet throughout the entire campus.

iv. Label each fiber connector in the fiber patch panels at the MDF or FDE with consecutive numbers reading left to right, top to bottom. The numbering system should start at the MDF and work outward.

v. *Note - Label the Rebox on the inside and outside **of the door and on** multi-media outlet box.

F. Labeling for the backbone distribution fiber cable - At the MDF label all fiber connectors sequentially from left to right, top to bottom. This number should carry all the way to the Rebox. These numbers shall match at

all FDEs. Tag cables at all connections. **Format of label is *"*Fiber** Feeder Cable to **X**-RM**NNN FNNN-FNNN**":

I. **Where *"X"* equals "MDF" or "FDE"**.

II. Where *"NNN"* is the room number where the MDF or FDE is located.

III. Where *"NNN-NNN"* equals the beginning and ending numbers for that feeder cable.

G. Every fiber strand should be labeled with its unique fiber number with an approved labeling tape directly on the fiber boot. Also every six (6) strands of fiber should be labeled with an F1,F6,F7,F12,F13,etc. label on the front side of every six (6) pack or twelve (12) pack insert.

3.10 FIELD QUALITY CONTROL

A. Test Notice: Provide at least ten (10) days' notice in writing when the system is ready for final acceptance testing.

B. Acceptance Tests: Include the following for each pair or conductor of each cable run.

I. One hundred (100) percent of the horizontal and riser wiring pairs shall be tested for opens, shorts, polarity reversals, transposition and presence of AC voltage.

II. Data horizontal wiring pairs shall be tested from the TCO to the patch panel or block, the basic link test.

C. Data cables shall be tested for conformance to the specifications of TIA/EIA -568-B.2 for Cat6 copper cable.

I. Wire Mapping shall be done to ensure proper wiring and connectivity. Test for:

a. Continuity, end-to-end.

b. Shorts between any two or more conductors.

c. Crossed pairs

d. Reversed pairs

e. Split pairs

f. Other mis-wirings

g. Document as Pass/Fail

II. Length shall be measured. Indicate the length of the cable as the pair with the shortest length and record it

III. Attenuation shall be tested with a remote signal injector and a reading made at the local end. Evaluate the worst pair attenuation and record result on test report.

IV. Bi-Directional NEXT. Near-end crosstalk (NEXT) shall be tested on all six pair combinations in each four pair cable. Tests for NEXT shall be performed from both the work area outlet location and link origination point.

V. Fiber optic cables shall be tested in accordance with the requirements of TIA/EIA-526-14-A-B.1.4 Annex B (Bi-directional Testing). Maximum dB loss shall be **3**.0. **Show footage on test reports.** Notify WCPSS Technology Department of exceptions by cable ID number and give reasons for the exceptions.

VI. Computer generated test results must be submitted to the WCPSS Technology Department.

D. Re-testing: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify that the total system meets the Specifications and complies with applicable standards.

E. Report of Tests and Inspections: Prepare a written record of inspections, tests, and detailed test results in the form of a test log and format the log in cable ID number order.

3.11 Entrance Facilities:

A. An entrance raceway (conduit) meeting the following specifications shall be provided by the Contractor for the use of the local telephone service provider.

B. General - (Conduit)

I. Contractor shall install a quantity of two (2) four inch (4") conduits from the Owners' property line, as specified by the local telephone service provider, to the main telecommunications room.

II. Conduits to be intermediate metal, rigid metal or rigid non-metallic conduit installed in accordance with Articles 345, 346, or 347, respectively, of the National Electric Code Refer to Current Release Available.

III. Contractor shall bury conduit to a depth between twenty-four inches (24") and thirty-six inches (36") below final grade.

IV. Contractor shall equip conduit with no more than the equivalent of two (2) quarter bends (a total of 180 degrees) between cable pulling points.

V. All conduit bends shall have a minimum radius of ten (10) times the inside diameter of the conduit. LBs will not be acceptable.

VI. Contractor shall equip conduits with **mule tape with footage on tape**.

C. Field Side - (Conduit at Right of Way)

I. Contractor shall cap conduit to prevent debris and water from entering before cable placement.

II. Contractor shall install conduits to a hand hole thirty inches (30") by forty-eight inches (48") by thirty-six inches (36") and the hand hole in locations designated by the Owner.

D. Building side - (At Main Telecommunications Room)

I. The responsibility to seal entrance conduits to protect against water damage is left entirely with the Contractor.

II. All fire rated structures that are penetrated during conduit or cable placement must be fire-stopped by the Contractor.

E. The telephone service provider shall terminate its entrance cables inside the building in the Main Telecommunications Distribution Room. This area will be provided by the Contractor with the following requirements met:

I. Contractor shall equip area with an eight foot (8') wide x four foot (4') high x three quarter inch (¾") fire retardant non-painted plywood backboard, with visible fire rating, and securely fastened to the wall. The plywood should be installed on all walls.

II. Contractor shall equip backboard with a standard duplex convenience outlet.

III. Contractor shall maintain clear path to this area and a three foot (3') maintenance area directly in front of terminal area.

IV. Contractor shall equip area with direct lighting sufficient for a uniform light intensity of 30-foot candles measured at floor level.

F. Grounding and Bonding

I. Refer to **27 00 01 guidelines, section** 3.7. **(see exhibits 27 00 00 "E2.05" and "E2.06")**.

END OF SECTION 27 00 01

SECTION 28 23 00 – CCTV Video Management System

PART 1 GENERAL

1.01 General Requirements

A The surveillance software shall be of manufacturer's official product line, designed for commercial and industrial use.

B The surveillance software shall be non-proprietary and operate with multiple server, camera, and network hardware manufacturers while based on commercial-off-the-shelf (COTS) hardware and software. The approved Enterprise Surveillance Manager software is ipConfigure. All video surveillance management systems must integrate with WCPSS's existing enterprise surveillance manager, ipConfigure. All proposed equals must submit working demo systems for a minimum 30-60 day review process by Energy and Physical Plant and the Security Department.

1.02 Quality Assurance

A All surveillance software installation, configuration, setup, program and related work shall be performed by electronic technicians thoroughly trained by the manufacturer in the installation and service of the software provided.

B All software shall be backed by a minimum of a one year manufacturer warranty.

1.03 Certifications and standards

A The surveillance at minimum shall comply with the following approvals:

1. Section 508 – Accessibility Act
2. FDCC – Federal Desktop Core Configuration

B The video server shall meet or support the following standards

1. MJPEG, MPEG4, & H.264
2. Networking:
    a. IEEE 802.1X (Authentication)
    b. IEEE 802.3af (Power over Ethernet)
    c. IPv4 & IPv6
    d. SSL Encryption
    e. Quality of Service (QoS)
    f. Microsoft Active Directory compliant

1.04 REFERENCES:

A NFPA 70 – National Electric Code

B NFPA 72H – Guide for Test Procedures for Protective Signalling Systems

C NFPA 731 – Installation of Electronic Premises Security Systems

D NFPA 730 – Guide for Premises Security

1.05 SUBMITTALS:

A Samples: Complete manufacturer's product literature and samples (if requested) for all pre-approved substitutions to the recommended products made during the course of the Project.

B Permits: The Contractor shall obtain all required permits and provide copies to the Owner/Architect/Engineer

C Product Literature: Complete manufacturer's product literature for all electronics, cable, cable supports, cable labels, outlet devices, and other products to be used in the installation. In addition, whenever substitutions for recommended products are made, samples (when requested by the Owner/Architect/Engineer) and the manufacturer's supporting documentation demonstrating compatibility with other related products shall be included.

D Testing: Proposed Contractor test result forms, a list of instrumentation to be used for systems testing.

E A complete point-to-point floor plan diagram indicating camera locations and all required cabling to connect systems.

PART 2 PRODUCTS

2.01 General

A The surveillance software shall:

1. Be capable of supporting unlimited cameras, encoders, servers, locations, and users.

2. Be designed to support multiple simultaneous live viewings and recording of MJPEG, MPEG-4, and H.264 video at independent resolutions, frame rates and compression settings.

3. Be designed to stream live and record at 30 frames per second (NTSC) or 25 frames per second (PAL) per video channel for all resolutions in accordance with video hardware specifications.

4. Shall be compatible with the existing enterprise surveillance manager, ipConfigure.

B Cameras:

1. Refer to attachments 28 23 00 A1, A2, A3, A4.

2. All cameras shall be as shown on attachments or approved as equals by WCPSS maintenance department. Provide suggested manufacturers and models for approval prior to listing in project specifications.

3. Cameras shall typically have the following characteristics:

   A. Power – Power over ethernet IEEE 802.3.af

   B. Connectors – Terminal block for 1 alarm input and 1 output

   C. Edge storage – SD/SDHC/SDXC Slot supporting memory card up to 64GB Resolution – 1.3 MP (1280x960) or better as applicable

   D. Image Sensor – Progressive scan RGB CMOS

   E. Lens – Varifocal, remote focus and zoom, IR corrected, P-iris control, Megapixel resolution

   F. Day and Night Style – Automatically removable infrared-cut filter

   G. Video Compression – H.264 Baseline

   H. Video Streaming – Multiple, individually configurable streams in H.264 and Motion JPEG. Controllable frame rate and bandwith, VBR/CBR H.264

   I. Open application programming interface for software integration

   J. Event Triggers – Motion detection, external input, edge storage events

   K. Built-in aids – Remote zoom, remote focus, pixel counter

2.02 User interface

A The surveillance software user interface shall:

1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Internet Explorer, Mozilla Firefox, or Safari browsers while not requiring the installation of client software.

2. Provide unique user login based camera accessibility through either internal or Active Directory based user access management.

3. Provide real-time display of RSS feeds with source links.

4. Support multi-monitor viewing (Dual, Quad, etc.) of all software user interfaces (i.e. Maps, Matrix display, Archive, Alarm, LPR and Administration)

B Map graphical user interface shall:

1. Shall support JPEG or GIF images and allow UI (User Interface) based placed camera icons to include Fixed and Pan/Tilt/Zoom cameras. Provided by a/e.

2. Illustrate live camera video feeds upon mouse rollover of a camera icon.

3. Open a full resolution live camera video feed upon double clicking a camera icon with window resizing capabilities and multi-monitor support.

C Video matrix user interface shall:

1. Support the viewing of up to 30 live video feeds per monitor with the capability of supporting up to 120 live video feeds across four monitors.

2. Offer a custom camera layout based on unique user accounts.

3. Support sharing option of custom layouts to other system users.

4. Rotate (cycle) live cameras on matrix screen based on camera motion detection or timed interval.

D Archive search and playback interface shall:

1. Present video history in a calendar and search histogram that illustrates activity by each minute.

2. Support for thumbnail image search and playback of pre-alarm buffer and post-alarm buffer events.

3. Provide the option to copy video events into a user library for later retrieval while excluding library video events from the first-in-fist-out (FIFO) delete routine.

4. Allow for playback of definable segments of time.

5. Support search and playback of multiple cameras regardless of their geographic or logical location across the same period of time.

6. Provide the playback of up to 16 cameras simultaneously.

7. Display hourly summaries of recording durations and file size.

8. Support the download of either full-length video or still images.

9. Provide real-time evidentiary video authentication through file hashing based on U.S. Federal Information Processing Standard.

E Alarm monitoring interface shall:

1. Display motion based event information and allow for playback.

2. Display system based event information to include errors, alerts, and updates.

3. Allow for filtering of which events are displayed and the refresh rate frequency.

F License Plate Recognition software shall:

1. Detect and classify vehicle plate letters and number in the OCR detection process utilizing visible light based megapixel resolution images.

2. Detect and classify vehicle color megapixel information in the LPR detection process.

3. Support standard Internet Protocol (IP) megapixel cameras by Axis, Panasonic, and Bosch.

4. Support camera placement of up to 35 degree off vehicle license plate centerline, totaling 70 degrees of angle of sweep at up to 120ft distance.

5. Support color non-IR reflection based JPG images for daytime visual identification of vehicle make, model and other attributes.

6. Support both non-reflective and reflective paint license plates.

7. Support speeds up to 45 miles per hour without the use of IR illumination.

2.03 Administrative interface

A The surveillance software administrative interface shall:

1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Internet Explorer, Mozilla

Firefox, or Apple Safari browsers and not requiring the installation of PC or MAC client software.

2. Provide a single application interface to manage unlimited numbers of cameras, servers, and users.

3. Offer a pre-defined camera default configuration of basic camera settings to include IP addresses, recording criteria, and camera authentication information.

4. Offer simple map uploading and editing of camera placement on building facility floor plans.

B Camera setup interface shall:

1. Not require MAC address information in the configuration or activation of new or existing cameras.

2. Support auto discovery of supported/compatible IP camera manufacturers.

3. Support PTZ guard tours setup in the camera.

4. Allow for independent live and recording frame rate settings.

5. Offer trip-wire motion detection settings.

6. Offer depth perception motion detection settings.

7. Provide for user and security segmentation by group affiliation.

C Storage configuration shall:

1. Support any size storage volume and not be limited by the number or size of recordings in any single day.

2. Provide independent configuration of archive (recording storage) or library (user copied / saved recordings) storage.

3. Provide up to three different user defined recording retention settings: Short-term, Medium-term, and Long-term.

4. Support automated motion grooming (i.e. delete routine) of non-motion activity from continuous recordings after a user defined number of days.

D Email notification shall:

1. Be transmitted when camera connectivity or transmission failures occur.

2. Be transmitted and include a still image when motion is detected.

3. Support notifications based on a schedule.

2.04 System capabilities

A System server architecture shall:

1. Leverage a three-tier computing architecture which utilizes a web service, database service, and application service.

2. Be capable of installing on a single stand-alone server.

3. Be capable of installing on multiple distributed servers.

4. Operate on a Windows Server, Linux, or Solaris operating systems.

5. Support auto discovery of certain IP cameras.

6. Support single click mass-setting updates to selected camera.

B System performance shall:

1. Support any image resolution for live and recording that the camera is capable of streaming.

2. Be capable of recording on motion a minimum of 120 IP cameras using JPEG compression at 640 x 480 resolution and 7 frames per second on a single server.

2.05 Server Requirements

A Server specifications

1. Stand-alone architecture: based on MJPEG 640 x 480 resolution at 7 frames per second. MPEG4 & H.264 support ½ the quantity of cameras listed below based on 640 x 480 resolutions at 10 frames per second.

	8-32 Cameras @ 640x480	**32-64 Cameras @ 640x480**	**64-120 Cameras @ 640x480**
Processor Minimum	Xeon 5410 Quad Core	Xeon 5410 Quad Core	Xeon 5410 Quad Core
Sockets Minimum	1	2	4
RAM Minimum	4 GB	8 GB	16 GB
Storage Minimum	1 TB	2 TB	4 TB
Operating System	Windows Server 2003 or 2008	Windows Server 2003 or 2008	Windows Server 2003 or 2008
OS Architecture	32 / 64	32 / 64	32 / 64

Database	SQLServer Express 2005 or 2008	SQLServer Express 2005 or 2008	SQLServer Express 2005 or 2008
Drive Type	SATA, SAS, SCSI	SATA, SAS, SCSI	SATA, SAS, SCSI

2. Distributed architecture: based on 640 x 480 resolutions at 7 frames per second. MPEG4 & H.264 support ½ the quantity of cameras listed below based on 640 x 480 resolutions at 10 frames per second.

Management Server

Processor Minimum	Xeon 5410 Quad Core
Sockets Minimum	1
RAM Minimum	4 GB
Storage Minimum	1 TB
Operating System	Windows Server 2003 or 2008
OS Architecture	32 / 64
Database	SQL Server or SQL Server Express 2005 or 2008
Drive Type	SATA, SAS, SCSI

Recording Server(s)

	8-32 Cameras @ 640x480	**32-64 Cameras @ 640x480**	**64-120 Cameras @ 640x480**
Processor Minimum	Xeon 5410 Quad Core	Xeon 5410 Quad Core	Xeon 5410 Quad Core
Sockets Minimum	1	2	4
RAM Minimum	4 GB	8 GB	16 GB
Storage Minimum	1 TB	2 TB	4 TB
Operating System	Windows Server 2003 or 2008	Windows Server 2003 or 2008	Windows Server 2003 or 2008
OS Architecture	32 / 64	32 / 64	32 / 64
Database	SQLServer Express 2005 or 2008	SQLServer Express 2005 or 2008	SQLServer Express 2005 or 2008
Drive Type	SATA, SAS, SCSI	SATA, SAS, SCSI	SATA, SAS, SCSI

B Security

1. The video server shall for each video channel:
    a. Support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.

    b. Support IEEE 802.1x authentication.

    c. Provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.

    d. Restrict access to the built-in web server by usernames and passwords.

2. Be managed by group and associated with building and cameras.

C API support

1. The software shall support IP cameras with open and published APIs (Application Programmers Interface) that will provide the necessary information for integration in the software.

2. The software shall support SQL queries for all system setting variables, events, and analytical results.

D Maintenance

1. The surveillance software shall:

    a. Be supplied with management software which allows for configuration of the system to includes, cameras, users and servers.

    b. Offer on-demand or scheduled email reports to system administrators with enterprise wide status of cameras, server, storage, location and health status.

    c. Offer on-demand or schedule email reports to system administrators with enterprise user activity.

2. Customer-specific settings, including statically assigned IP address, the local time and date, event functionality and video configuration, shall be stored in the cameras non-volatile memory and shall not be lost during power outages or soft reset.

3. Monitor cameras by a recording service that can automatically re-initiate recording processes if a malfunction is detected.

2.06 Client PC requirements

A The surveillance software shall:

1. Operate independently of any single operating system and be accessible through an HTML interface compatible with Internet Explorer, Mozilla Firefox, or Apple Safari browsers while not requiring the installation of PC or MAC client software.

2.07 Environmental

A The surveillance software shall:

1. Operate in a temperature ranges that are compliant with supporting hardware.

2. Operate in a humidity ranges that are compliant with supporting hardware.

PART 3 EXECUTION

3.01 Installation

A The Contractor shall carefully follow instructions in documentation provided by the manufacturer to insure all steps have been taken to provide a reliable, easy-to-operate system.

B All software shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.

C All software products shall be the latest versions and most up-to-date builds provided by the manufacturer.

D All equipment requiring users to log on using a password shall be configured with user/site-specific password/passwords. No system/product default passwords shall be allowed.

E Exterior cameras: Provide an exterior 4x4 gang box for all exterior cameras. The exterior camera can be mounted on surface plate of the gang box. All connections will be made inside box. BNC-crimp on connector and 2 conductor power cables in box for accessibility and repairs without having to enter the building for repairs or disconnects in walls, from the gang box to the ceiling. Provide plastic bushings or insulated throat connectors shall be used in all conduit terminations. Conduits are not required in ceilings for CCTV Systems. Provide plenum rated cables where required.

F Interior Cameras: Wire cameras to closest IDF room, coordinate installation with WCPSS Security Shop maintenance technician.

11 68 13-A SPECIFICATION FOR GENERAL PLAY EQUIPMENT

1.0 SCOPE AND CLASSIFICATION:

1.1 Scope: These specifications are the requirements and provisions for all Wake County Public School System (WCPSS) Playground Equipment.

This specification does not eliminate the need for supervision of children on public playground equipment. It is intended to minimize the likelihood of life- threatening or debilitating injuries, such as those identified by the Consumer Product Safety Commission (CPSC). Playground supervisors should be aware that not all playground equipment is appropriate for all children who may use the playground. Supervisors should look for posted signs indicating the appropriate age of the users and direct children to equipment appropriate for their age.

1.2 INSTALLATION: Playground Equipment requiring assembly and installation should be contracted with a manufacturers-certified installer. Vender is to provide certification that playground equipment is installed properly, according to manufacturer's installation instructions, and meets applicable guidelines, regulations and standards.

2.0 APPLICABLE PUBLICATIONS AND CERTIFICATIONS:

2.1 All play equipment must meet the following requirements, guidelines and specifications. Manufacturers must provide written documentation of compliance with the following guidelines, publications and certifications for each submittal.

DEFINITIONS: For the purpose of this Specification:

"Playground Equipment: Composite play structure, Individual Freestanding Apparatus, Composite Parts, which can be added to or combined with, composite play structure."

Physical fitness climbing equipment does not contain decks, steps, or ramps as normally found in traditional playground equipment.

1. Most current American Society for Testing and Materials (ASTM F 1487) Standard Consumer Safety Performance Specifications for Playground Equipment for Public Use. Certification that all equipment meets the ASTM- F 1487 (or most current) performance specifications is mandatory and required for approval by the Owner, Project Architect and or Engineer or Owners appointed representative. (Copies may be obtained from American Society for Testing and Materials, 100 Barr Harbor Dr., West Conshohocken, PA 19428)

2. All Playground Equipment Certification submittals to be as follows:
   The International Play Equipment Manufacturers Association (IPEMA) third party certification program that certifies manufacturers compliance to ASTM F 1487. ALL individual play COMPONENTS that make up a composite structure must be individually certified by IPEMA. All individual equipment must be certified by IPEMA. IPEMA certification is required in submittal review prior to approval of any play equipment. Submission of detailed drawings with IPEMA

Certification Seal and the following stated below the seal is required: “The play components identified on this plan are IPEMA certified. The use and layout of these components conform to the requirements of ASTM F 1487.” Manufacturers' membership in IPEMA does not constitute equipment certification and approval for use. Proposed equipment must meet the above criteria for review and approval for use.

3. U.S. Consumer Product Safety Commission- Handbook for Public Playground Safety Publication No. 325 (Copies may be obtained from U.S. Consumer Product Safety Commission, Washington, DC 20207)

4. Manufacturers of play equipment must be certified by the following:
   A. The International Organization for Standardization (ISO)
      1. ISO 9001- Quality Standards certifying manufacturers processes.
      2. Certification of all ISO Standards are required and must be submitted for review by owners representative or Architect.
      3. All playground equipment provided must be manufactured by companies who are currently ISO certified per the above standards.

5. The Americans with Disabilities Act (ADA)- Current Americans with Disabilities Act Architectural Guidelines (ADAAG) as set forth in the Federal Register. All playground equipment both independent and composite structures shall meet the current standards as developed by the Federal Access Board. All manufacturers must provide documentation as stated below that proposed equipment meet or exceed the ADAAG guidelines.

   A. Manufacturers of play equipment must provide drawings that include the following:
      1. Manufacturers statement that proposed equipment conforms to the ADA Accessibility Guidelines (ADAAG)
      2. Breakdown of playground components certifying compliance to the ADAAG guidelines as follows:
         a. Total elevated play components
         b. Total elevated components accessible by ramp.
         c. Total elevated components required.
         d. Total elevated components accessible by transfer.
         e. Total elevated components required.
         f. Total accessible ground level components.
         e. Total accessible ground level components required.

6. NPSI-National Playground Safety Institute identification of (12) leading causes of injuries on playground. (Copies may be obtained from National Recreation and Park Association, 2775 South Quincy Street, Suite 300, Arlington, VA 22206)

3.0 ACCEPTABLE AND EXCLUDED PRODUCTS:

Equipment not specifically designated as acceptable products for this specification are excluded. Determination of the acceptability of products for this specification is at the sole discretion of the Wake County Public School System.
Inclusion of unacceptable products will result in the submittal being returned. Approved submittals shall not be changed to include unacceptable products. If changes are required, please re-submit application and submittal with changes.

4.0 GENERAL MATERIALS AND MINIMUM REQUIREMENTS:

All materials shall be structurally sound and suitable for intended use and safe play. Durability shall be ensured on all aluminum and steel parts by the use of time-tested coatings such as zinc plating, zinc-nickel plating, powdercoating, PVC- coating, etc. Colors shall be specified by the WCPSS.

4.1 POSTS:

1. **All aluminum posts are to be 4.5" to 5" outside diameter with** .118"minimum thickness and manufactured from extruded tubing conforming to ASTM B-221. Minimum yield strength shall be 35,000 psi and minimum tensile strength (min): 38,000 psi
2. All steel posts shall be 4.5" to outside diameter, 11 gauge (.120") galvanized round tubing, manufactured to ASTM A-500 Grade B tolerances from cold-formed steel conforming to ASTM A-569 Sheet Spec for steel coil. Minimum yield strength shall be 50,000 psi and minimum tensile strength shall be 55,000 psi. The exterior surface is hot dip galvanized, chromate conversion coated, and a clear high performance organic polymer is applied. The inside diameter has 81% minimum zinc rich primer capable of providing excellent rust protection and fabrication characteristics. All coatings are applied inside and out after welding for superior corrosion protection throughout. Exterior surface galvanizing zinc purity is 99% or per ASTM B-6 high grade and special high grade. Galvanizing coverage shall demonstrate the ability to exceed 1000 hours salt spray corrosion exposure in accordance with ASTM B-117. Internal surface zinc rich 81% minimum zinc dust content in organic resin, as per ASTM F-1234, Section 5.2.4, Type D.
3. Physical fitness climbing equipment posts shall be 3.5" outside diameter, 13 gauge (.095") galvanized round tubing, manufactured minimum to ASTM A-500 Section II tolerances from cold-formed steel conforming to ASTM A-569 Sheet Spec for Steel Coil Minimum yield strength shall be 50,000 psi and minimum tensile strength shall be 55,000 psi. The exterior surface is hot dip galvanized, chromate conversion coated, and a clear high performance organic polymer is applied. The inside diameter has 81% minimum zinc rich primer capable of providing excellent rust protection and fabrication characteristics. All coatings are applied inside and out after welding for superior corrosion protection throughout. Exterior surface galvanizing zinc purity is 99% as per ASTM B-6 high grade and special high grade. Galvanizing coverage shall demonstrate the ability to exceed 1000 hours salt spray corrosion exposure in accordance with ASTM B-117. Internal surface zinc rich 81% minimum zinc dust content in organic resin, as per ASTM F-1234, Section 5.2.4, Type D.
4. All posts shall be powdercoated to specified color. (See Powdercoat Section 4.3 for more detail.) or hot dipped galvanized steel.
5. All posts shall have a "finished grade marker" positioned on the post, required for correct installation and the top of the protective surfacing.

6. Top caps for posts shall be aluminum (plastic caps are not acceptable), and Powdercoat finished to match the post color. All caps shall be factory installed and secured in place using aluminum or stainless steel self-sealing rivets.
7. A molded low-density polyethylene cap, with drain holes, may be pressed onto the bottom end of the post at the factory to increase the footing area. Crushed or dimpled bottom post ends are not acceptable.
8. Arch posts shall be of one continuous piece construction. Arch posts shall be 4.5”-5” O.D. aluminum or steel with a powdercoated finish. There shall be no welds or additional pieces mechanically fastened to manufacture the arch.

4.2 FASTENERS:
1. Primary fasteners shall be tamperproof in design, and stainless steel per ASTM F-879.
2. Manufacturer to provide special tools for pinned hex fasteners.
3. Fasteners shall be corrosion resistant, theft resistant and shall meet or exceed ASTM Standards.

4.3 POWDERCOATING:
1. All metal components to be powdercoated shall be free of excess weld and spatter.
2. Powdercoating shall be electrostatically applied and oven cured. Average thickness shall be 3-5 mils. and shall be Super Durable TGIC or Standard TGIC polyester powdercoat. (Any other finish is not acceptable).
   A. Super Durable TGIC polyester powder shall be specially formulated for optimum U.V. stability and glossiness and shall meet or exceed ASTM Standards for: Adhesion (D-3359B), Hardness (D-3363), and Impact (D-2794), and Salt Spray Resistance (B-117).

4.4 PVC COATING
1. All metal components to be PVC-coated shall be thoroughly cleaned in a hot phosphatizing pressure washer, then primed with a clear acrylic thermosetting solution.
2. Primed parts shall be preheated prior to dipping in U.V. stabilized, liquid poly vinyl chloride, then salt cured.
3. The finished coating shall be between 80-100 mils. thick and have a textured or matte finish.

4.5 DECKS:
1. Decks shall be manufactured from a single piece of low carbon minimum 11 GA hot rolled sheet steel conforming to ASTM specification A-569. The sheet shall be perforated and reinforced as necessary to ensure structural integrity.
2. The unit shall be PVC-coated.

4.6 ROTATIONALLY MOLDED POLY PARTS:
1. These parts shall be molded using low-density polyethylene (high density polyethylene is not acceptable) with a tensile strength that meets or exceeds ASTM D-638 and with color and UV-stabilizing additives.
2. Wall thickness may vary by product from .187" (3/16") to .312" (5/16").
3. At least 4 standard colors must be available from which to choose.

4.7 POLYETHYLENE PARTS:
1. These parts shall be manufactured from polyethylene that has been specially formulated for optimum U.V. stability and color retention.

2. Products shall meet or exceed: Density, ASTM D1505, and Tensile strength, ASTM D638.
3. Various solid colors shall be available as well as various two-color options.

4.8 CLAMPS:

1. All clamps, unless otherwise noted, shall be aluminum alloy.
2. Clamps must attach securely "around the post", not bolt directly through the post. **The clamp design must be shown as part of the playground submittal for approval.**
3. Each functional clamp assembly shall have an appropriate number of half clamps and shall be fastened to mating parts with fasteners and hardware that meets or exceeds requirements of ASTM F-879 and IFI-125. A drive rivet w/stainless steel pin is used to insure a secure fit to the post. A drive rivet is required on every clamp that secures a deck or overhead event to the post, and it is recommended but not mandatory on all other clamps.
4. The following clamp types are not acceptable:

    A) Hinged clamps that do not seat completely around the post leaving gaps between the post and the clamp.
    B) Any mounting system utilizing only a bolt through system into the post.
    C) Steel clamps are not acceptable due to the high likelihood of rust forming on these parts.

5. **Clamps must have a Powdercoat finish.**

4.9 SLIDES:

1. All slides will be one piece roto-molded from LDPE as specified and shall have full hoods with integrated handhold and sliding footers, slide entry barrier or other device that will cause the user to sit down before sliding. No sectional slides
2. Wall thickness of polyethylene may vary from .187" (3/16") to .312" (5/16") depending on the product.
3. Slides must not be allowed to pull away from the deck due to seasonal expansion and contraction. This event would be cause for removal and replacement by the manufacturer during the first 15 years of the slide's use.

4.10 ACTIVITY PANELS:

1. All activity panels shall be rotationally molded or ¾" thick laminated high- density polyethylene with color throughout the thickness of the product.
2. All graphics on activity panels shall be routed in to expose the middle color of the sandwiched two-color polyethylene.
3. Decals are not acceptable for graphics on activity panels.

5.0 <u>WARRANTY:</u>

1. All play structures and/or equipment shall conform in kind and quality to the qualifications set forth in the specifications and will be free of defects in manufacturing and material.
2. All warranties shall be for an established term of years. Vague warranties that are open to interpretation such as "Lifetime Warranty" will not be accepted. The "Lifetime Warranty" must be stated in writing by the manufacturer as to

exactly how many years the item is under warranty. As a further indication of quality the following minimum warranties shall be standard:

A. 100-Year Limited Warranty for all posts, clamps, fasteners, beams, hardware, and caps, against structural failure due to corrosion/natural deterioration or manufacturing defects. This warranty does not include any cosmetic issues or wear and tear from normal use.
B. 15 -Year Limited Warranty for all decks, non-moving aluminum, and steel components against structural failure due to corrosion/natural deterioration or manufacturing defects. This warranty does not include any cosmetic issues or wear and tear from normal use.
C. 10-Year Limited Warranty for all polyethylene, roto-molded slides, PVC Coating, and any other plastic components. This warranty does not include any cosmetic issues or wear and tear from normal use.
D. 3-Year Limited Warranty for all other parts, i.e.: Moving parts, Track ride trolleys and bumpers, etc. against failure due to corrosion/natural deterioration or manufacturing defects. This warranty does not include any cosmetic issues or wear and tear from normal use.

3. A full text of the warranty with any exclusions will accompany the submittal.

6.0 MANUFACTURER REQUIREMENTS

1. Must supply a maintenance kit with each order. The entire kit is to be sent to the WCPSS. The Kit must include:
    A. Wrenches for tamperproof hardware.
    B. One (1) container of Graffiti remover (8oz minimum)
    C. Primer and touch-up paint to match each color on the structure.
    D. Sandpaper
    E. Comprehensive maintenance manual to include:
        1. Complete plan drawing of the structure.
        2. Inspection report forms.
        3. Installation instructions and parts list for the structure ordered.

Any variation to these specifications must be approved by the owner.

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