MAXWELL CONSTRUCTION

Sunman-Dearborn Community Schools
BP#1 - Early Mechanical

ADDENDUM 1
Added Specs

Date: 8/5/24

440 Nowlin Avenue, Greendale, IN 47025 (812) 537-2200 www.maxwellbuilds.com

SECTION 01 9100 – GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.

B. Section Includes:
   1. General requirements that apply to implementation of the commissioning process.
   2. The Contractor's requirements that apply to the implementation of the commissioning process.

C. Related Specification Sections:
   1. 230800 – Commissioning of HVAC

D. Commissioning Provider:
   1. Zerhusen Holten Commissioning (ZHCx) 267 Main Street, Florence, KY 859-282-6467

E. Commissioning Provider Project Manager:
   1. Chris Zerhusen, CxA, 513-295-0904, chris@zhcommissioning.com

1.2 GENERAL REQUIREMENTS

A. Contractors shall include all labor, materials and equipment cost within their scope to complete their responsibilities within the commissioning process.

1.3 DEFINITIONS (ADAPTED FROM ASHRAE GUIDELINE 0-2019, SECTION 4)

A. Commissioning Process (Cx) – A quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the OPR.

B. Owner's Project Requirements (OPR) – A document that details the requirements of a project and the expectations of how it will be used and operated, including project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, training requirements, documentation requirements, and supporting information. The owner's project requirements, for this project, will start with the bidding documents.

C. Commissioning Plan – A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Cx. This is produced by ZHCx and administered at the commissioning kick off meeting.

D. Commissioning Provider (CxP) – An entity, identified by the Owner, who leads, plans, schedules, and coordinates the CxP Team to implement the Cx.

E. Cx Provider Team (CxP Team) – The team of specialists and related support staff who are responsible for the management of actions and the generation of deliverables by the CxP as outlined in the contract between the Owner and the CxP and in the Cx Plan. The CxP Team may consist of several companies, including subcontractors to the CxP who acts as the contact to the Owner.

F. Progress Report - a written document detailing activities completed as part of the Cx, and significant findings from those activities, that is continuously updated during a project.

G. Cx Testing – The evaluation and documentation of the equipment and assemblies, delivery and condition, installation, proper function according to the manufacturer specifications, and project documentation to meet the criteria in the OPR.

H. Prefunctional Performance Checklists – A form used to document equipment design, submittal data and installation.

I. Functional Performance Testing (FPT) – A set of tests that define the functionality and verify the behavior of a system. These tests are defined by the commissioning authority to verify that building systems are completed to satisfy the owner's project requirements and demonstrate functional performance.

J. Issues and Resolution Log – A formal and ongoing record of problems or concerns—and their resolution—that have been compiled by members of the CxP Team during the Cx.

K. Systems Manual – A system-focused composite document that includes the design and construction documentation, Facility Guide and operation manual, maintenance information, training information, Cx records, and additional information of use to the Owner during occupancy and operations.

L. Training Plan: a written document that details the expectations, schedule, duration, and deliverables for Cx Activities related to training of project O&M personnel, users, and occupants.

1.4 REFERENCES

A. General:
1. ASHRAE Guideline 0-2019 (The Commissioning Process)
2. ANSI/ASHRAE/IES Standard 202-2013 (Commissioning Process for Buildings and Systems)

1.5 COMMISSIONING TEAM

A. The commissioning team is composed of the following:
1. Owner
2. Architect
3. Mechanical Engineer
4. Electrical Engineer
5. Commissioning Provider
6. Construction Manager
7. Mechanical Contractor
8. Direct Digital Controls Contractor
9. Testing, Adjusting and Balance Contractor

1.6 SYSTEMS TO BE COMMISSIONED

A. Commissioning will be performed on the following systems:
1. Heating, Cooling, Refrigeration, Ventilation Systems and Controls
2. Domestic Water Heating Systems

1.7 SUBMITTALS

A. The Construction Manager shall submit a copy of the initial construction schedule and subsequent construction schedule updates to ZHCx.

B. The Construction Manager shall submit copies of all Division 230000 submittals to ZHCx at the same time these are distributed to the owner and design team. If construction software is used ZHCx requires access. ZHCx is required to review submittals at the same time the review is being conducted by the design team.

C. The Construction Manager shall submit copies of the Construction Meeting Minutes, Answered Request for Information (RFIs), Owner Approved Supplemental Instructions and Change Orders to ZHCx.

1.8 COMMISSIONING PROCESS ACTIVITIES

A. The CxP for this project is ZHCx, who is responsible for administering the commissioning process and coordinating commissioning activities. Chris Zerhusen is the project manager for ZHCx and will be leading the process for this project.

B. The commissioning plan is created by ZHCx. The commissioning plan defines the roles of the team members during the commissioning process, entwines the commissioning activities into the project schedule and provides guidance to the team in respect to commissioning throughout the project.

C. ZHCx will submit commissioning related activities to the Construction Manager for inclusion into the overall construction schedule.

1.9 COMMISSIONING MEETINGS

A. ZHCx organizes commissioning meetings time and date with the Construction Manager. At a minimum all contractors and subcontractors associated with the commissioning process are required to attend. This includes the Construction Manager, mechanical contractor, direct digital controls contractor and testing, adjusting and balancing contractor.

B. Subcontractors are required to have their on-site foreman attend the commissioning kick-off meeting.

1.10 DIRECT DIGITAL CONTROLS KICKOFF MEETING

A. Prior to DDC controls system submittals being submitted to the engineer a controls meeting will be scheduled. In this meeting we shall review the intended points list and sequence of operations.

1.11 REPORTING

A. Following a site visit a commissioning progress report will be issued to the owner. Copies of the progress report are sent to all commissioning team members. The Construction Manager is responsible for distribution of these reports to the subcontractors.

B. Progress reports will recap the general work occurring by ZHCx while on site.

1.12 RESOLUTION TRACKING

A. ZHCx uses an online reporting system to document findings and resolutions. This is identified as a Resolution Tracking Form. All reporting is centralized in one location and spans all visits. This allows you to see all open and resolved items in one location and on one page.

B. Findings are specific items that differ from the Construction Documents. In addition, a finding may be the expressed opinion of the CxP that requires discussion and resolution.

C. Each finding will be designated with a responsible party. ZHCx is not always privy to the contractual arrangements, it is still the responsibility of the Construction Manager to address these findings.

D. Our resolution tracking form is NOT a final punch list, but a living document. No matter the stage of the project a finding can be documented. It is the intent that these findings are presented in real time or as close to real time as possible.

E. The resolution tracking form is available at any time during the project. ZHCx will share a link to our database that allows instant up to date access of all findings and their status. The Construction Manager, along with the sub-contractors associated with the commissioning process will have access to respond to their items via the internet. ZHCx will provide specific instructions on how to access and maneuver through the electronic database during the commissioning kick off meeting.

F. ZHCx will backcheck findings recorded on the resolution tracking form to verify that every item has been resolved.
   1. The responsible party must respond to each finding on the list in writing, with reference to the finding number in the report. Backcheck will occur once ZHCx has received this information from the responsible party. ZHCx will backcheck each finding one time and may be during different visits.
   2. If findings require more than one backcheck due to contractor negligence, ZHCx reserves the right to additional compensation. Cost will be submitted to the Construction Manager for payment at one of the following rate schedules.
      a. ZH Commissioning Partner: $185
      b. CxP (Commissioning Provider): $165
      c. CxT (Commissioning Technician): $125
   3. If responses have not been received or items have not been resolved within 3 weeks of the original report date, a meeting between responsible parties will be required to resolve the issue. The Construction Manager and all sub-contractors associated with the unresolved finding are required to attend this meeting.

1.13 PRE-FUNCTIONAL CHECKLIST AND TESTING

A. ZHCx utilizes project specific pre-functional checklists to document the designed and approved equipment is installed. These checklists are created by ZHCx and filled out by ZHCx.

B. Contractors and subcontractors are not required to fill out these checklists. No sampling techniques are used for pre-functional testing.

1.14 FUNCTIONAL PERFORMANCE TESTING

A. Point-to-Point Verification: After pre-functional checklists are completed and prior to functional performance testing, ZHCx completes a point-to-point check of the automatic control system. The intent of this test is to document control points exist and are adequately operating, sensing, and communicating correctly. Upon completion of the point-to-point verification the functional performance testing can occur. Sampling techniques are not used for point-to-point verification.

B. Functional Performance Testing: The ZHCx authority will lead and document functional performance testing. Functional performance testing will not begin until the system testing, and balancing is completed. Utilizing checklists developed by ZHCx the sequence of operation and performance of the installed equipment and systems is documented. Trending data is collected and analyzed as a supplement to the functional performance testing. Opposite season functional performance testing will occur as soon as weather permits. Monitoring the building throughout the entire year will enhance the functional performance testing process. Sampling techniques are not used for functional performance testing.

1.15 SEASONAL TESTING

A. Seasonal Functional Performance Testing: The ZHCx authority will lead and document seasonal functional performance testing. Utilizing the checklists developed by ZHCx the sequence of operation and performance of the installed equipment and systems is reviewed for appropriate modes of operation.

1.16 TERMS AND CONDITIONS

A. If, due to contractor negligence, poor communication, or any other scenario that causes ZH Commissioning additional visits outside of the baseline scope of work, ZH Commissioning reserves the right to invoice the client for the additional efforts required to complete the commissioning process. This includes inaccurate, incomplete, or mis-stated contractor responses to the issues resolution tracking form that cause ZH Commissioning multiple attempts to back check commissioning issues. ZH Commissioning will quantify the additional efforts caused by the contractor and submit that information to the Client so they may back charge the responsible contractor. Prior approval for additional compensation is required from the Client.

END OF SECTION

SECTION 23 0800 – COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents

1. Drawings, specifications, and general provisions of the Subcontract apply to this Section.

B. Section Includes

1. Construction Manager and Subcontractors requirements for the successful implementation of commissioning the heating, ventilating and air conditioning (HVAC) systems, assemblies, and components.

C. Related Requirements:

1. 019100 General Commissioning Requirements

2. Division 230000 HVAC Sections

1.2 REFERENCES

A. Not used

1.3 DESCRIPTION

A. ZH Commissioning (ZHCx) will be the commissioning provider for this project.

B. The purpose of commissioning is to ensure that work meets the owner's project requirements, satisfies the basis of design, is functioning in the manner as described in Division 23 HVAC Sections and the systems can be operated and maintained by a well-trained staff.

1.4 SYSTEMS TO BE COMMISSIONED

A. Commissioning will be performed on the following systems.

1. Bright Elementary School
   a. Air Handling Unit 1 – Prefunctional and Functional Performance Testing
   b. Air Handling Unit 2 – Prefunctional and Functional Performance Testing
   c. Air Handling Unit 3 – Prefunctional and Functional Performance Testing
   d. Air Handling Unit 4 – Prefunctional and Functional Performance Testing
   e. Unit Heaters – Prefunctional and Functional Performance Testing
   f. Domestic Hot Water Heaters - Prefunctional and Functional Performance Testing

2. North Dearborn Elementary School
   a. Kitchen Makeup Air Unit - Prefunctional and Functional Performance Testing
   b. Hot Water Boilers - Prefunctional and Functional Performance Testing
   c. Hot Water Pumps - Prefunctional and Functional Performance Testing
   d. Exhaust Fans - Prefunctional and Functional Performance Testing
   e. Existing Chilled Water Plant – Functional Performance Testing
   f. Existing Air Handling Unit CSAC-A1 - Functional Performance Testing
   g. Existing Air Handling Unit CSAC-B1 - Functional Performance Testing
   h. Existing Air Handling Unit CSAC-C1 - Functional Performance Testing
   i. Existing Air Handling Unit CSAC-D1 - Functional Performance Testing
   j. Existing Air Handling Unit CSAC-E1 - Functional Performance Testing
   k. Existing Air Handling Unit CSAC-F1 - Functional Performance Testing

l. Existing Air Handling Unit CSAC-F2 - Functional Performance Testing
m. Existing Air Handling Unit CSAC-G1 - Functional Performance Testing
n. Existing Air Handling Unit CSAC-H1 - Functional Performance Testing
o. Existing Air Handling Unit CSAC-H2 - Functional Performance Testing
p. Existing Air Handling Unit CSAC-J1 - Functional Performance Testing
q. Air Cooled Condensing Unit ACCU-A1 - Prefunctional and Functional Performance Testing
r. Air Cooled Condensing Unit ACCU-B1 - Prefunctional and Functional Performance Testing
s. Existing ERW-A1 - Functional Performance Testing
t. Variable Air Volume Boxes - Functional Performance Testing on 20% of Total Boxes.
u. Radiant Ceiling Panels - Functional Performance Testing
v. Convectors, Fin Tube and Unit Heaters – Functional Performance Testing
w. Refrigerant Leak Detection System – Functional Performance Testing

3. Sunman Elementary School
a. Hot Water Boilers – Prefunctional and Functional Performance Testing
b. Hot Water Pumps – Prefunctional and Functional Performance Testing
c. Existing Chilled Water Plant – Functional Performance Testing
d. Rooftop Units – Prefunctional and Functional Performance Testing
e. Existing Air Handling Unit 1 - Functional Performance Testing
f. Existing Air Handling Unit 2 - Functional Performance Testing
g. Existing Air Handling Unit 3 - Functional Performance Testing
h. Existing Air Handling Units E1-E4 - Functional Performance Testing
i. Unit Ventilators – Prefunctional and Functional Performance Testing on 20% of all UVs.
j. Variable Air Volume Boxes - Functional Performance Testing on 20% of Total Boxes.
k. Mini Split System – Prefunctional and Functional Performance Testing
l. Make Up Air Unit – Prefunctional and Functional Performance Testing
m. Exhaust Fans - Functional Performance Testing
n. Fan Coil Units - Functional Performance Testing
o. Cabinet Unit Heaters - Functional Performance Testing
p. Radiant Ceiling Panels - Functional Performance Testing
q. Duct Heating Coils - Functional Performance Testing
r. Domestic Water Heating System – Prefunctional and Functional Performance Testing
s. Domestic Water Booster Pumping – Prefunctional and Functional Performance Testing

1.5 COMMISSIONING KICK OFF MEETING

A. Within two weeks following the pre-construction meeting or as coordinated with the construction manager, ZHCx will conduct a commissioning kick off meeting. The purpose of the meeting is defined as follows.

1. Introduce team members and identify roles and responsibilities.

2. Explain the process to be used on the project that will also be described in the commissioning plan.

3. Describe reporting and the purpose of the resolution tracking form.

4. Describe prefunctional observations.

5. Describe functional performance testing.

B. The following participants are required to attend the commissioning kick off meeting.

1. Construction Manager Site Superintendent.

2. Mechanical Contractor Job Site Foreman. If there is more than one foreman due to the work occurring at the three schools, then the foreman for each school is required to attend.

3. Automatic Temperature Controls Contractor.

4. Testing, Adjusting and Balancing Contractor.

1.6 COMMISSIONING SCHEDULING

A. ZHCx will develop commissioning activities to be included in the overall construction schedule. This contractor and subcontractors shall be prepared to assist in development of the schedule. Assistance is defined as follows.

1. Participate in one scheduling meeting.

2. Provide milestone activities.

3. Provide start up dates.

1.7 COMMISSIONING PROGRESS MEETINGS

A. This contractor shall attend commissioning progress meetings as required by the commissioning agent. Commissioning meetings, when scheduled, will occur after regularly scheduled construction project meetings.

1.8 CONTROLS KICKOFF COORDINATION MEETING

A. Prior to DDC controls system submittals being sent to the engineer for review a controls meeting will be scheduled.

1.9 PREFUNCTIONAL PERFORMANCE TESTING CHECKLIST

A. The commissioning agent, ZHCx, will write project specific pre functional performance testing checklists for their use during site observations.

B. ZHCx will document the installation of the HVAC equipment during typical site visits utilizing pre functional performance testing checklists.

C. Deficiencies identified during the site observations will be identified in writing on the resolution tracking form and distributed to the contractor. This contractor shall respond to these items in writing back to the commissioning provider. The response shall state the item is complete or rebut the finding from the commissioning agent. The contractor is not required to state the item is ongoing.

1.10 TESTING, ADJUSTING AND BALANCING

A. ZHCx will witness balancing activities as is appropriate to develop a final functioning system. This contractor and subcontractor shall assist in balancing activities.

1.11 FUNCTIONAL PERFORMANCE TESTING

A. ZHCx will work directly with the contractor to schedule functional performance testing of the system.

B. Direct digital controls contractor shall provide ZHCx all log in credentials including a username and password specific to ZHCx.

C. The commissioning agent, ZHCx, will create project specific functional performance testing checklists to document testing.

D. Functional performance testing will be completed in three parts, point to point testing, sequence of operation review and final functional performance testing.

1. Point to Point Testing: Conducted once all control and monitoring points, specific to the equipment being tested, are installed and visible via the final graphical user interface.

2. Sequence of Operation Review: Following point to point review with no deficiencies. Every aspect of the sequence is tested to verify the system is operating according to the intended sequence of operation.

3. Final Functional Performance Testing: Completed after point to point and sequence of operation review with no deficiencies.

E. ZHCx will direct and document the functional performance testing using their checklists. The temperature control contractor shall be available to operate the system as instructed by ZHCx.

F. Deficiencies identified during the testing can be corrected during testing. If the correction takes more than 30 minutes to resolve ZHCx has the right to abort the test. A new date and time will be scheduled after the deficiency is corrected. The deficiency will be documented in the resolution tracking form. This contractor shall respond to these items in writing, stating that the item is no longer deficient or rebutting the finding from the commissioning agent.

1.12 DEFERRED OR SEASONAL TESTING

A. ZHCx will complete functional performance testing at (2) 3-month intervals. Depending on the season in which functional performance testing is initially done. Temperature control contractor shall be prepared to spend a total of (1) 8-hour day during this testing, for a total of 16 hours.

END OF SECTION 230800

MAXWELL CONSTRUCTION

Sunman-Dearborn Community Schools
BP#1 - Early Mechanical

ADDENDUM 1
Updated Specs

Date: 8/5/24

440 Nowlin Avenue, Greendale, IN 47025 (812) 537-2200 www.maxwellbuilds.com

SECTION 23 0993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:
1. Division 23 Section "Instrumentation and Control for HVAC" for control equipment and devices and for submittal requirements.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. VAV: Variable air volume.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

BRIGHT ELEMENTARY

3.1 ALARMS

A. Generate an alarm at the PC workstation when any space temperature is <50 def F for 15 minutes (adjustable) and an immediate alarm when any space temperature is <40 deg F (adjustable).

B. Coordinate with the owner to identify alarms as "general" or " critical". General alarms will only be displayed at the PC workstation. Critical alarms will be displayed at the PC workstation and dialed-out to pre-programmed telephone numbers through the internal PC modem.

3.2 HVAC ZONE CONTROL SEQUENCES

A. Provide software time clock and set-up schedule to place each HVAC system into occupied or unoccupied mode. Provide an override push button on each space temperature sensor to place the respective zone air handler into the occupied mode for a two-hour period (adjustable) when button is pushed. When the button is pushed again prior to the override time expiring, the zone air handler will revert to the scheduled operating mode.

B. Where carbon dioxide (CO2) sensors are present, the BMS shall monitor the space or return duct CO2 concentration and reset the outside air damper to increase ventilation rates to prevent high levels of CO2 in a space.
1. If CO2 is above 900 ppm for a period of at least 5 minutes and the space in an occupied mode, increase OA damper position 5% every 5 minutes until the space CO2 decreases below 700 ppm, the resume normal OA setpoint.

2. Maximum outside air damper position shall be determined if supply air temperature setpoint can not be maintained with 100% heating or cooling, depending on mode. Do not sacrifice supply air temperature upper and lower limits during CO2 reset mode.

C. All systems and spaces shall be linked to a global room temperature setpoint value that the Owner can change a single value that effectively creates a single temperature setpoint with specified adjustment (+2 deg/-2 deg) that all systems and all spaces use for master control of the facility/campus temperature and energy control.

D. Equipment rotation shall be configured on all systems where more than one equipment item is used to function as a team, such as pumps, chillers, boilers, relief fans, etc. The controls shall be configured to equalize run time on all items. Utilize a “first-on, first-off” approach unless noted otherwise or if Owner’s campus standards stipulate specific rotation schedules.

E. All heating hot water coils shall utilize the following for coil freeze protection if they are the primary heating coil for air handlers, unit ventilators, single zone duct coil, that has outside air to the equipment.
1. If outside air temperature is less than 35 deg F (global adj.) the hot water coil shall never close 100%. Maintain coil a minimum of 10% open at all times, even with equipment fans turned off.
2. If unit is shut off and outside air temperature is less than 35 deg (global adj.), mixed air temperature sensor and freezestat shall monitor temperature inside of air handler equipment such that if duct temperature less than 40 deg F is detected, BMS shall activate fan to circulate air through the unit at minimum speed until mixed air temperature is above 50 deg F and a minimum run time of 15 minutes (global adj).
3. If mixed air temperature drops to below 30 deg F while the unit is off, BMS shall generate critical alarm and open hot water coil 100%.

3.3 TERMINAL UNIT CONTROL SEQUENCES

A. Unit Heater Control: A 24-volt wall mounted thermostat shall cycle fan motor to maintain space temperature between set point and 2 deg F (adjustable) below set point.

3.4 AIR HANDLING UNITS CONTROL SEQUENCES

A. Safety Controls:
1. Provide an electric low limit thermostat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow.
2. Low limit control shall be wired as a software point only and not hardwired to fan circuit. If low limit is detected, the BMS shall close the outside air damper, maintain supply fan on, display a low limit notification on the graphics, and wait 15 minutes. Reset to normal mode and open outside air damper.
3. If low limit sensor trips 3 times within a 1 hour time frame, generate a critical low limit alarm and lock out the unit requiring a software reset before running. Close outside air damper to 0%, open return damper to 100%, stop all supply, return, and relief fans.

4. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.
5. Provide strap-on aquastat on the leaving water side of the hot water coil to stop the supply fan (return fan to operate if applicable), close the outside air damper (and relief dampers if applicable) and position control valve for full coil water flow (operate coil circulating pump if applicable) if leaving water temperature drops below 40 deg F (adjustable).
6. Provide a high-limit controller to prevent unit discharge air from rising above 125 deg F (adjustable). Sensor shall be located at the discharge of the unit.

B. AHU-1, AHU-3, AHU-4
1. Occupied Mode:
   a. Supply fan shall operate continuously. BMS shall modulate ECM supply fan to maintain duct static pressure setpoint. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).
   b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain return air CO2 level at 800 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
   c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and chilled water coil control valve as required to maintain DAT set point.

2. Unoccupied Mode:
   a. Close outside air dampers, unit supply fan to remain off. Cycle fan hot water coil control valve, and chilled water coil control valve to maintain unoccupied DAT set point.
   b. If outside air temperature is above 55 deg F (adjustable) and there is a call for cooling, enable supply fan and modulate chilled water coil control valve to maintain unoccupied DAT set point.

C. AHU-2
1. Occupied Mode:
   a. Supply fan shall operate continuously. BMS shall modulate ECM supply fan to maintain duct static pressure setpoint. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).
   b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain return air CO2 level at 800 ppm (adj). If outside air temperature is less than space and cooling

is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and stages of DX cooling as required to maintain DAT set point.

2. Unoccupied Mode:
   a. Close outside air dampers, unit supply fan to remain off. Cycle fan hot water coil control valve, and stages of DX cooling to maintain unoccupied DAT set point.
   b. If outside air temperature is above 55 degrees F (adj) and there is a call for cooling, enable supply fan and modulate stages of DX cooling as required to maintain unoccupied DAT set point.

NORTH DEARBORN ELEMENTARY

3.5 ALARMS

A. Generate an alarm at the PC workstation when any space temperature is <50 def F for 15 minutes (adjustable) and an immediate alarm when any space temperature is <40 deg F (adjustable).

B. Coordinate with the owner to identify alarms as "general" or " critical". General alarms will only be displayed at the PC workstation. Critical alarms will be displayed at the PC workstation and dialed-out to pre-programmed telephone numbers through the internal PC modem.

3.6 MONITORING SEQUENCES

A. Monitor temperature(s) of walk in food freezer(s) and cooler(s) and trend this data for a period of two weeks (adjustable) and a sample rate of one reading every 5 minutes (adjustable). Generate an alarm at the PC workstation if the temperature rises above user defined set point.

B. Monitor each boiler room containing gas fired boilers or water heaters with a carbon monoxide sensor and trend for a minimum of 48 hours. Provide an audio/visual alarm with a minimum of 85 dB sound level. Provide signage near the alarm reading “Carbon Monoxide Alarm”.
   1. On alarm exceeding 200 ppm, all gas fired equipment shall be shut down.
   2. A local alarm inside the room shall activate with the following levels:
      a. 9 ppm or greater for a duration of 8 hours.
      b. 40 ppm or greater for a duration of 5 hours.
      c. 70 ppm or greater for a duration of 1 hour.
      d. 200 ppm or greater for a duration of 15 minutes.

C. Monitor status of refrigerant monitoring system. On a local alarm by the refrigerant monitoring system, generate an alarm at the PC workstation stating, “REFRIGERANT SYSTEM ALARM”.
   1. Provide with manual HOA over-ride button outside of chiller equipment room for BMS to disable chiller plant by shutting down all chillers in the room. Button shall be secured with beak-glass box.
   2. Provide with manual HOA over-ride button outside of chiller equipment room to over-ride purge fan and associated intake/exhaust control dampers. Button shall be secured with break-glass box.

D. Monitor temperature of domestic hot water downstream of thermostatic mixing valve and generate an alarm if the temperature rises 5 degrees (adjustable) above specified set point.

E. Monitor pressure of domestic water main entrance (downstream of booster pump) and generate an alarm if the system pressure drops below 35 psi (adjustable).

F. Monitor status of kitchen exhaust hood fan.

3.7 HVAC ZONE CONTROL SEQUENCES

A. Provide software time clock and set-up schedule to place each HVAC system into occupied or unoccupied mode. Provide an override push button on each space temperature sensor to place the respective zone air handler into the occupied mode for a two-hour period (adjustable) when button is pushed. When the button is pushed again prior to the override time expiring, the zone air handler will revert to the scheduled operating mode.

B. Where carbon dioxide (CO2) sensors are present, the BMS shall monitor the space or return duct CO2 concentration and reset the outside air damper to increase ventilation rates to prevent high levels of CO2 in a space.
   1. If CO2 is above 900 ppm for a period of at least 5 minutes and the space in an occupied mode, increase OA damper position 5% every 5 minutes until the space CO2 decreases below 700 ppm, the resume normal OA setpoint.
   2. Maximum outside air damper position shall be determined if supply air temperature setpoint can not be maintained with 100% heating or cooling, depending on mode. Do not sacrifice supply air temperature upper and lower limits during CO2 reset mode.

C. All systems and spaces shall be linked to a global room temperature setpoint value that the Owner can change a single value that effectively creates a single temperature setpoint with specified adjustment (+2 deg/-2 deg) that all systems and all spaces use for master control of the facility/campus temperature and energy control.

D. Equipment rotation shall be configured on all systems where more than one equipment item is used to function as a team, such as pumps, chillers, boilers, relief fans, etc. The controls shall be configured to equalize run time on all items. Utilize a “first-on, first-off” approach unless noted otherwise or if Owner’s campus standards stipulate specific rotation schedules.

E. All heating hot water coils shall utilize the following for coil freeze protection if they are the primary heating coil for air handlers, unit ventilators, single zone duct coil, that has outside air to the equipment.
   1. If outside air temperature is less than 35 deg F (global adj.) the hot water coil shall never close 100%. Maintain coil a minimum of 10% open at all times, even with equipment fans turned off.
   2. If unit is shut off and outside air temperature is less than 35 deg (global adj.), mixed air temperature sensor and freezestat shall monitor temperature inside of air handler equipment such that if duct temperature less than 40 deg F is detected, BMS shall activate fan to circulate air through the unit at minimum speed until mixed air temperature is above 50 deg F and a minimum run time of 15 minutes (global adj).

F. If mixed air temperature drops to below 30 deg F while the unit is off, BMS shall generate critical alarm and open hot water coil 100%.

3.8 TERMINAL UNIT CONTROL SEQUENCES

A. Unit Heater Control: A 24-volt wall mounted thermostat shall cycle fan motor to maintain space temperature between set point and 2 deg F (adjustable) below set point.

B. Cabinet Unit Heater Control:
   1. BMS shall cycle supply fan motor and hot water control valve to maintain space temperature setpoint of 70 deg F (adj).

C. Duct heating coil (DC) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

D. Radiant ceiling panel (RCP) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

E. Finned tube radiation (FTR) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

F. Hot water convector (CONV) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

3.9 SINGLE DUCT SHUT-OFF VAV TERMINAL WITH HOT WATER REHEAT SEQUENCE

A. Occupied Mode: Modulate open primary air valve with a rise in space temperature. With a fall in space temperature, modulate primary air valve towards the minimum setting. With a continued fall in space temperature below the heating set point, modulate open the hot water coil control valve (unit mounted coils and duct mounted booster coils), when valve is 100% open, modulate air valve increasing air flow to maintain space heating set point. In areas with wall radiation, modulate radiation control valve as first stage of heat, modulate reheat coil valve after radiation valve is 100% open. If hot water is not available, close primary air valve 100% with a fall in space temperature below heating set point.

1. The supply air temperature shall be limited to a maximum of 100 deg (adj) to prevent stratification of the space. If the space is not satisfied, modulate the supply air valve open and maintain fixed supply air temperature to satisfy the space.

B. Unoccupied Mode: Open primary air valve, close hot water coil control valve. In areas with wall radiation, modulate radiation control valve as source of heat to maintain reduced heating set point.

3.10 SERIES FAN POWERED VAV TERMINAL UNIT WITH REHEAT SEQUENCE

A. Occupied Mode: Continuous unit fan operation. Modulate open primary air valve with a rise in space temperature. With a fall in temperature, modulate primary air valve towards the minimum setting. With a continued fall in space temperature below the heating set point, modulate open the hot water coil control valve. In areas with wall radiation, modulate radiation control valve as first stage of heat, modulate reheat coil valve after radiation valve is 100% open.

B. Unoccupied Mode: Cycle unit fan and hot water coil valve for full flow to maintain reduced space set point temperature. Close primary air valve. In areas with wall radiation, modulate radiation control valve as first stage of heat to maintain reduced heating set point.

3.11 AIR HANDLING UNITS CONTROL SEQUENCES

A. Safety Controls:
1. Provide an electric low limit thermostat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow.
2. Low limit control shall be wired as a software point only and not hardwired to fan circuit. If low limit is detected, the BMS shall close the outside air damper, maintain supply fan on, display a low limit notification on the graphics, and wait 15 minutes. Reset to normal mode and open outside air damper.
3. If low limit sensor trips 3 times within a 1 hour time frame, generate a critical low limit alarm and lock out the unit requiring a software reset before running. Close outside air damper to 0%, open return damper to 100%, stop all supply, return, and relief fans.
4. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.
5. Provide strap-on aquastat on the leaving water side of the hot water coil to stop the supply fan (return fan to operate if applicable), close the outside air damper (and relief dampers if applicable) and position control valve for full coil water flow (operate coil circulating pump if applicable) if leaving water temperature drops below 40 deg F (adjustable).
6. Provide a high-limit controller to prevent unit discharge air from rising above 125 deg F (adjustable). Sensor shall be located at the discharge of the unit.

B. CSAC-A1
1. Occupied Mode:
a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static

pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).

b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. Modulate the hot water coil control valve and stages of DX cooling as required to maintain DAT set point.

2. Unoccupied Mode:

a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and stages of DX cooling as required to maintain unoccupied space set point.

C. CSAC-B1, C1

1. Occupied Mode:

a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).

b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.

c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and chilled water coil control valve as required to maintain DAT set point.

2. Unoccupied Mode:

a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and chilled water coil control valve to maintain unoccupied DAT setpoint.

D. CSAC-E1, F1, F2
   1. Occupied Mode:
      a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).
      b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
      c. Modulate the hot water coil control valve and chilled water coil control valve as required to maintain DAT set point.

   2. Unoccupied Mode:
      a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and chilled water coil control valve as required to maintain unoccupied space set point.

E. CSAC-D1
   1. Occupied Mode:
      a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25" every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0" w.c. (adjustable).
      b. The outside air damper shall be opened to provide minimum outside air from ERV. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate economizer outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
      c. Modulate the hot water coil control valve and stages of DX cooling as required to maintain DAT set point.

   2. Unoccupied Mode:
      a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve,

and stages of DX cooling as required to maintain unoccupied space set point.

F. CSAC-G1
1. Occupied Mode:
a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain constant supply air CFM as determined by TAB.
b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
c. Modulate the hot water coil control valve and chilled water coil control valve as required to maintain space temperature setpoint.
d. If outside air temperature is greater than 35 degrees F (adj) and the zone relative humidity rises above 55% (adj) BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate chilled water coil control valve as required to maintain space temperature setpoint.

2. Unoccupied Mode:
a. Close outside air dampers, unit supply fan to remain off. On call for heating or cooling from any zone, cycle fan, hot water coil control valve, and chilled water coil control valve as required to maintain unoccupied space set point.
b. If outside air temperature is greater than 35 degrees F (adj) and the zone relative humidity rises above 55% (adj) BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate chilled water coil control valve as required to maintain space temperature setpoint.

G. ERW-A
1. Occupied Mode:
a. Open outside air and relief air dampers.
b. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain constant supply air CFM as determined by TAB.
c. Relief fan shall operate continuously. Variable speed drive (VSD) shall modulate relief fan to maintain constant supply air CFM as determined by TAB.
d. BMS shall enable energy recovery wheel VFD to run at constant speed.

2. Unoccupied Mode:
a. Close outside air dampers, unit supply fan and relief fan to remain off. Energy recovery wheel shall remain off.

3.12 SINGLE DUCT SHUT-OFF VAV TERMINAL WITH HOT WATER REHEAT SEQUENCE

A. Occupied Mode: Modulate open primary air valve with a rise in space temperature. With a fall in space temperature, modulate primary air valve towards the minimum setting. With a continued fall in space temperature below the heating set point, modulate open the hot water coil control valve (unit mounted coils and duct mounted booster coils), when valve is 100% open, modulate air valve increasing air flow to maintain space heating set point. In areas with wall radiation, modulate radiation control valve as first stage of heat, modulate reheat coil valve after radiation valve is 100% open. If hot water is not available, close primary air valve 100% with a fall in space temperature below heating set point.
   1. The supply air temperature shall be limited to a maximum of 100 deg (adj) to prevent stratification of the space. If the space is not satisfied, modulate the supply air valve open and maintain fixed supply air temperature to satisfy the space.

B. Unoccupied Mode: Open primary air valve, close hot water coil control valve. In areas with wall radiation, modulate radiation control valve as source of heat to maintain reduced heating set point.

3.13 EXHAUST FAN CONTROL SEQUENCES

A. General: Motorized dampers associated with exhaust fans shall be interlocked to open 100% and prove open prior to fan activation.

B. General exhaust fans (EF): Scheduled operation. During occupied mode, BMS shall open exhaust air damper. On contact closure from exhaust air damper end switch, BMS shall enable exhaust fan. During unoccupied mode, BMS shall disable fan and close exhaust air damper.

C. Refrigerant exhaust fan EF-1: BMS shall open dampers and energize fan from the refrigerant monitoring system to purge room of refrigerant. Interlock with motorized damper located in intake opening to open 100%.

D. Relief fans (RF): Scheduled operation. During occupied cycle of associated air handling equipment, BMS shall open relief air damper. If space static pressure rises to above 0.05” WC (adj), BMS shall enable and modulate relief fans to maintain space static pressure at 0.05” WC (adj). For air handling systems with multiple relief fans, BMS shall stage relief fans lead-lag. BMS shall enable lead fan and modulate from 30% (adj) to 50% (adj) speed. When lead fan is at 50% speed, if space static is above setpoint, BMS shall enable lag fan and modulate at 50% speed. Additional lag fans shall be enabled and modulated individually and consecutively from 30% (adj) to 50% (adj) as required to maintain space static setpoint. If all fans have been enabled and space static pressure if above setpoint, BMS shall modulate all fans simultaneously from 50% (adj) to 100% (adj) as required to maintain space pressure setpoint. Fans shall be disabled in the same sequence they are enabled. BMS shall alternate lead fan daily.

3.14 PUMP CONTROL SEQUENCES

A. P-1, P-2 (Variable Flow Primary Hot Water Loop): Variable volume, lead/lag parallel pumping. Energize lead variable volume pump on a call for hot water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains as locations shown on plans or approximately 2/3 down the longest run. Energize the variable speed lag pump (second stage) and match speed of pumps to maintain minimum differential pressure across supply and return main sensor(s). De-energize the lag pump with pump speed falls 10% (adjustable) below the speed established immediately after starting the lag pump. The BMS shall monitor each differential pressure sensor across the supply and return mains at least once every two (2) seconds. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading “PUMP FAILURE” to be automatically displayed on the workstation PC monitor.

B. P-X (Chiller Primary Chilled Water Loop): BMS is to cycle pumps with their respective chillers when BMS has chiller enabled. Pump shall continue to operate for a period of 30 seconds (adjustable) following the shutdown of the chiller.

C. P-X (Secondary Building Chilled Water Distribution Loop): Variable volume pumping. Energize lead variable volume pump on a call for chilled water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains at locations shown. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading "SECONDARY BUILDING CHILLED WATER DISTRIBUTION LOOP LEAD PUMP FAILURE" to be automatically displayed on the work station PC monitor.

3.15 BOILER AND HEATING WATER CONTROL SEQUENCES

A. The BMS shall enable the boiler plant and provide 4-20 mA or 0-10 Volt setpoint to packaged boiler controller. Reset maximum HW Setpoint based on outside air reset schedule (editable via graphics).
   1. When outside air is 0 deg F, HW Supply shall be 180 deg F.
   2. When outside air is 60 deg F, HW Supply shall be 140 deg F.

B. On a call for hot water the BMS shall energize the hot water distribution pump(s), and packaged controls shall be enabled to maintain the hot water loop temperature. The packaged controls shall activate and stage boilers and their associated control valves as required to maintain the loop supply and return water temperatures. The boiler controller shall sequence the boilers and modulate output such that total system efficiency is maximized by using multiple boilers on low fire. The BMS shall monitor all spaces and set the heating water temperature as low as possible to heat all spaces in the building and send a signal to the packaged controller to reset the supply water temperature. If any space is unable to maintain space temperature, reset the supply water temperature up by 5 deg F and when this space is at setpoint, return to previous value. The packaged controller shall have a set of dry contacts to notify the BMS of any alarm state within the boiler plant or controller.

3.16 CHILLER AND CHILLED WATER CONTROL SEQUENCE

A. During "Occupied Mode", the BMS shall enable the lead chiller when economizer cooling is not sufficient to satisfy space cooling needs, the ambient temperature is above 50 deg F, and there is a call for chilled water. The supply water temperature will be reset by a 4-20 mA or 0-10 VDC output signal from the BMS to the chiller microprocessor to satisfy zone with greatest cooling demand or dehumidification demand. If any zone humidistat exceeds set point, the BMS will reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. Contractor shall provide interlock wiring between flow switches and discharge controller sensors at chiller evaporator and condenser water barrels and chiller control panel.

B. During "Unoccupied Mode", when any zone humidistat exceeds set point and outdoor air enthalpy is not adequate for dehumidification, the BMS shall enable the lead chiller and reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. All chillers are to remain off otherwise.

C. Monitor and trend chiller electrical load (kW) on a daily basis and maintain the maximum electrical load for each chiller on each day for a period of one year in a trend log.

D.

SUNMAN ELEMENTARY

3.17 ALARMS

A. Generate an alarm at the PC workstation when any space temperature is <50 def F for 15 minutes (adjustable) and an immediate alarm when any space temperature is <40 deg F (adjustable).

B. Coordinate with the owner to identify alarms as "general" or " critical". General alarms will only be displayed at the PC workstation. Critical alarms will be displayed at the PC workstation and dialed-out to pre-programmed telephone numbers through the internal PC modem.

3.18 MONITORING SEQUENCES

A. Monitor temperature(s) of walk in food freezer(s) and cooler(s) and trend this data for a period of two weeks (adjustable) and a sample rate of one reading every 5 minutes (adjustable). Generate an alarm at the PC workstation if the temperature rises above user defined set point.

B. Monitor each boiler room containing gas fired boilers or water heaters with a carbon monoxide sensor and trend for a minimum of 48 hours. Provide an audio/visual alarm with a minimum of 85 dB sound level. Provide signage near the alarm reading “Carbon Monoxide Alarm”.
   1. On alarm exceeding 200 ppm, all gas fired equipment shall be shut down.
   2. A local alarm inside the room shall activate with the following levels:
      a. 9 ppm or greater for a duration of 8 hours.

b. 40 ppm or greater for a duration of 5 hours.
c. 70 ppm or greater for a duration of 1 hour.
d. 200 ppm or greater for a duration of 15 minutes.

C. Monitor status of refrigerant monitoring system. On a local alarm by the refrigerant monitoring system, generate an alarm at the PC workstation stating, “REFRIGERANT SYSTEM ALARM”.
1. Provide with manual HOA over-ride button outside of chiller equipment room for BMS to disable chiller plant by shutting down all chillers in the room. Button shall be secured with beak-glass box.
2. Provide with manual HOA over-ride button outside of chiller equipment room to over-ride purge fan and associated intake/exhaust control dampers. Button shall be secured with break-glass box.

D. Monitor temperature of domestic hot water downstream of thermostatic mixing valve and generate an alarm if the temperature rises 5 degrees (adjustable) above specified set point.

E. Monitor pressure of domestic water main entrance (downstream of booster pump) and generate an alarm if the system pressure drops below 35 psi (adjustable).

F. Monitor status of kitchen exhaust hood fan.

3.19 HVAC ZONE CONTROL SEQUENCES

A. Provide software time clock and set-up schedule to place each HVAC system into occupied or unoccupied mode. Provide an override push button on each space temperature sensor to place the respective zone air handler into the occupied mode for a two-hour period (adjustable) when button is pushed. When the button is pushed again prior to the override time expiring, the zone air handler will revert to the scheduled operating mode.

B. Where carbon dioxide (CO2) sensors are present, the BMS shall monitor the space or return duct CO2 concentration and reset the outside air damper to increase ventilation rates to prevent high levels of CO2 in a space.
1. If CO2 is above 900 ppm for a period of at least 5 minutes and the space in an occupied mode, increase OA damper position 5% every 5 minutes until the space CO2 decreases below 700 ppm, the resume normal OA setpoint.
2. Maximum outside air damper position shall be determined if supply air temperature setpoint can not be maintained with 100% heating or cooling, depending on mode. Do not sacrifice supply air temperature upper and lower limits during CO2 reset mode.

C. If space has occupancy sensors present, BMS shall integrate them into controls for stand-by mode. TCC shall connect to auxiliary contacts on the sensor where possible, or provide a relay powered by the lighting circuit downstream of the occupancy sensor to indicate occupancy.
1. If space is in occupied mode, but occupancy is not detected for more than 20 minutes (adj), the BMS shall place the space into standby mode. When occupancy is detected, the BMS shall immediately revert back to normal occupied mode.

2. If a space is in standby mode and schedule changes to unoccupied mode, the system shall revert to unoccupied mode and discontinue the standby mode.
3. If a space is placed into standby mode
   a. The outside air damper(s) shall close 100% for unit ventilators, fan coils, and single zone air handlers.
   b. VAV box zones shall set the box to minimum airflow setting.
   c. Maintain space temperature at an offset of 2 deg F (adj) below the current effective space setpoint in heating mode, and 2 deg F (adj) above the current effective space setpoint in cooling mode.

D. All systems and spaces shall be linked to a global room temperature setpoint value that the Owner can change a single value that effectively creates a single temperature setpoint with specified adjustment (+2 deg/-2 deg) that all systems and all spaces use for master control of the facility/campus temperature and energy control.

E. Equipment rotation shall be configured on all systems where more than one equipment item is used to function as a team, such as pumps, chillers, boilers, relief fans, etc. The controls shall be configured to equalize run time on all items. Utilize a “first-on, first-off” approach unless noted otherwise or if Owner’s campus standards stipulate specific rotation schedules.

F. All heating hot water coils shall utilize the following for coil freeze protection if they are the primary heating coil for air handlers, unit ventilators, single zone duct coil, that has outside air to the equipment.
1. If outside air temperature is less than 35 deg F (global adj.) the hot water coil shall never close 100%. Maintain coil a minimum of 10% open at all times, even with equipment fans turned off.
2. If unit is shut off and outside air temperature is less than 35 deg (global adj.), mixed air temperature sensor and freezestat shall monitor temperature inside of air handler equipment such that if duct temperature less than 40 deg F is detected, BMS shall activate fan to circulate air through the unit at minimum speed until mixed air temperature is above 50 deg F and a minimum run time of 15 minutes (global adj).
3. If mixed air temperature drops to below 30 deg F while the unit is off, BMS shall generate critical alarm and open hot water coil 100%.

3.20 FAN COIL UNIT CONTROL SEQUENCES

A. Fan Coil Unit (FCU):
1. Occupied Mode: Continuous fan operation, modulate stages of DX cooling as required to maintain cooling set point.
2. Unoccupied Mode: Cycle fan and stages of DX cooling to maintain reduced unoccupied space set point.

3.21 TERMINAL UNIT CONTROL SEQUENCES

A. Unit Heater Control: A 24-volt wall mounted thermostat shall cycle fan motor to maintain space temperature between set point and 2 deg F (adjustable) below set point.

B. Cabinet Unit Heater Control:
   1. BMS shall cycle supply fan motor and hot water control valve to maintain space temperature setpoint of 70 deg F (adj).

C. Duct heating coil (DC) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

D. Radiant ceiling panel (RCP) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

E. Wall mounted radiant panel (RAD) control: BMS shall modulate the hot water control valve to maintain space temperature set point.

3.22 UNIT VENTILATOR CONTROL SEQUENCE

A. Safety Controls:
   1. Provide an electric low limit thermostat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow. Controls shall be wired as a software point only and not hardwired to fan circuit.
   2. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.

B. UV (Heating, Cooling, & Ventilating)
   1. Occupied Mode:
      a. Supply fan shall operate continuously. Open outside air damper to provide minimum ventilation. Modulate outside air damper position to maintain space CO2 at 1000 ppm (adj).
      b. Modulate the hot water coil control valve and chilled water coil control valve to maintain space temperature set point.
      c. If outside air dry bulb temperature is less than space and cooling is required, modulate outside and return air dampers for economizer cooling while maintaining a minimum discharge temperature based on the following reset schedule:

SPACE TEMPERATURE	DISCHARGE AIR TEMPERATURE
Set point + 4 deg F	55 deg F (adjustable)
Set point	65 deg F (adjustable)

      d. If outside air temperature drops below 35 deg F (adj) modulate hot water coil control valve 100% open and modulate face and bypass dampers to maintain space temperature setpoint.
      e. Base Bid: Dehumidification Sequence
         a) If zone humidity rises above set point (55% RH, adjustable) at the zone humidistat and outside air temperature is above 60 degrees F (adj), enable dehumidification sequence as follows:
         b) When space temperature is below setpoint, close outside air damper, modulate fan speed to 50% (adj), modulate face and bypass damper to 100% bypass, and close chilled water valve
         c) When space temperature is above setpoint, open chilled water valve 100%.
         d) After 60 second time delay (adj), modulate face and bypass damper to 50% open (adj), modulate supply fan speed to 50%

(adj), and modulate outside air damper to maintain space CO2 at 800 ppm (adj).

e) When space temperature is below setpoint, close outside air damper, modulate fan speed to 50% (adj), modulate face and bypass damper to 100% bypass, and close chilled water valve. Repeat 1-4 until zone humidity is below 50% RH (adj) when zone temperature is at space cooling temperature setpoint.

2) Alternate Bid: Dehumidification Sequence

a) When outside air temperature is above 50 degrees F (adj), enable hot water reheat coil control valve to modulate as required to maintain zone relative humidity at 50 % RH (adj).

2. Unoccupied Mode:

a. Cycle fan, hot water coil control valve, and chilled water coil control valve to full open to maintain reduced unoccupied space temperature set point. Limit discharge air temperature to 30 degrees above space temperature. Close outside air damper.

b. Base Bid: Dehumidification Sequence

1) If zone humidity rises above unoccupied set point (60% RH, adjustable) at the zone humidistat and outside air temperature is above 60 degrees F (adj), enable unoccupied dehumidification sequence as follows:

a) Modulate fan speed to 100% (adj) and modulate hot water control valve to maintain space temperature at 78 degrees F (adj) for 30 minutes (adj).

b) Modulate fan speed to 30% (adj), modulate hot water control valve to 0%, modulate face and bypass damper to 50% (adj), and modulate chilled water control valve to 100% until space temperature is at 68 degrees F (adj).

c) Modulate fan speed to 0% (adj), modulate chilled water control valve to 0 %, and modulate face and bypass damper to 100% open through bypass.

d) After time delay of 30 minutes (adj) modulate fan speed to 100% (adj), modulate chilled water control valve to 0 %, and modulate face and bypass damper to 100% open through bypass.

e) After time delay of 30 minutes (adj) modulate hot water control valve to 50% open (adj).

f) After time delay of 10 minutes (adj) end unoccupied dehumidification sequence and return to unoccupied space temperature setpoint control.

g) If zone humidity rises above unoccupied set point (60% RH, adjustable) at the zone humidistat and outside air temperature is above 60 degrees F (adj) and time is before 3:00 AM, repeat 1-6.

c. Alternate Bid: Dehumidification Sequence

a) When outside air temperature is above 50 degrees F (adj), enable hot water reheat coil control valve to modulate as required to maintain zone relative humidity at 50 % RH (adj).

3.23 AIR HANDLING UNITS CONTROL SEQUENCES

A. Safety Controls:
1. Provide an electric low limit thermostat element serpentined across the face of the leaving air side of the heating coil which will stop the supply fan, close the outside air damper and position heating control valve for full coil water flow.
2. Low limit control shall be wired as a software point only and not hardwired to fan circuit. If low limit is detected, the BMS shall close the outside air damper, maintain supply fan on, display a low limit notification on the graphics, and wait 15 minutes. Reset to normal mode and open outside air damper.
3. If low limit sensor trips 3 times within a 1 hour time frame, generate a critical low limit alarm and lock out the unit requiring a software reset before running. Close outside air damper to 0%, open return damper to 100%, stop all supply, return, and relief fans.
4. Low limit capillary shall have 1 ft of tube for every 1 sq ft of coil surface.
5. Provide strap-on aquastat on the leaving water side of the hot water coil to stop the supply fan (return fan to operate if applicable), close the outside air damper (and relief dampers if applicable) and position control valve for full coil water flow (operate coil circulating pump if applicable) if leaving water temperature drops below 40 deg F (adjustable).
6. Provide a high-limit controller to prevent unit discharge air from rising above 125 deg F (adjustable). Sensor shall be located at the discharge of the unit.

B. AHU-1, AHU-3
1. Occupied Mode:
a. Supply fan shall operate continuously. Variable speed drive (VSD) shall modulate supply fan to maintain the variable air volume (VAV) terminal unit with the greatest call for cooling at least 85% open. Increase duct static pressure at a rate of 0.25” every 10 minutes (adjustable) until any VAV terminal unit exceeding 95% open, closes down to 85% open. Duct static pressure shall be determined by pressure sensors located 2/3 down the longest duct run. A high limit discharge pressure sensor, located at the fan discharge, shall prevent the supply fan from generating a discharge pressure greater than 4.0” w.c. (adjustable).
b. The outside air damper shall be opened to provide minimum outside air. Minimum outside air volume shall be maintained by modulating outside air damper and return air damper as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
c. If the outside air temperature is below 35 deg F (adjustable), provide full heating coil flow and modulate face and bypass dampers as required to maintain discharge air temperature (DAT) set point. If outside air temperature is 35 deg F or higher (adjustable), provide full airflow to the face of the coil and modulate the hot water coil control valve and stages of outside air module DX cooling as required to maintain outside air module DAT set point and stages of return air module DX cooling as required to maintain return air module DAT setpoint.

2. Unoccupied Mode:

a. Close outside air dampers, unit supply fan to remain off. Cycle fan and hot water coil control valve to maintain reduced unoccupied space heating set point. If outside air temperature is below 35 degrees F (adj), close heating coil face and bypass dampers and open heating coil control valve 10% (adj).
b. If outside air temperature is above 55 deg F (adjustable) and there is a call for cooling, enable supply fan and modulate stages of return air module DX cooling to maintain return air module DAT setpoint.

C. AHU-2
1. Occupied Mode:
a. Supply fan shall operate continuously. BMS shall supply signal to variable speed drive (VSD) to maintain design supply air CFM as determined by Test and Balance (TAB).
b. BMS shall modulate outside air dampers to maintain minimum outside air intake airflow. BMS shall modulate outside air damper and return air damper position as required to maintain maximum zone CO2 level at 1000 ppm (adj). If outside air temperature is less than space and cooling is required, modulate outside air damper open to provide outside air economizer cooling. A mixed air temperature controller shall maintain a minimum DAT of 55 deg F.
c. Modulate stages of DX cooling and hot water coil control valve as required to maintain space temperature setpoints.
d. If outside air temperature is greater than 35 degrees F (adj) and the zone relative humidity rises above 55% (adj) BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate stages of DX cooling as required to maintain space temperature setpoint.
2. Unoccupied Mode:
a. BMS shall close outside air dampers. Cycle fan, hot water coil control valve, and stages of DX cooling as required to maintain unoccupied space heating and cooling setpoint. If zone relative humidity rises above 60% RH (adj), BMS shall modulate supply fan speed to 50%, modulate hot water reheat coil control valve as required to maintain zone relative humidity below 50% RH (adj). Modulate stages of DX cooling as required to maintain space temperature setpoint.

3.24 ROOFTOP UNIT SEQUENCES

A. RTU-1, 2, 3
1. Occupied Mode:
a. Supply fan shall operate continuously. Activate stages of DX cooling as required to maintain space temperature.
2. Unoccupied Mode:
a. Cycle supply fan and stages cooling as required to maintain set back temperature.

3.25 EXHAUST FAN CONTROL SEQUENCES

A. General: Motorized dampers associated with exhaust fans shall be interlocked to open 100% and prove open prior to fan activation.

B. General exhaust fans (EF): Scheduled operation. During occupied mode, BMS shall open exhaust air damper. On contact closure from exhaust air damper end switch, BMS shall enable exhaust fan. During unoccupied mode, BMS shall disable fan and close exhaust air damper.

C. Refrigerant exhaust fan EF-1: BMS shall open dampers and energize fan from the refrigerant monitoring system to purge room of refrigerant. Interlock with motorized damper located in intake opening to open 100%.

D. Relief fans (RF): Scheduled operation. During occupied cycle of associated air handling equipment, BMS shall open relief air damper. If space static pressure rises to above 0.05" WC (adj), BMS shall enable and modulate relief fans to maintain space static pressure at 0.05" WC (adj). For air handling systems with multiple relief fans, BMS shall stage relief fans lead-lag. BMS shall enable lead fan and modulate from 30% (adj) to 50% (adj) speed. When lead fan is at 50% speed, if space static is above setpoint, BMS shall enable lag fan and modulate at 50% speed. Additional lag fans shall be enabled and modulated individually and consecutively from 30% (adj) to 50% (adj) as required to maintain space static setpoint. If all fans have been enabled and space static pressure if above setpoint, BMS shall modulate all fans simultaneously from 50% (adj) to 100% (adj) as required to maintain space pressure setpoint. Fans shall be disabled in the same sequence they are enabled. BMS shall alternate lead fan daily.

3.26 SINGLE DUCT SHUT-OFF VAV TERMINAL WITH HOT WATER REHEAT SEQUENCE

A. General:
1. This sequence applies to VAVs with re-heat where the associated AHU is scheduled either ON or OFF.
2. Rooms that have occupancy sensors associated with their VAV terminals will have the following modes:
   a. Occupied Mode - AHU scheduled ON - Occupancy sensor Occupied
   b. Standby Mode - AHU scheduled ON - Occupancy sensor Unoccupied
   c. Unoccupied Mode - AHU scheduled OFF (Occupancy sensor is not considered)
3. Rooms that do not have occupancy sensors associated with their VAV terminals will have only Occupied Mode and Unoccupied Mode (matching the AHU Schedule - ON and OFF consecutively)
4. Normally Occupied spaces include all spaces except the following: Hallways, mechanical and electrical rooms, and IT closets.

B. Occupied Mode (AHU scheduled ON; Occupancy sensor is "Occupied"):
1. Cooling: When space temperature is above the Occupied cooling setpoint, the VAV damper will modulate from minimum CFM up to maximum CFM. On a fall in space temperature, the VAV damper will modulate back to minimum CFM. The reheat valve will remain closed.
2. Heating: When space temperature falls below the Occupied heating setpoint, the following will occur:
   a. With the primary VAV damper open to minimum airflow, the reheat valve will modulate open up to the point that the discharge temperature reaches 90°F.

b. If the heating setpoint is still not satisfied, the VAV primary air damper will slowly modulate open up to the scheduled maximum cfm while maintaining a 90°F discharge temperature. The increase in airflow shall stop if the 90°F discharge temperature cannot be maintained.
c. On an increase in space temperature above the heating setpoint, the VAV damper will modulate back to minimum CFM while the reheat valve simultaneously modulates to maintain the 90F discharge temperature.
d. When the VAV is at minimum flow and the space is still above the Occupied setpoint, the reheat valve will modulate closed.

C. Standby Mode (AHU scheduled ON; Occupancy sensor is "Unoccupied"):
1. The minimum flow setpoint will be reset to minimum airflow.
2. Cooling: When space temperature is above the Standby cooling setpoint, the VAV damper will modulate from minimum airflow up to maximum CFM to maintain the standby cooling setpoint. On a fall in space temperature, the VAV damper will modulate back to minimum airflow. The reheat valve will remain closed.
3. Heating: When space temperature falls below the Standby heating setpoint, the following will occur:
a. With the primary VAV damper open to minimum occupied airflow, the reheat valve will modulate open up to the point that the discharge temperature reaches 90°F.
b. If the standby heating setpoint is still not satisfied, the VAV primary air damper will slowly modulate open up to the scheduled maximum cfm while maintaining a 90°F discharge temperature. The increase in airflow shall stop if the 90°F discharge temperature cannot be maintained.
c. When the space temperature warms to the standby heating setpoint, the VAV damper will modulate back to minimum occupied airflow.
4. If the space temperature is still above standby heating setpoint the reheat valve will close and the VAV damper will close.

D. Unscheduled Mode (AHU scheduled OFF, Occupancy sensor not considered):
1. The VAV damper will go to minimum airflow.
2. Cooling: When space temperature rises above the Unscheduled cooling setpoint for any normally occupied space, the following will occur:
3. The associated air handling unit will start. (see AHU sequence)
4. Open the VAV damper fully for any normally occupied space that is less than 5 degrees below the Unscheduled cooling setpoint. (any space above 80)
5. When the space temperature cools to 5°F below the Unscheduled setpoint, the VAV damper will go to minimum airflow.
6. Once all the normally occupied spaces are 5°F below the Unscheduled cooling setpoint, the air handling unit will shut off. (see AHU sequence)
7. Heating: When the space temperature falls below the Unscheduled heating setpoint, the following will occur:
a. Open the VAV damper fully and start the associated AHU.
b. With the VAV damper open, the reheat valve will modulate open until the discharge temperature reaches 90°F.
c. When the space temperature warms to 5°F above the unscheduled setpoint the associated AHU will stop, the reheat valve will close, and after 5 minutes (adj.) the VAV damper will close.

E. CO2 Mode (For Spaces with CO2 sensors in the Occupied Mode)
   1. Maintaining carbon dioxide concentrations below the maximum setpoint will be accomplished with a supervisory control loop running in parallel with the temperature control described in the Occupied Mode. This loop shall compare the measured room CO2 concentration with the setpoint and output a flow demand for the VAV.
   2. As CO2 concentration increases from 500 ppm to 900 ppm, the control loop will increase its output from minimum airflow to the VAV maximum
   3. The VAV damper shall control to the higher of the CO2 loop flow demand and the temperature control flow demand.
   4. The re-heat valve will modulate as required to maintain room temperature setpoint without increasing the discharge air temperature above 95°F.

3.27 PUMP CONTROL SEQUENCES

A. P-1, P-2 (Variable Flow Primary Hot Water Loop): Variable volume, lead/lag parallel pumping. Energize lead variable volume pump on a call for hot water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains as locations shown on plans or approximately 2/3 down the longest run. Energize the variable speed lag pump (second stage) and match speed of pumps to maintain minimum differential pressure across supply and return main sensor(s). De-energize the lag pump with pump speed falls 10% (adjustable) below the speed established immediately after starting the lag pump. The BMS shall monitor each differential pressure sensor across the supply and return mains at least once every two (2) seconds. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading “PUMP FAILURE” to be automatically displayed on the workstation PC monitor.

B. P-X (Chiller Primary Chilled Water Loop): BMS is to cycle pumps with their respective chillers when BMS has chiller enabled. Pump shall continue to operate for a period of 30 seconds (adjustable) following the shutdown of the chiller.

C. P-X (Secondary Building Chilled Water Distribution Loop): Variable volume pumping. Energize lead variable volume pump on a call for chilled water. Modulate lead pump with a 4-20 mA output to the variable speed drive (VSD) to maintain a 10 PSIG (adjustable) differential pressure across the supply and return mains at locations shown. With a failure of the lead pump to establish flow within 15 seconds after a call to operate, start the lag pump and generate an alarm message reading "SECONDARY BUILDING CHILLED WATER DISTRIBUTION LOOP LEAD PUMP FAILURE" to be automatically displayed on the work station PC monitor.

3.28 BOILER AND HEATING WATER CONTROL SEQUENCES

A. The BMS shall enable the boiler plant and provide 4-20 mA or 0-10 Volt setpoint to packaged boiler controller. Reset maximum HW Setpoint based on outside air reset schedule (editable via graphics).
   1. When outside air is 0 deg F, HW Supply shall be 180 deg F.
   2. When outside air is 60 deg F, HW Supply shall be 140 deg F.

B. On a call for hot water the BMS shall energize the hot water distribution pump(s), and packaged controls shall be enabled to maintain the hot water loop temperature. The packaged controls shall activate and stage boilers and their associated control valves as required to maintain the loop supply and return water temperatures. The boiler controller shall sequence the boilers and modulate output such that total system efficiency is maximized by using multiple boilers on low fire. The BMS shall monitor all spaces and set the heating water temperature as low as possible to heat all spaces in the building and send a signal to the packaged controller to reset the supply water temperature. If any space is unable to maintain space temperature, reset the supply water temperature up by 5 deg F and when this space is at setpoint, return to previous value. The packaged controller shall have a set of dry contacts to notify the BMS of any alarm state within the boiler plant or controller.

3.29 CHILLER AND CHILLED WATER CONTROL SEQUENCE

A. During "Occupied Mode", the BMS shall enable the lead chiller when economizer cooling is not sufficient to satisfy space cooling needs, the ambient temperature is above 50 deg F, and there is a call for chilled water. The supply water temperature will be reset by a 4-20 mA or 0-10 VDC output signal from the BMS to the chiller microprocessor to satisfy zone with greatest cooling demand or dehumidification demand. If any zone humidistat exceeds set point, the BMS will reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. Contractor shall provide interlock wiring between flow switches and discharge controller sensors at chiller evaporator and condenser water barrels and chiller control panel.

B. During "Unoccupied Mode", when any zone humidistat exceeds set point and outdoor air enthalpy is not adequate for dehumidification, the BMS shall enable the lead chiller and reset the chiller leaving water temperature to the 42 deg F (adjustable) minimum leaving water temperature. All chillers are to remain off otherwise.

C. Monitor and trend chiller electrical load (kW) on a daily basis and maintain the maximum electrical load for each chiller on each day for a period of one year in a trend log.

END OF SECTION 23 0993

SECTION 23 0923 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:
1. Division 23 Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 DEFINITIONS

A. AHU: Air handling unit.

B. DDC: Direct digital control.

C. I/O: Input/output.

D. LAN: Local area network for data and communications systems.

E. MS/TP: Master slave/token passing.

F. PC: Personal computer.

G. PID: Proportional plus integral plus derivative.

H. RTD: Resistance temperature detector.

I. VAV: Variable air volume (terminal).

1.3 SYSTEM PERFORMANCE AND DESCRIPTION OF WORK

A. Work Included: It is the intent of this specification such that the building automation system be a complete Direct Digital Control (DDC) system installed as a complete package by a single contractor. This system shall include all computer software and hardware, controllers, sensors, actuators, transmission equipment, wire and cables, workstations, installation, engineering, supervision, commissions, acceptance testing, training, and warranty service.

B. Retrofit of controls shall include complete removal of all pneumatic systems and prior control systems such that no devices are reused unless specifically noted. All controls shall be new including, but not limited to, temperature control boards, JACE's, sensors, thermostats, relays, control panels, control units, unitary controllers, power supplies, actuators, low-voltage control cables and wires, conduit, surface raceway, pneumatic tubing, and wire mold. Disconnect all existing control devices and replace with new equipment in every respect. Existing control panel cabinets may be reused, however must be completely re-wired to comply with specifications and cable management

systems. Retrofit of controls at Sunman Elementary and North Dearborn Elementary shall include all equipment within the entire buildings. Retrofit of controls at Bright Elementary shall be limited to the equipment being replaced only, and all other existing equipment and controls shall remain with no integration or migration of existing systems.

C. The control contractor shall extend the Owner's existing Niagara version 4 platform to work at Sunman Elementary, North Dearborn Elementary, and Bright Elementary and shall comply with all campus standards for wiring, graphics, point naming, etc. The control contractor shall utilize the Owner's existing Niagara version 4 server located at East Central High School. All work on existing server shall utilize a unique vendor identification number. All work on existing server shall utilize existing graphics libraries and comply with Owner's standards for graphics and control point identification. Control Contractor shall be responsible to conduct a meeting with Owner and Engineer to verify standards prior to submittal of product data and shop drawings.

D. All low voltage wiring and conduit is the responsibility of this section. All 120 volt and higher power wiring by others.

E. Rough-in of wall boxes for thermostats shall be the responsibility of control contractor.

F. The building automation system shall use an 'open protocol' that is non-proprietary for all levels of communication. Acceptable protocols are BACNET and shall be implemented in a manner that allows other system devices from other vendors to communicate with all other devices without limitation and without the use of proprietary gateways. This system shall communicate to third party systems for chillers, boilers, air handlers, fire alarm systems, and access control systems with open and interoperable communications.

G. The building automation system shall utilize its own CAT6 Ethernet control network that is separate from the Owner's network for communication between network controllers (if required). The Owner's LAN shall be connected via a single point by means of a router provided by this contractor. All network switches, routers, and Ethernet cabling required for the control system shall be included in this scope of work for a fully functional control system in every respect. All Ethernet cable used in this network shall be color coded for identification as prescribed in following sections. Note that all ethernet cabling shall comply with SDCS campus standards and be independently tested with test report submitted for review.

H. The mechanical contractor shall be responsible for all interlock wiring between mechanical equipment and chiller controllers, boiler sequencers, water heaters, and other third-party control devices. TCC shall assist with the programming and configuration of these controllers to achieve specified control.

1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:
    a. Wiring diagrams for control units with termination numbers.
    b. Schematic diagrams and floor plans for field sensors and control hardware.
    c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:
    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

D. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

E. Qualification Data: For Installer and manufacturer.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

1.5 PROTECTION OF SOFTWARE RIGHTS

A. Owner shall receive licensed software for all system workstations, portable laptop computers, service tools, and web servers installed as part of this project as follows:
1. Workstations: (5) licensed installations on desktop and portable laptop computers that include all programming, graphics creation/editing, and service/diagnostic tools. Desktop and portable laptop computers to be furnished by Owner.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project. Installer organization shall submit a list of recent installations that are of similar scope and size with a listing of contact names and phone numbers at these facilities.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Source limitations: obtain control devices of a single type through one source from a single manufacturer.

D. All components and wire installed in return air plenums shall be listed by a recognized listing agency for compliance with smoke and flame spread ratings.

E. Comply with ASHRAE 135 for DDC system components.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.8 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate equipment with Division 26 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

D. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Wall thermostat sensors: Provide (5) for every type used.
2. VAV box controller: Provide (3) extra controllers with damper actuators.

1.10 WARRANTY

A. All control hardware and wiring shall be provided with a full 1-year warranty from the final date of substantial completion on the project. This shall include failure of any sensor, actuator, wiring, or other hardware device on the system with labor and materials covered.

B. For a period of 1 year from the final data of substantial completion, the control contractor shall be required to provide and install all software, firmware, and product enhancement updates that are available to the Owner at no cost.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

A. Manufacturers:
1. Johnson Controls Facilities Explorer with Niagara 4 front end.
2. Automated Logic Controls with Niagara 4 front end. (WebCtrl is not acceptable).

B. Approved control installation firms must meet the following requirements:
1. Have a main or branch office located within 150 miles of the project location.

2. Must have a full-time control service technician stationed within f a radius of 50 miles from the project location.
3. Employ a full-time project manager that will work on this project with factory certification and training on Niagara version 4 systems.

C. The Niagara version 4 server shall be an open license that allows multiple control vendors to provide hardware and programming without restriction to the Owner on what vendor works on this system. All licenses shall be in the name of the Owner with no master passwords that would prevent them from having full control of the control server licensing. All additional work as part of this project shall comply in every respect to allow for interoperability between different systems.
1. The feature name entries shall read as follows:
   a. Station compatibility In = All (Accept.station.in="*")
   b. Station compatibility Out = All (Accept.station.out="*")
   c. Tool compatibility In = All (Accept.wb.in="*")
   d. Tool compatibility Out = All (Accept.wb.out="*")
2. All server graphics shall be consistent with the Owner's existing standards with layout, colors, labeling, etc.
3. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multi-user, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics. The network shall consist of communication on multiple layers and communication backbones.
4. The top-most communication layer shall consist of an Ethernet network using the TCP/IP BACNET protocol to communicate between workstations, web servers, and building level controllers. Proprietary communications protocols shall not be used at any level and all devices and control point must ultimately be accessible at the top-most level. The building level controllers will then communicate with application specific controllers, sensors, and actuators with either:
   a. A twisted pair network using BACNET MS/TP protocol at a minimum communication speed of 78 Kbps.
   b. An ethernet network using BACNET IP protocol at a minimum communication speed of 10/100 Mbit. Controllers shall utilize dual RJ-45 ports to allow for controllers to daisy chain the communication trunk from one controller to the next. TCC shall be responsible to provide and install all ethernet cabling required for the control network to function.

D. Trend logging abilities shall allow at least 50 different logs to be running simultaneously with a duration of at least 40 hours of data sampled every minute without the need to archive data. Trend logs shall be able to graph/log multiple data points on each trend report with a time and date stamp for each value. At a minimum, the following trends shall be preprogrammed and configured for the system.
1. Alarms shall be configurable such that they may be categorized as "critical", "attention", or "informational". Alarms shall be able to be routed to multiple users by email, onscreen, pager, or alarm printer and shall have 'time of day' triggers to determine what alarms are sent out via email/pager/onscreen. Coordinate with Owner for prioritization of alarms and configuration of recipients. At a minimum,

the following alarm conditions shall be preprogrammed and configured for the system

2. Failure of any system to start or stop as commanded.
   a. Failure of any device to respond to commands by the BMS.
   b. Failure of any sensor to report a value or if reported value is out of range.
   c. If any space temperature falls below 50 deg F (adjustable).
   d. If any coil freeze-stat trips on low temperature.
   e. If any sump pump/sewage ejector is in a high alarm or general alarm condition.
   f. Failure of any boiler or chiller equipment and associated pumps to operate.
   g. Loss of system pressure on heating or cooling water building loop.
   h. Filter pressure drop exceeds dirty level specified (adjustable).
   i. If temperature of any walk-in cooler/freeze exceeds user specified level.
   j. A loss of utility power or phase loss that exceeds 2 seconds and resumption of utility power.
   k. If any heating or cooling loop exceeds high/low temperature setting or pressure setting.
3. Audit logs shall be kept for all user activities that include, user login, logoff, setpoint change, alarm acknowledgement, override, shutdown, startup, and programming change. This log shall be retained indefinitely on the system.
4. Run time reports shall be maintained for every boiler, chiller, supply fan, return fan, relief fan, exhaust fan, pump, etc. Log all run hours into a cumulative counter that the user can view and reset when desired. User shall be able to create maintenance notifications based on run time for each item for maintenance items such as belt changes, bearing lubrication, seal maintenance, filter maintenance, etc.
5. User security shall be implemented such that every user must provide a username and password to gain access to the control interface. Each user shall have assigned rights and privileges that are assigned based on their role. After a period of inactivity the user shall automatically be logged off requiring them to re-authenticate with the system.

E. Internet/Web Interface: It is the intent that this control system will utilize the Owner's existing Niagara v4 server that is connected to the Owner's data/communications network that will allow users the ability to view the control system via any computer workstation without the use of any proprietary software such that the only software required is a standard web browser such as Internet Explorer. Pre-loaded graphics shall not be required to view the system graphics. This web server shall be used to host all buildings under control by this vendor and have the ability to connect all future buildings, as well. This web interface shall provide the following minimum functions.
   1. Login: User shall authenticate with a username and password pair.
   2. Graphics: This web interface shall look and feel like the graphical interface available on the workstation.
   3. Status: Interface shall allow full view of the status of all equipment, sensors, and data points showing setpoint values, current values, etc.
   4. Setpoint override: User shall be able to change setpoint values and start/stop equipment.
   5. Scheduling: User shall be able to view existing schedules, edit existing schedules, and create new schedules.
   6. Alarms: User shall be able to view alarm status and history.
   7. Trends: User shall be able to view existing data trend logs.

8. Trend Archiving: The server shall receive all trend data from the local control panels and archive this data for retrieval via the web interface.
9. Simultaneous Users: The system shall be configured to allow at least (15) simultaneous users.
10. Location of graphics: All graphics for the web interface shall not reside within the operator workstation and shall be accessible if this workstation is offline. Graphics must reside with either a dedicated web-server or within the upper level network controller panels. If a dedicated web server is used, this system must be furnished with a battery back power supply that is capable of providing power for a period of at least 20 minutes on a loss of utility power.

2.3 DDC EQUIPMENT

A. Application Software:
   a. I/O capability from operator station.
   b. System security for each operator via software password and access levels.
   c. Automatic system diagnostics; monitor system and report failures.
   d. Database creation and support.
   e. Automatic and manual database save and restore.
   f. Dynamic color graphic displays.
   g. Custom graphics generation and graphics library of HVAC equipment and symbols.
   h. Alarm processing, messages, and reactions.
   i. Trend logs retrievable in spreadsheets and database programs.
   j. Alarm and event processing.
   k. Object and property status and control.
   l. Automatic restart of field equipment on restoration of power.
   m. Data collection, reports, and logs. Include standard reports for the following:
      1) Current values of all objects.
      2) Current alarm summary.
      3) Disabled objects.
      4) Alarm lockout objects.
      5) Logs.
   n. Custom report development.
   o. Utility and weather reports.
   p. ASHRAE Guideline 3 report.
   q. Workstation application editors for controllers and schedules.
   r. Maintenance management.
2. Custom Application Software:
   a. English language oriented.
   b. Full-screen character editor/programming environment.
   c. Allow development of independently executing program modules with debugging/simulation capability.
   d. Support conditional statements.
   e. Support floating-point arithmetic with mathematic functions.
   f. Contains predefined time variables.

B. Local Control Panels: All control units, I/O boards, relays, contactors, switches, transducers, etc. shall be panel mounted in a key-lockable NEMA enclosure suitable

for the environment. Each panel shall have a 120 volt duplex convenience outlet in the panel. All panels shall have a color coded wiring schematic of the panel on the inner surface of the hinged door that is accurate to the as-built condition with all wired and terminations identified. All wiring shall be routed with wiring trays in a neat and orderly fashion in accordance with NEMA and UL standards, and shall meet all local electrical codes.

C. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
   1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse I/O.
      c. Monitoring, controlling, or addressing data points.
      d. Software applications, scheduling, and alarm processing.
      e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
   3. Standard Application Programs:
      a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
      b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
      c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
      d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
      e. Remote communications.
      f. Maintenance management.
      g. Units of Measure: Inch-pound and SI (metric).
   4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
   5. All controllers that communicate via Ethernet or fiber cables on a TCP/IP network shall support network addressing for both IPv4 and IPv6.

D. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
   1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse I/O.
      c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

E. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights.
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

F. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 WORKSTATION GRAPHIC STANDARDS

A. Navigation:
1. The operator interface shall have “home page” that is displayed automatically when the system is launched. This page shall contain a master navigation pane that is replicated on every subsequent screen. This navigation pane shall allow the user to jump to any building, floor, air handler, heating plant, or chilled water plant with a navigation tree structure. The user shall have a “back” button allowing return to the previous screen and a “home” button allowing return to the “home page”.
2. The “home page” shall contain a full color graphic of the finished facility and shall display the current outside air conditions, a link to an external weather service, such as weather.com shall also be on this page if a constant connection to the “internet” is active, an alarm status window showing all alarms that have not been previously acknowledged, and a list of maintenance notifications.

3. The graphical interface shall be configured with a second user profile that is specific to mobile devices such as smartphones or tablet computers that utilize a touch screen and do not use a mouse. The nature of this interface profile shall allow the user to interact with the graphic interface without the need for Adobe Flash or Java plug-ins. The graphics shall be designed to be navigated with using touch functions with text links/graphic links of appropriate size that is easily selected by a human finger without errors in navigation due to small icon size. Use of "right-click" mouse functions for any part of the navigation shall not be used. TCC shall review Owner's mobile device platform (iOS/Android/Windows) prior to graphic creation and test the graphic navigation using selected mobile platform to verify use and function. The following minimum functions shall be displayed in this mobile user profile;
   a. Status values display of each system listing all sensor values, command values, and setpoints.
   b. Setpoint adjustment via either a scroll wheel icon, up/down icon, or direct text entry.
   c. Alarm console listing all alarms in plain text with the ability to acknowledge alarms.
   d. Scheduling allowing the activation of global schedules such as holidays, snow days, weather delay, night purge enable, etc.

B. Graphics:
1. Graphics shall utilize Owner's existing graphics library and conform to Owner's standards for graphics and naming. The graphics shall accurately represent the configuration of the system being controlled. All data points (inputs, outputs, set points, etc.) associated with the system shall be shown graphically on the system graphics with the correct units of measure, such as "% Open", "CFM", "GPM" and not applied voltages to the actuator. Adjustable set points shall have either a text entry box, scroll bar, or drop-down menu to allow values to be changed.
2. Graphic screen shall be able to display real-time values, animation, color spectrums, logs, graphs, HTML and XML links, schedules, and hyperlinks to other files and locations. It is encouraged to use graphics that are free from use of external browser plug-ins and utilize HTML5 encoding to allow for universal access on platforms that include PC's, Mac, iPad, Android, etc.
3. Floor Plan Temperature Graphic: Each floor of the facility shall have a graphic screen that shows the actual building floor plan with all zone temperatures shown in text and represented with a dynamic color shade relating to the room temperature. Rooms that are within the deadband range shall be shown with a green color. Rooms that are below set point shall have a blue hue of increasing intensity as the room temperature drops farther below set point. Similarly, rooms that are warmer than set point shall be shown with a red hue with increasing intensity. Each zone shall identify the equipment that it is served by. When a user clicks on a specific zone, they shall be directed to a graphic screen showing the specific equipment serving this space (VAV box, unit ventilator, fan coil, finned tube radiation, etc.) At this screen, the user shall have the ability to see the status and values of every data point for that piece of equipment. The floor plan graphics shall show the actual locations of all equipment in the facility that is controlled or monitored by the system. The plan shall also show the physical boundaries of each air handler zone if more than one space is served by it.
4. Boiler plant/chiller plant graphic: A graphic screen shall be created that accurately depicts the piping configuration, location and quantity of all equipment and control

devices associated with each system. This graphic shall display all data points, setpoints, over-rides, enable/disable, alarm resets, and status point contained within the BMS. Verify exact configuration of piping and equipment before generating graphics.

5. Equipment/system graphics: Every air handler, pump, VAV terminal, unit ventilator, fan, etc. shall have a graphics screen that shows every data point contained within the BMS. This graphic shall have links that allow the user to jump to a screen associated with any system that is fed from or feeds this system. (Ex. An air handler graphic shall allow the user to jump directly to any VAV connected to this system, the hot water boiler plant, chilled water plant, or any interlocked fans, etc. Additionally, a VAV terminal graphic shall allow the user to jump to the air handler graphic that serves this device and the boiler plant supplying hot water to the reheat coil.)
6. The graphics screens shall also contain links to all product information sheets of the devices installed such as actuators, valves, sensors, controllers, etc. These documents shall be stored and displayed in a standard form such as Adobe PDF files with appropriate viewer software installed.
7. The user shall be able to jump from a specific system graphic screen to the as-built wiring schematics for that system. These files shall be stored in a standard form such as Adobe PDF files. A text narrative of the sequence of operations shall also be linked to each system that the user shall be able to view on demand.
8. **Prior to creating any graphics, the temperature control contractor shall meet with the Owner to view examples of graphics for other projects and determine any additional graphical requirements of the Owner. Before final acceptance of graphics, TCC shall schedule a meeting with the Project Engineer to review all graphics for completeness.**

C. Control Functions:
1. The Home Page for the campus and each individual building shall contain graphic buttons that enable the user to perform the following actions with a single user operation. Each of these functions shall be available on a campus level and building level.
   a. Outside Air Shutdown - Close all outside air dampers, air inlets, and shut down all exhaust fans. Systems shall revert to 100% return air and continue to operate per sequence.
   b. Mechanical System Shutdown - Shutdown all mechanical air supply and exhaust systems.
   c. Building Purge - Initiate a full building ventilation sequence with all systems running in maximum economizer mode and all exhaust systems on. (Minimum mixed air temperatures shall still be met to protect water coils from freeze.)
   d. Resume Normal operation – Initiates a command to all equipment to return to normal mode with automatic control.
   e. Emergency Power Mode – While under generator power with a loss of utility feed, the BMS shall prioritize control functions and fail safe with sequences to ensure continuity of operations. This mode is explained in the sequence of operations, but shall be able to be enabled/disabled/tested via the graphic interface.

2.5 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
   1. Configuration: Diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72 -hour battery backup.
   2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
   3. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

2.6 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:
   1. Accuracy: Plus or minus 0.5 deg F at calibration point.
   2. Wire: Twisted, shielded-pair cable.
   3. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
   4. Averaging Elements in Ducts: 72 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
   5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
   6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Concealed.
      b. Set-Point Indication and current space temperature: Digital LCD readout with large visibility display.
      c. Input Jack: Provide an exposed port for the insertion of a service tool to connect to the digital control system.
   7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   8. Room Security Sensors: Stainless-steel cover plate with insulated back thermistor attached to the back face. Include a screen-printed label on the cover plate to indicate that the plate is a temperature control device and not an empty j-box. This can include a logo of the controls firm, or similar.

C. Humidity Sensors: Bulk polymer sensor element.
   1. Accuracy: 2 percent full range with linear output.
   2. Room Sensor Range: 20 to 80 percent relative humidity.
   3. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   4. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
   5. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F.
   6. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

D. Pressure Transmitters/Transducers:
   1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
      a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
      b. Output: 4 to 20 mA.
      c. Building Static-Pressure Range: 0- to 0.25-inch wg.
      d. Duct Static-Pressure Range: 0- to 5-inch wg.
   2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.
   3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
   4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
   5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.7 STATUS SENSORS

A. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

B. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

C. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

E. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.8 FLOW MEASURING STATIONS

A. Multi-port airflow measuring system: Combination of multiple sensor probes with transmitter panel.
   1. Manufacturers;
      a. Ebtron; Gold Series Advantage.
      b. Air Monitor Corporation.
   2. Sensor probes: Shall consist of a multi-port tube with thermistors.
   3. Transmitter: Factory supplied controller that all sensor probes are wired to. Each probe shall independently determine air temperature and airflow rate. Transmitter shall have an LCD that is capable of displaying either airflow volume rate, temperature, or airflow velocity. Device shall have (2) analog outputs either 4-20 mA or 0-10 VDC, one consisting of airflow velocity in FPM and the second consisting of airflow temperature in DEG F.

4. Range of operation: 0 to 5000 fpm air velocity, -20 deg F to 160 deg F air temperature, and 0 to 99% RH (non-condensing).
5. System Accuracy: 3% of airflow on ducted applications and 10% of airflow on fan inlet applications.
6. Repeatability: 0.25% of reading.
7. Mounting: Stainless steel mounting brackets.

2.9 THERMOSTATS

A. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.

B. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F set-point range, and 2 deg F maximum differential.
1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

C. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, automatic-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point. Sensor shall not be hardwired to the supply fan. Wire into the control system as a software point.
1. Bulb Length: Minimum 20 feet.
2. Quantity: One thermostat for every 20 sq. ft. of coil surface.

2.10 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc.

b. Johnson Controls, Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque required by damper manufacturer:
   a. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   b. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24 -V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: Minus 22 to plus 122 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.

2.11 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Hydronic system globe valves shall have the following characteristics:
   1. NPS 2 and Smaller: Class 250 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with back-seating capacity re-packable under pressure.
   2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
   3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
      a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
      b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
   4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:
      a. Two Position: Line size.
      b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
      c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
   5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
   6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

C. Butterfly Valves: 200-psig, 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
   1. Body Style: Wafer, Lug, or Grooved.
   2. Disc Type: Elastomer-coated ductile iron or Epoxy-coated ductile iron.
   3. Sizing: 1-psig maximum pressure drop at design flow rate.

D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
   1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
   2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
   3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.12 DAMPERS

A. Manufacturers:
   1. TA Morrison.
   2. Ruskin.

B. Standard Control Dampers: AMCA-rated, parallel and opposed-blade design; 0.080-inch-thick extruded aluminum damper frame and 4 inches deep with extruded aluminum blades and end caps on each blade end.
   1. Secure blades to a heavy-duty zinc-plated steel and aluminum drive linkage within the frame housing, out of the airstream.
   2. Operating Temperature Range: From minus 40 to plus 200 deg F.
   3. Ultra Low Leakage Blade and Edge Seals, Standard Pressure Applications: Extruded silicone secured in an integral slot within the aluminum extrusions.
   4. Leakage Rate: No more than 3 cfm/sq.ft. at 1” w.c for a 48”x48”.
   5. Blade and Jamb Seals: Extruded silicone fixed in a channel within the aluminum extrusion and shall be remain flexible at minus 40 deg F or a flexible metal compression jamb seal.
   6. Application: Use in locations with tempered air streams that are not subject to freeze conditions such as return air and supply air.

C. Cold Environment Insulated Control Dampers: AMCA-rated parallel and opposed blade design; 0.080-inch-thick extruded aluminum or 16 ga. Galvanized frame, 4 inches deep.
   1. Secure blades a heavy-duty zinc-plated steel and aluminum drive linkage within the frame housing, out of the air-stream.
   2. Insulated Blades: Extruded aluminum profile or formed galvanized blade insulated with eith3er expanded foam or fliberglass fill.
   3. Operating Temperature Range: From minus 40 to plus 200 deg F.
   4. Leakage Rate: No more than 3 cfm/sq.ft. at 1” w.c. per AMCA 500-D Standard.
   5. Blade and Jamb Seals: Extruded silicone fixed in a channel within the aluminum extrusion. Seals shall remain flexible at minus 40 deg F.
   6. Application: Use for all dampers that are directly exposed to outside air conditions such as intake dampers, relief dampers, exhaust dampers, etc.
   7. Application: Use for all dampers that are directly exposed to outside air conditions such as intake dampers, relief dampers, exhaust dampers, etc.

2.13 CONTROL CABLE AND WIRING

A. All Ethernet cable installed as part of the top level communications bus shall be CAT6 cable with terminations that comply with the CAT6 specification and able to communicate at 1 GB speeds.

B. All control cables located in mechanical rooms and areas subject to physical damage shall contained in conduit. All conduit used for control cables shall be EMT with a continuous BLUE dyed exterior equal to “Allied TRU COLOR EMT”.

C. **ALL** cable and wires used for building automation and control network shall have a jacket color of **BLUE** for easy identification of this system. Sensor wiring does not have to comply, only network communication trunks.

D. All control cables in plenums shall be supported from structure every 4 feet by use of J-hooks and bridle rings. Do not support from any duct, pipe, conduit, light fixture, ceiling grid or tie wires. Cable shall be routed in a neat and orderly fashion parallel and perpendicular to building walls. Do not route control cables in trays with data and voice cables. All cable and wiring in plenums shall be plenum rated in accordance with UL smoke and flame test requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 PROJECT MANAGEMENT

A. Designate a single project manager who shall as part of his duties be responsible for the following activities;
   1. Coordinate between this contractor and all other trades, design engineer, and local authorities.
   2. Schedule manpower, material delivery, and equipment installation in a manner that maintains the overall workflow of the project schedule.
   3. Maintain as-built documentation and field installation details.
   4. Be present and assist with performance testing and commissioning activities.

3.3 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 46 inches above the floor to the center of the device in accordance with ADA accessibility guidelines.
   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install guards on thermostats in the following locations:
   1. Entrances.
   2. Public areas that do not have plate style sensors.
   3. Where indicated.

E. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

G. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

H. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."

I. Remove all abandoned pneumatic tubing in it's entirety back to the nearest active main the remains. Cap air tight. All tubing that is buried within walls may be abandoned in place but cut within the wall cavity. Do not abandon tubing above ceilings or in mechanical rooms.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."

B. Install signal and communication cable.
   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
   3. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   4. Code conductors for future identification and service of control system. Numbering shall be on both ends of the cable such that the code at the device end shall designate what control panel it is connected to and the code at the panel end shall designate what sensor it is connected to.
   5. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

D. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
   4. Test each point through its full operating range to verify that safety and operating control set points are as required.
   5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
   6. Test each system for compliance with sequence of operation.
   7. Test software and hardware interlocks.
   8. Simulate all sequence of control actions such that all modes are tested and verified to be working correctly. Test every alarm condition to verify that alarm is generated and correct control response takes place.

C. DDC Verification:
   1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
   2. Check instruments for proper location and accessibility.
   3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
   4. Check temperature instruments and material and length of sensing elements.
   5. Check control valves. Verify that they are in correct direction.
   6. Check DDC system as follows:
      a. Verify that DDC controller power supply is from emergency power supply, if applicable.
      b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
      c. Verify that spare I/O capacity has been provided.
      d. Verify that DDC controllers are protected from power supply surges.

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

3.6 ADJUSTING

A. Calibrating and Adjusting:
   1. Calibrate instruments.
   2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
   3. 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.
   4. Control System Inputs and Outputs:
      a. Check analog inputs at 0, 50, and 100 percent of span.
      b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
      c. Check digital inputs using jumper wire.

d. Check digital outputs using ohmmeter to test for contact making or breaking.
e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:
   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
   b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
   b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.
8. 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.
9. 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.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. 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 visits to Project during other than normal occupancy hours for this purpose.

3.7 CLOSEOUT DOCUMENTATION

A. As-Built Documents: After successful acceptance demonstration of the control system, the contractor shall submit as-built drawings of the completed project for final approval by the project design engineer. Upon receiving approval, supply six (6) complete as-built drawing sets to the Owner with one copy of as-built drawings on CD-ROM in an AutoCAD format. Color coded as-built wiring schematics shall also be inserted in each control panel enclosure on the back of each door.

B. Operation and Maintenance Manuals: Submit one (1) copy to the project design engineer for approval. Upon approval, submit three (3) copies to Owner. Manuals shall have a cover and binding, such as a 3-ring binder and contain the following items.
1. Manufacturer’s catalog data and specifications on all sensors, transmitters, controllers, control valves, dampers, actuators, gauges, indicators, terminals, and any other components used. Indicate the exact models and options used.

2. An operator's manual that includes detailed instructions for all operations of the system such as creating new schedules, user accounts, trend logs, alarm events and how to adjust setpoints, respond to alarms.
3. An operators reference table that lists all addresses and connected points with normal set values.
4. A printed narrative of all control sequences.
5. A troubleshooting guide for diagnosing problems with the control system.
6. A backup copy of the workstation software installation custom programming database on removeable media for use in reloading software in the event of workstation failure.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

B. Provide a minimum of 20 hours of onsite training to Owner's staff such that 12 hours occurs upon project completion and the remaining hours shall occur at a point 3 months after completion and 12 months after completion. All training shall be video recorded to digital movie files and supplied to Owner on removable USB media. This training shall include the following, as a minimum:
   1. Overview of system architecture and location of each control panel.
   2. Review of each panel and what it's function is and what equipment is served.
   3. Review of basic wiring methods for each type of control device, should a device need to be replaced.
   4. Review of the graphical workstation functions with demonstrations on how to:
      a. Navigate the graphic system.
      b. View and acknowledge alarms.
      c. Configure new alarms.
      d. View and export trend logs.
      e. Configure new trend logs.
      f. Add new users and configure security privileges.
      g. View the control logic and make revisions.
      h. Upload new firmware and programs to logic controllers.
      i. Backup and restore control system software to all devices, workstations, and servers.
      j. Generate maintenance reports for items requiring routine service (Ex. Motor lubrication based on run hours, filter changes based on filter pressure drops, etc.) and how to configure them to automatically print when service is required.

END OF SECTION 23 0923

SECTION 23 0800 – COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents

1. Drawings, specifications, and general provisions of the Subcontract apply to this Section.

B. Section Includes

1. Construction Manager and Subcontractors requirements for the successful implementation of commissioning the heating, ventilating and air conditioning (HVAC) systems, assemblies, and components.

C. Related Requirements:

1. 019100 General Commissioning Requirements

2. Division 230000 HVAC Sections

1.2 REFERENCES

A. Not used

1.3 DESCRIPTION

A. ZH Commissioning (ZHCx) will be the commissioning provider for this project.

B. The purpose of commissioning is to ensure that work meets the owner's project requirements, satisfies the basis of design, is functioning in the manner as described in Division 23 HVAC Sections and the systems can be operated and maintained by a well-trained staff.

1.4 SYSTEMS TO BE COMMISSIONED

A. Commissioning will be performed on the following systems.

1. Bright Elementary School
   a. Air Handling Unit 1 – Prefunctional and Functional Performance Testing
   b. Air Handling Unit 2 – Prefunctional and Functional Performance Testing
   c. Air Handling Unit 3 – Prefunctional and Functional Performance Testing
   d. Air Handling Unit 4 – Prefunctional and Functional Performance Testing
   e. Unit Heaters – Prefunctional and Functional Performance Testing
   f. Domestic Hot Water Heaters - Prefunctional and Functional Performance Testing

2. North Dearborn Elementary School
   a. Kitchen Makeup Air Unit - Prefunctional and Functional Performance Testing
   b. Hot Water Boilers - Prefunctional and Functional Performance Testing
   c. Hot Water Pumps - Prefunctional and Functional Performance Testing
   d. Exhaust Fans - Prefunctional and Functional Performance Testing
   e. Existing Chilled Water Plant – Functional Performance Testing
   f. Existing Air Handling Unit CSAC-A1 - Functional Performance Testing
   g. Existing Air Handling Unit CSAC-B1 - Functional Performance Testing
   h. Existing Air Handling Unit CSAC-C1 - Functional Performance Testing
   i. Existing Air Handling Unit CSAC-D1 - Functional Performance Testing
   j. Existing Air Handling Unit CSAC-E1 - Functional Performance Testing
   k. Existing Air Handling Unit CSAC-F1 - Functional Performance Testing

l. Existing Air Handling Unit CSAC-F2 - Functional Performance Testing
m. Existing Air Handling Unit CSAC-G1 - Functional Performance Testing
n. Existing Air Handling Unit CSAC-H1 - Functional Performance Testing
o. Existing Air Handling Unit CSAC-H2 - Functional Performance Testing
p. Existing Air Handling Unit CSAC-J1 - Functional Performance Testing
q. Air Cooled Condensing Unit ACCU-A1 - Prefunctional and Functional Performance Testing
r. Air Cooled Condensing Unit ACCU-B1 - Prefunctional and Functional Performance Testing
s. Existing ERW-A1 - Functional Performance Testing
t. Variable Air Volume Boxes - Functional Performance Testing on 20% of Total Boxes.
u. Radiant Ceiling Panels - Functional Performance Testing
v. Convectors, Fin Tube and Unit Heaters – Functional Performance Testing
w. Refrigerant Leak Detection System – Functional Performance Testing

3. Sunman Elementary School
a. Hot Water Boilers – Prefunctional and Functional Performance Testing
b. Hot Water Pumps – Prefunctional and Functional Performance Testing
c. Existing Chilled Water Plant – Functional Performance Testing
d. Rooftop Units – Prefunctional and Functional Performance Testing
e. Existing Air Handling Unit 1 - Functional Performance Testing
f. Existing Air Handling Unit 2 - Functional Performance Testing
g. Existing Air Handling Unit 3 - Functional Performance Testing
h. Existing Air Handling Units E1-E4 - Functional Performance Testing
i. Unit Ventilators – Prefunctional and Functional Performance Testing on 20% of all UVs.
j. Variable Air Volume Boxes - Functional Performance Testing on 20% of Total Boxes.
k. Mini Split System – Prefunctional and Functional Performance Testing
l. Make Up Air Unit – Prefunctional and Functional Performance Testing
m. Exhaust Fans - Functional Performance Testing
n. Fan Coil Units - Functional Performance Testing
o. Cabinet Unit Heaters - Functional Performance Testing
p. Radiant Ceiling Panels - Functional Performance Testing
q. Duct Heating Coils - Functional Performance Testing
r. Domestic Water Heating System – Prefunctional and Functional Performance Testing
s. Domestic Water Booster Pumping – Prefunctional and Functional Performance Testing

1.5 COMMISSIONING KICK OFF MEETING

A. Within two weeks following the pre-construction meeting or as coordinated with the construction manager, ZHCx will conduct a commissioning kick off meeting. The purpose of the meeting is defined as follows.

1. Introduce team members and identify roles and responsibilities.

2. Explain the process to be used on the project that will also be described in the commissioning plan.

3. Describe reporting and the purpose of the resolution tracking form.

4. Describe prefunctional observations.

5. Describe functional performance testing.

B. The following participants are required to attend the commissioning kick off meeting.

1. Construction Manager Site Superintendent.

2. Mechanical Contractor Job Site Foreman. If there is more than one foreman due to the work occurring at the three schools, then the foreman for each school is required to attend.

3. Automatic Temperature Controls Contractor.

4. Testing, Adjusting and Balancing Contractor.

1.6 COMMISSIONING SCHEDULING

A. ZHCx will develop commissioning activities to be included in the overall construction schedule. This contractor and subcontractors shall be prepared to assist in development of the schedule. Assistance is defined as follows.

1. Participate in one scheduling meeting.

2. Provide milestone activities.

3. Provide start up dates.

1.7 COMMISSIONING PROGRESS MEETINGS

A. This contractor shall attend commissioning progress meetings as required by the commissioning agent. Commissioning meetings, when scheduled, will occur after regularly scheduled construction project meetings.

1.8 CONTROLS KICKOFF COORDINATION MEETING

A. Prior to DDC controls system submittals being sent to the engineer for review a controls meeting will be scheduled.

1.9 PREFUNCTIONAL PERFORMANCE TESTING CHECKLIST

A. The commissioning agent, ZHCx, will write project specific pre functional performance testing checklists for their use during site observations.

B. ZHCx will document the installation of the HVAC equipment during typical site visits utilizing pre functional performance testing checklists.

C. Deficiencies identified during the site observations will be identified in writing on the resolution tracking form and distributed to the contractor. This contractor shall respond to these items in writing back to the commissioning provider. The response shall state the item is complete or rebut the finding from the commissioning agent. The contractor is not required to state the item is ongoing.

1.10 TESTING, ADJUSTING AND BALANCING

A. ZHCx will witness balancing activities as is appropriate to develop a final functioning system. This contractor and subcontractor shall assist in balancing activities.

1.11 FUNCTIONAL PERFORMANCE TESTING

A. ZHCx will work directly with the contractor to schedule functional performance testing of the system.

B. Direct digital controls contractor shall provide ZHCx all log in credentials including a username and password specific to ZHCx.

C. The commissioning agent, ZHCx, will create project specific functional performance testing checklists to document testing.

D. Functional performance testing will be completed in three parts, point to point testing, sequence of operation review and final functional performance testing.

1. Point to Point Testing: Conducted once all control and monitoring points, specific to the equipment being tested, are installed and visible via the final graphical user interface.

2. Sequence of Operation Review: Following point to point review with no deficiencies. Every aspect of the sequence is tested to verify the system is operating according to the intended sequence of operation.

3. Final Functional Performance Testing: Completed after point to point and sequence of operation review with no deficiencies.

E. ZHCx will direct and document the functional performance testing using their checklists. The temperature control contractor shall be available to operate the system as instructed by ZHCx.

F. Deficiencies identified during the testing can be corrected during testing. If the correction takes more than 30 minutes to resolve ZHCx has the right to abort the test. A new date and time will be scheduled after the deficiency is corrected. The deficiency will be documented in the resolution tracking form. This contractor shall respond to these items in writing, stating that the item is no longer deficient or rebutting the finding from the commissioning agent.

1.12 DEFERRED OR SEASONAL TESTING

A. ZHCx will complete functional performance testing at (2) 3-month intervals. Depending on the season in which functional performance testing is initially done. Temperature control contractor shall be prepared to spend a total of (1) 8-hour day during this testing, for a total of 16 hours.

END OF SECTION 230800