ATTACHMENT B

ADMINISTRATIVE OFFICE OF THE COURTS

OFFICE OF COURT CONSTRUCTION AND MANAGEMENT

Project Specifications

BAS Replacement Project

Civic Center Courthouse
400 McAllister Street
San Francisco, CA 94102
Building No.: 38-A1

January 20, 2014

Prepared By:

enovity inc
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PROJECT#: 0413-019

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INSTRUCTIONS FOR PROCUREMENT

PART 1
PART 2 GENERAL

2.01 INSTRUCTIONS TO BIDDERS

A. Bidder Requirements: All bidders must be licensed contractors in the State of California regularly engaged in the type of work described herein.

B. Project Title: Civic Center Courthouse BAS Upgrade

C. Proposal Schedule

RFP Issuance:

Jobwalk Date:	TBD
RFI/Questions Deadline:	TBD
Bid Due Date:	TBD
Anticipated Award Date:	TBD
1st Contractor Submittals:	TBD
Submittal Approval:	TBD
Order and Deliver Materials:	TBD

D. Proposal Submittal Format

Email Instructions.

a. Bid Format. Bids shall be submitted in Adobe Acrobat™ (.pdf) format as one complete file. Naming convention shall be as follows:

1) Naming Convention Structure: "CCC-BASPpsl-Company.pdf". Bidder shall replace "Company" portion of the naming convention with their abbreviated company name (limit to 8 characters). Any proposal revisions shall add "R#" immediately following company name with"#" representing the revision number.

2) Base Bid plus Bid Alternate Structure. Provide Base Bid pricing, with each Bid Alternate on each line thereafter.

Base Bid	$
Bid Alternate #1	$
Bid Alternate #2	$
Bid Alternate #3	$
Bid Alternate #4	$
Unit Price #1	$
Unit Price #2	$
Unit Price #3	$
Unit Price #4	$
Unit Price #5	$
Unit Price #6	$

b. Bid Submittal. Proposals shall be emailed to the AOC Project Manager at the following:

Glenn.mantoani@jud.ca.gov

E. All inquires for information should be directed to the AOC Project Manager:

Glenn Mantoani

Glenn.mantoani@jud.ca.gov

PART 3 PRODUCT – NOT USED

PART 4 EXECUTION

4.01 PRE-BID MEETING

A. A MANDATORY job walk will be held at the project site, 400 McAllister Street, San Francisco CA 94102 (meet in rear of building near garage entry), as outlined above.

4.02 QUESTIONS

A. Questions must be provided in writing and submitted by the date in the above section. A response will be submitted back to the contractor in writing within 4 working days of the Questions Due date.

B. Parking is available in the Civic Center Plaza garage, entry off of McAllister Street.

4.03 CONTROLS CONTRACTOR QUALIFICATIONS

A. The Contractor shall engineer, install, test and calibrate all systems associated with the scope of work.

B. Contractor shall provide a final approved drawings package stamped by the mechanical engineer of record.

C. The Contractor shall have in place a support facility located within 150 miles of the project site with technical staff and all necessary test and diagnostic equipment. Factory trained technicians shall provide instruction, routine maintenance, and emergency service within 24 hours upon receipt of request.

D. The Contractor must be regularly engaged in the service and installation of building automation systems (BAS) as specified herein. In addition, the contractor shall employ and assign to this project, engineers and mechanics that are regularly engaged in the service and installation of BAS control systems as specified herein.

E. Contractor must have no less than three (3) similar demonstration projects, which have a similar scope of work.

4.04 CONTRACTOR PROPOSALS

A. Work shall be performed as a design-build fixed price project. Contractor shall visit site prior to submitting a bid proposal. Ascertain and check all conditions and take all measurements that may effect the work. Drawings provided are to be used at Contractor's risk; drawings are schematic and may or may not be drawn accurately. No allowance shall subsequently be made for any additional expenses or claims due to the failure or neglect under this section to make such examination, including examination of restricted working conditions or such other difficulties that can be visually observed during site visit.

B. By submitting a price, Contractor guarantees that the proposal is complete, except where specific exceptions are provided herein or clearly noted in the Contractor's proposal.

C. Proposals shall include:

1) Reference to specific project.

2) General description of scope of work and reference to the specification set
3) Proposed location of equipment outlined in the Scope of Work
4) Preliminary schedule based upon anticipated date of contract award
5) Construction plan of installation for major equipment retrofit, including the estimated maximum downtime for the equipment being replaced. Describe the estimated number of shutdowns needed (including time of day and week) for all systems.
6) List of inclusions
7) Clarifications and exclusions
8) All labor required to complete the above scope of work during unoccupied times as applicable.
9) List of project team members and their qualifications including direct experience related to their project role.
10) List of subcontractors, their project team, their project role, and their qualifications.
11) Estimated maximum downtime of equipment and potential impact to court operations.
12) Proposed Fixed Price Fee, as follows
    a. Base Scope of Work
13) List of (3) representative sample HVAC/BAS projects including client name, company, email, and phone number.

END OF SECTION 00 20 00

SECTION 01 00 00
GENERAL REQUIREMENTS

PART 1 GENERAL

1.01 EXISTING CONDITIONS

A. Contractor is responsible for examining existing site conditions and equipment conditions. Specification documents provide performance requirements. It is the Contractor's responsibility to engineer, permit, provide, and install a fully functioning system. Equipment selection shall be the Contractor's responsibility with the approval of the Owner and Owner's Representatives.

1.02 WORK INCLUDED:

A. Demolition; all old equipment that is replaced shall be removed from the site and disposed of in accordance with local regulations. The Owner shall have first right of salvage for removed equipment.

B. Rigging

C. New equipment

D. Temporarily removing and repairing doors, walls, ceilings, or roof sections for access as required

E. Seismic restraints

F. Electrical power wiring, disconnects, etc. for new equipment

G. Direct Digital Controls (DDC)/Building Automation System (BAS)

H. Test, Adjust, and Balance (TAB)

I. Operator training

J. All required permits and associated fees

K. Commissioning of the new BAS controls

1.03 REFERENCE STANDARDS:

A. Requirements of Regulatory Agencies:

1. Nothing in drawings or specifications shall be construed to permit work not conforming to applicable codes, ordinances, rules, regulations.

2. When drawings or specifications exceed requirements of applicable codes, ordinances, rules and regulations, comply with documents establishing the more stringent requirement.

3. Applicable codes include the current version of those listed below, in addition to others specified in individual sections:

4. IMC -International Mechanical Code

5. IPC - International Plumbing Code

6. NFPA - National Fire Protection Association

7. NEC - National Electrical Code

8. If any of above requirements is in conflict with one another, or with Specifications' requirements, the most stringent requirement shall govern. Where codes are silent on an issue, NFPA Standards shall apply.

B. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in this Section:
   1. AABC - Associated Air Balance Council
   2. ADC - Air Diffuser Balance Council
   3. AMCA - Air Moving and Conditioning Association
   4. ANSI - American National Standards Institute
   5. ARI - Air Conditioning and Refrigeration Institute
   6. ASHRAE ~ American Society of Heating, Refrigeration and Air Conditioning Engineers
   7. ASME - American Society of Mechanical Engineers
   8. ASTM - American Society for Testing and Materials
   9. ETL - Intertek Semko (Formerly Electrical Testing Laboratories)
   10. IEEE -Institute of Electrical and Electronic Engineers
   11. NEMA - National Electrical Manufacturer's Association
   12. NFPA - National Fire Protection Association
   13. NUSIG - National Uniform Seismic Installation Guidelines
   14. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
   15. UL - Underwriters' Laboratories.

C. Industry standards and manufacturers' recommendations, diagrams or requirements shall be strictly adhered to for installation of materials and equipment.

1.04 QUALITY ASSURANCE:

A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.

B. All items of a given type shall be the products of same manufacturer.

C. Supply all equipment and accessories new and free from defects.

D. Supply all equipment and accessories in compliance with the applicable standards listed in Paragraph 1.03-B with all applicable national, state and local codes.

1.05 DEFINITIONS:

A. Definitions of terms used in this section may differ from those given in general and supplementary conditions and take precedence over them.

B. "Provide": to supply, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.

C. "Install": to erect, mount and connect complete with related accessories.

D. "Supply": to purchase, procure, acquire and deliver complete with related accessories.

E. "Work": labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

F. "Piping": pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

G. "Wiring": raceway, fittings, wire, boxes and related items.

H. "Concealed": embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.

I. "Exposed": not installed underground or "concealed" as defined above.

J. "Indicated," "shown" or "noted": as indicated, shown, or noted on drawings or specifications.

K. "Similar" or "equal": of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified product, conforming to PART 2 Products.

L. "Reviewed," "satisfactory," or "directed": as reviewed, satisfactory, or directed by or to Owner's Representative.

M. "Motor Controllers": manual or magnetic starters (with or without switches), individual pushbuttons or hand-off-automatic (HOA) switches controlling the operation of motors.

N. "Control or Actuating Devices": automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 WORK REQUIREMENTS AND RESPONSIBILITIES

A. Definitions

1. BAS: Building Automation System
2. DCU: Digital Control Unit
3. DDC: Direct Digital Control
4. HMI: Human Machine Interface
5. LAN: Local Area Network
6. OWS: Operator Workstation

B. Owner Responsibilities

1. Asbestos abatement shall be performed as needed for all areas of work under a separate contract prior to the commencement of this project work.

C. Construction Manager Responsibilities

1. Bids. CM shall request and obtain all Contractor bids and present them to the Owner and the Owner's representatives for review prior to commencement of any work.
2. Commissioning Support. Construction Manager (CM) shall designate one person as the Commissioning Coordinator (CxC) to interface with the Commissioning Authority (CxA) throughout the project.
3. Schedule. CM shall construct and maintain a project schedule and communicate the progress of the project with the CxA and/or the Owner.
4. Kick-off Meeting. A coordination meeting with the Construction Manager, Owner Service Provider, Commissioning Authority, and Owner representatives shall take place prior to commencement of any work.

D. Contractor(s) Responsibilities

1. Cleaning:

   a. Thoroughly clean all equipment, etc. free of dust, scale, filings, plaster, grease, oil, paint and other construction debris.

   b. All areas where contractor is working including mechanical and electrical rooms must be left clean and free of debris after every shift.

2. General. Contractor(s) shall provide design, submittals, materials, installation and start-up of equipment listed in representative line items in Section 01 11 00 – Summary of Work.

3. Working Conditions. Portions of the work can be performed during normal working hours (6.00 AM to 6.00 PM), but the contractor shall perform the work such that none of the controlled equipment is unavailable during their work. If off-hour work is required, the contractor shall schedule employees in a shift manner in an effort to eliminate overtime.

4. Commissioning. Completely install and thoroughly inspect, test, and document the commissioning of all systems and equipment as directed by the CxA. The contractor shall provide a dependable and fully functional system that operates properly and efficiently. Reference Section 23 08 05 for complete Commissioning guidelines and responsibilities.

3.02 SUBMITTALS:

A. Schedule:

1. Product data, construction drawings, and shop drawings: Allow 10 working days for approval, unless AOC agrees to accelerated schedule.

2. Testing, Adjusting, and Balancing Procedures: Submit at least 30 days prior to performing any TAB work.

3. Operations and Maintenance Manuals: Submit prior to requesting acceptance of work and allow 10 working days for approval.

B. Submit drawings, product data, samples and certificates of compliance required as hereinafter specified in this Section.

C. Submission Procedure:

1. Initial submittal:

   a. Product data and Operations and Maintenance Manuals: Submit two electronic copies in word-searchable format such as Adobe pdf. Paper copies will not be accepted.

      1) It is acceptable to submit product data selection submittals prior to the release of final construction drawings in an effort to expedite long lead equipment items.

   b. Construction drawings and Shop drawings:

      1) Construction Drawings shall be submitted to the Owner for review at the 75% stage.

      2) Submit five (5) copies in hard copy format (18” x 24”)

      3) Submit one (1) electronic copy of all drawings in PDF format

   c. Submittal will be reviewed and comments returned to Contractor

2. Resubmission:
    a. Make any corrections or change in submittals as required
    b. Resubmit for review in the formats described above until no exceptions are taken.
3. Final approval: Once submission is accepted, Contactor shall provide:
    a. Two (2) bound sets of hard copy and two electronic copies of product data and Operations and Maintenance data in word-searchable format such as Adobe pdf. Provide additional sets for coordination with other trades, as required.
    b. Five (5) copies of 100% CD drawings in hard copy and one (1) soft copy; in AutoCAD format and/or Microsoft Visio, and pdf format on portable media (e.g. CD) including all referenced background drawings.
    c. Complete As-Built Record Drawing Package (Visio, PDF) shall be on the control system front end computer. (Viewing software by others). Items shall include:
        1) Final As-built Mechanical Plans (stamped by Mechanical PE)
        2) Final As-built BAS drawings and product data (stamped by Mechanical PE)

D. Submittal Content
1. BAS submittals shall include:
    a. A schedule for all items of the same type that includes: manufacturer, model, size, specific information that makes that item unique, service, and the system served by the item.
    b. Manufacturer's name and model number
    c. Physical Data, as applicable, including dimensions, weight, finishes and colors.
    d. Performance Data, as applicable, including rated capacities, performance curves and operating temperature and pressure.
    e. Electrical requirements
    f. Flow and wiring diagrams as applicable
    g. Description of system operation
    h. All other pertinent information requested in individual sections
2. Test, Adjust, and Balance (TAB) submittals shall include:
    a. Interim Reports
    b. A written description of the balance procedures
    c. All test and report forms that will be submitted for the final TAB report
3. Operating Instructions & Maintenance Manuals shall include:
    a. All information organized and assembled in order of relevant specification section, in heavy-duty three-ring binder.
    b. All submittal data submitted herein above, as installed. The intent of this section is that a single document contains all relevant information about each piece of equipment.
    c. Manufacturer's name, model number, service manual, spare-parts list, and descriptive literature for all components

d. Installation instructions

e. Maintenance instructions

f. Wiring diagrams

g. Listing of possible breakdown and repairs

h. Instruction for starting, operation and programming

i. Detailed and simplified: l one line, color coded flow and wiring diagram

j. Name, address and phone number of contractors equipment suppliers and service agencies

k. Warranty/Guarantee period, including start and end dates

l. Start up test readings, dated and signed by testing technician

4. Record Drawings shall include:

a. Provide 3 bound hard copies and 1 electronic copy in DVD. Provide Record Drawings in editable format, Visio or AutoCAD.

b. Updated design/shop CAD drawings to "as- built" conditions:

c. Fully incorporated revisions made by all crafts in course of work.

d. All field changes, adjustments, variances, substitutions and deletions, including all Change Orders and Requests for Information.

e. Exact location of all installed instrumentation, sensors, and control devices.

E. Completion Requirements:

1. Until the documents required in this section are submitted and approved, the system will not be considered "accepted" and final payment to contractor will not be made.

a. O&M Manual reference specification Section 01 78 23

b. Training reference specification Section 01 79 00

c. Warranty reference specification Section 01 78 36

F. Startup: Contractor shall start up all new equipment according to the manufacturers recommended start up procedures and shall provide Start Up Documentation signed by the responsible start up technician.

3.03 WORK RESTRICTIONS

A. Schedule of Work:

1. Design and construction work to be approved by the AOC prior to start. Contractor shall meet the established schedule requirements.

2. Contractor shall provide a detailed two week look ahead schedule update each week and coordinate necessary schedules that may affect building operations and occupants.

3. Include all labor required to perform work as specified herein.

4. The project will be performed in an occupied building. All HVAC, Lighting, Electrical, Controls, Fire Life Safety systems must remain on line and fully functional during the hours of 6:00 AM to 6:00 PM Monday thru Friday; any and all exceptions to this must be approved by the AOC or their representative.

5. The Contractor shall not perform work in tenant spaces between the hours of 6:00 AM to 6:00 PM Monday thru Friday; any and all exceptions to this must be approved by the AOC or their representative.

B. Access To Site

1. Background security checks for all personnel will be required. At least thirty (30) days prior to starting work, the Contractor shall provide the a list containing the following information for each employee that will be working at the project site:
   a. Full legal name,
   b. Date of birth,
   c. Social security number and
   d. California driver's license number, or ID number.
2. Contractor's employees will not be admitted to the job site until the Court Security Division of the Sheriff's Department has issued a clearance to the Project Manager granting admission of contractor's personnel. The Sheriff's Department reserves the right to disallow any individual to work on the site.
3. Contractor personnel are required to check-in with the CM at the beginning of each shift and present a valid form of picture identification when reporting and working on job site.
4. The Contractor's workers and equipment shall be limited to the work areas designated by the contract.
5. In the event the Contractor, his/her employees, or subcontractors fail to adhere to the Court's security provisions, the Court has the right to deny access to the work site to that employee or subcontractor without an extension of time being granted to the Contractor.
6. At the beginning of each shift, security badges will be issued to all personnel working at the project site. This badge must be worn at all times in the facility or on the project site. The badge shall be turned in and shall remain at the site each time an individual leaves the site. The badge will allow workers to only be in the immediate vicinity of the construction work.
7. Keys will not be distributed. Work must be coordinated in advance with the Construction Manager for where access shall be needed and the times and dates required for access.

C. Storage of Supplies, Materials, Equipment, Inc.

1. The contractor shall obtain the prior approval of the Owner for any area or space required for Contractor's storage during construction operations. Materials, equipment, etc. shall not be piled or stored in any location that interferes with the conduct or normal functions of the building and/or facilities, and shall not constitute a hazard to persons or property. Any required safety precautions such as signs, danger signals, lanterns, barricades, etc. shall be installed by the Contractor during construction operations.
2. Note that existing storage areas on site are limited. All tools, equipment and material shall either be removed from site daily or stored in a locked box or container. The Administrative Office of the Courts and San Francisco County Superior Courts are not responsible for the theft of any tools, equipment, and material left on site by the Contractor.

D. Signs

1. No advertising signs of any kind will be permitted except by written permission of the AOC.

E. Construction Site Utilities

1. Water: Contractor may connect to a temporary line to the existing water service lines at the site. The Contractor shall be responsible for verifying all existing conditions associated with a water connection. Connections to existing water service lines shall be coordinated with, and accepted by, the Project Inspector.
2. Electrical Power: The facility's electrical power shall be made available for the Contractor's use as long as the Contractor's power requirements are below the available capacities in the immediate area of work. The Contractor's shall be responsible to verify all existing conditions associated with an electrical connection. Connections to existing electrical service shall be coordinated with and accepted by the Project Inspector. The Contractor shall provide a portable generator for any power needs in excess of available electrical power.
3. Telephone: Contractor shall not have access to phones on site and therefore, shall arrange for his own cell phone if needed for on-site communication.
4. Field Toilets: Designated existing restrooms will be available for use by all workers, subcontractors, consultants, and County personnel associated with the project. Contractors will be responsible for maintaining and keeping restroom clean after use. The restrooms shall not be used for project cleanup.

F. Parking

1. All parking costs are the responsibility of the contractor, and under no circumstances shall the Owner receive requests for additional monies due to parking related issues.

END OF SECTION 01 00 00

SECTION 01 11 00
SUMMARY OF WORK

PART 1 GENERAL

1.01 PROJECT INFORMATION

A. Project Identification: BAS Replacement

B. Owner

1. Judicial Council of California – Administrative Office of the Courts

C. Owners Representative (Specifications & Commissioning Authority)

1. Enovity, Inc., 26 Executive Park, Suite 170, Irvine, CA, 92614-2708

D. Construction Management

1. TBD

E. O&M Service Provider

1. Enovity, Inc., 100 Montgomery St., Suite 600, San Francisco, CA

1.02 GENERAL BUILDING DESCRIPTION

A. Overview

1. The Civic Center Courthouse is a six-story 189,575 square foot court facility located at 400 McAllister Street, San Francisco, CA.
2. Normal Building Occupancy is Monday through Friday 8:00 a.m. – 5:00 p.m.
3. Equipment Schedules:
   a. On Mondays, fans start at 4:00. On Tuesdays, fans start at 5:00. Fans start at 6:00 on Wednesdays, Thursdays, and Fridays. Air Handling Equipment is scheduled OFF at 18:00 Monday through Friday.
   b. Schedules will be revised per the Sequence of Operations to include optimal start.

B. Existing Chilled Water System Description

1. There are two (2) water cooled liquid chillers and one (1) air cooled liquid chiller. All chillers serve the same hydronic piping system. The air cooled chiller is the smallest of the three and is sized to cover the building base cooling load (mostly fan coil units in equipment rooms).
2. Each chiller has a dedicated chilled water circulating pump. Each of the two water cooled chillers has a dedicated condenser water pump.
3. The water cooled chillers reject heat to a pair of cooling towers. The cooling towers are equipped with two-speed fans and are installed and operated as a single, two-cell cooling tower.

C. Existing Heating Hot Water Plant

1. Heating Hot Water for this building is provided by the San Francisco City Steam Utility. The steam/water heat exchanger and associated valves are property of the city and county of San Francisco. The temperature control valve position and hot water supply and return temperatures are monitored by the BAS.
2. The Heating Hot Water system is equipped with two circulating pumps. Each pump is equipped with a VFD. The pumps are the responsibility of the building O&M staff.
3. Domestic Water Heating is also provided by city steam. The building owns and operates a domestic hot water circulating pump.

D. Existing Air-side HVAC System

1. Air Handling Units

a. There are five variable air volume (VAV) air handling units serving various court rooms and support areas.

b. Zones are conditioned by 265 VAV terminals, 159 with hot water reheat.

2. Fan Coil Units

a. There are 10 fan coil units located in electrical/telecommunications rooms. These fan coil units are intended to serve areas with a heat load that is independent of the building's occupied hours. The fan coil units utilize building chilled water 24hrs/day, 7days/week. (contractor to verify count prior to submitting bids)

3. Exhaust Fans

a. Four general exhaust fans are monitored and controlled via BAS

4. Controls

a. HVAC systems are currently controlled using an Alerton IBEX BAS.

E. Existing Miscellaneous Monitoring and Control

1. Lighting

a. Lighting is controlled by approximately 60 lighting control relays. The lighting control relays are located in lighting control panels on each floor of the building.

2. Garage CO System

a. The parking garage under the building is equipped with a CO monitoring system. The BAS monitors this system, but does not perform the code- required monitoring and ventilation of the area (monitoring only).

b. Monitoring includes: CO alarm monitoring, sensor alarm monitoring (sensor failure/status), and exhaust fan speed/status monitoring.

3. Sump Level Monitoring

a. The BAS monitors sump level alarms for elevator sumps as well as drainage sumps located in the basement of the building.

4. Emergency Generator Monitoring

5. Fire Panel Monitoring

a. Integration of the BAS with the Fire/Life Safety System (FLSS) is for monitoring purposes only. Control of any equipment associated with the FLSS from the BAS is neither required nor desired.

6. Fuel Oil System Monitoring

1.03 PROJECT INTENT

A. Contractor(s) shall provide a design-build project for the following work.

1. BAS. Remove the existing BAS controllers and present to the building owner for salvage. Only upon the Owner's request, dispose of the existing BAS controllers in the most eco-friendly manner, meets local codes, and recycle where applicable.

2. New BAS. Provide and install new BACnet® -based software and controllers to fully encompass existing building equipment and new sequences of operations per these documents. Equipment controlled and/or monitored shall include, at a minimum; all equipment associated with the building HVAC systems, building interior lighting

systems, fire alarm system monitoring, and utility systems monitoring. All new points shall be controlled and/or monitored via a BACnet® controller as stated in section 23 09 23.

3. Cable and Conduit. Install required cable, conduit, for a local BAS/LAN connection between the new controllers as needed. Install required cable, conduit, for Connection to field devices.
4. Controller Power. Provide line voltage wiring and control transformers as needed to accomplish the above.
5. System Software. Provide and install one (1) original licensed copy of all required software for the Owner's system.
6. System Server. Provide one (1) new Dell server for the database software. Server (described in item #7) shall not be the same Operator Workstation.
7. Operator Workstation. Provide and install one (1) workstation with printer for the DDC system as outlined herein. This workstation shall be configured as a full client (Full-Weight Client).
8. Portable Workstation. Provide one (1) portable operating terminal/Laptop PC with a licensed copy of all software required to monitor, modify, and balance the system from the panel locations.
9. Software. Provide an original license copy of software and labor to install and configure MS SQL.
10. Control Panel Enclosures. Install new enclosures or utilize existing enclosures to install new Direct Digital Controllers. New panels shall include power supply, fused disconnect switch, terminal strip, panduit, and 120 VAC power duplex power outlet. Reference section 23 09 27 Field Panels.
11. Dampers. For all HVAC equipment not replaced under this scope, service and lubricate control equipment including economizer dampers (as applicable) for full stroke operation.
12. Damper Operators. All new actuators shall be electronic as specified herein. Reference 23 09 13 Instrumentation and Control Field Devices
13. Point Additions. Contractor shall analyze Exhibit A (Suggested Minimum Points List) and recommend point additions for optimal control. These points should be presented before contract award to prevent any change orders during the project. If a point is needed after award of contract, the contractor shall absorb all cost associated with the addition of that point.
14. Graphics. Provide a fully functional graphics package as outlined herein. Graphics backgrounds are to match Exhibit B. Contractor to provide sample graphics with bid package.
15. Training. Provide onsite labor and phone support for training and assistance on the system. Reference section 01 79 00 Demonstration and Training for detailed requirements.
16. WAN/Internet Connection. For remote access capabilities, provide cabling as needed to the new or existing connection and coordinate with the customer and service provider as needed. Installation and ongoing LAN/Internet service costs shall be under a separate contract and are not within the scope of this project. Contractor to verify the quality of the connection to the BAS.

17. Design and Project Documentation. Owner will provide the Contractor with all available architectural, mechanical, and electrical drawings showing existing conditions as they are available. Contractor shall include at a minimum, the following in their design and project submittals:
    a. BAS Network diagram showing all new equipment, including room numbers.
    b. Electrical and electrical detail wiring diagrams showing connection of the existing control panels to the new Operator Workstation and Server.

PART 2 PRODUCTS

2.01 GENERAL

A. Products are referenced in separate specification sections.
B. All products shall be new except as noted.

PART 3 EXECUTION

3.01 SCOPE OF WORK – BASE BID

A. Provide and install a complete new Enterprise Server and a graphical user workstation with complete engineering, database generation and graphics for all systems.
B. Provide and install new DDC controls for the following:
    1. Five built-up custom AHU's.
    2. Chilled Water and Condenser Water plant.
    3. Hot Water plant.
    4. Ten Fan Coil Units
    5. Four General Exhaust Fans
    6. 60 existing lighting sweep relay controls.
C. Provide and install new DDC control interface with the Garage CO system for 20 devices.
D. Provide and install new DDC misc. monitoring points for 40 items such as emergency generators, sump pumps, security, fire alarm etc.
E. Provide and install new DDC zone controls for 265 VAV zone controls (159 w/reheat).
    1. Provide new DDC controllers, valve actuators, damper actuators, and room sensors.
F. Building Automation System (BAS)
    1. Replace BAS to control and/or monitor all major HVAC systems throughout the facility.
    2. All control devices shall be new. The re-use of any control devices is not permitted unless specifically stated herein.
    3. BAS shall monitor and provide enable/disable signal via chiller BACnet based network card.
    4. Locate new BAS front end in location determined by the AOC. Contractor shall confirm the client's desired location prior to commencement of work.
G. Coordination
    1. Disconnection of the existing system must be thoroughly coordinated with the building occupant at least one month prior to any major shut-down of the facility.
    2. Working Conditions. The work can be performed during the hours of (6:00 PM to 6:00 AM Monday through Friday, and as required to maintain the overall project schedule, Saturday and Sunday with no overtime impact to the AOC). The contractor shall perform the work such that none of the controlled equipment is unavailable during their work. If

off-hour work is required, the contractor shall schedule employees in a shift manner in an effort to eliminate overtime.

3.02 SCOPE OF WORK – ADD ALTERNATES

A. ADD ALT #1: Retrofit Garage Lighting

1. There are approximately 25 100-watt and 8 150-watt halogen lamps throughout the parking garage. Provide pricing to retrofit these lamps with 32- and 42-watt compact fluorescent lamps respectively. This retrofit requires replacing the existing ballasts and lamps. The existing fixture can be reused for this project. Contractor to verify exact count prior to bid.

B. ADD ALT #2: Variable Flow CHW with DP Reset

1. Currently, the chilled water pumps are not capable of operating at reduced speeds because they are not equipped with variable speed drives (VFD's). It is recommended to install VFD's on the chilled water pumps to reduce energy consumption. Provide pricing to install three variable speed drives and a differential pressure (DP) sensor at the furthest chilled water coil. The existing 3-way valves will have to be modified to operate as 2-way valves by closing the bypass legs. One of the valves can remain partially open to ensure a minimum rate of flow through the chiller. A pump speed control sequence shall be installed on the BAS to vary the pumps speeds to maintain a DP set point.
2. Currently, the chilled water pumps operate at full speed whenever there is a call for chilled water. Provide pricing to implement a DP reset pumping strategy based on demand for chilled water.

C. ADD ALT #3: Bi-Level Occupancy Controlled Lighting in Stairwells

1. The stairwell lighting is composed of 2-lamp four–foot T8 fixtures. There are three stairwells in the building, each with two landings per floor. Each landing is equipped with one fixture. The stairwells are illuminated 24 hours a day, 7 days per week, regardless of stairwell occupancy.
2. Provide pricing to install new bi-level fixtures with infrared occupancy sensors. The light output of the new T8 fixtures will be controlled by the occupancy sensor mounted in the fixture, which triggers the electronic ballast to turn off when unoccupied and turn on when occupied. The fixture also comes equipped with a 7-watt CFL that stays illuminated 24/7 to provide acceptable lighting until the occupancy sensor is triggered.

D. ADD ALT #4: Raise Space Temperature and Limit Supply Fan Speed

1. Provide pricing to program a demand response event so that the BAS can raise the temperature of non-critical zones 2°F for a level one event and 4°F for a level two event. In addition, the supply fan speed shall be lowered to 85%.

E. UNIT Pricing: Provide Unit Pricing for the following in the case that the as-found conditions differ from these documents:

1. Fan Coil Unit monitoring and control
2. VAV with re-heat monitoring and control
3. VAV cooling only monitoring and control
4. Lighting Relay
5. Garage CO devices
6. Exhaust Fans

END OF SECTION 01 11 00

SECTION 01 78 23
OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Operation and Maintenance Manual Components
   1. Warranty Documents
   2. As-Built Documents
   3. System Manual Components
   4. Maintenance and Service Requirements
   5. System Engineering and Operating Manuals
   6. Product Data Sheets
   7. Electronic Documents

B. Document Submittal

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.01 OPERATION AND MAINTENANCE MANUAL COMPONENTS

A. Warranty Documents
   1. Provide copy of the warranty letter
   2. Provide any manufacturer's warranty data as applicable

B. As-Built Documents
   1. Single-line Diagrams
   2. As-built wiring design diagram for each control panel.
   3. As-built wiring design diagram for all components.
   4. Installation design details for each I/O device.
   5. As-built for each system.
   6. Sequence of control for each system.

C. Systems Manual Components
   1. Sequence of Operations (for the entire system)
   2. Specifications of the Control System Installed
   3. Manual Operating Procedure (if the automation system fails)
   4. Spare Parts List

D. Maintenance and Service Requirements
   1. System Maintenance Tasks. Provide a list of recommended maintenance tasks associated with the system servers, operator workstations, data servers, web servers and web clients.

a. Provide names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.

b. Provide a description of maintenance tasks and frequency

c. Reference the product manual that includes instructions on executing the task.

E. System Engineering and Operating Manuals

1. This shall include but not be limited to the following:

a. Operating the system.

b. Administrating the system.

c. Application programming.

F. Product Data Sheets

1. This shall include but not be limited to the following:

a. Product data sheet for each component.

b. Installation data sheet for each component.

G. Electronic Documents

1. Firmware Files (As Applicable)

a. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.

b. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.

c. Submit a LICENSED COPY of all application files that were created during the execution of the project if applicable.

3.02 DOCUMENT SUBMITTAL

A. As-Built Set Submittal

1. Final deliverable shall be submitted as follows:

a. Printed Copy Documents: (2) Full Sets

1) The information shall be in three ring binders with tabs and a table of contents for each binder set.

2) Diagrams shall be on 11” by 17” foldouts. If color has been used to differentiate information, the printed copies shall be in color.

b. Electronic Documents:

1) Three (3) Electronic sets submitted via flash drive

2) Drawings shall contain a copy in editable format (MS Visio or AutoDesk AutoCAD). Legend layer may be omitted.

c. Installation Media

d. Complete System Backups

END OF SECTION 01 78 23

SECTION 01 78 36
WARRANTIES

PART 1 GENERAL

1.01 SUMMARY

A. The Contractor shall guarantee the following:

1. All new materials, new equipment, apparatus and workmanship shall be free of defective materials and faulty workmanship.
2. All equipment and material will produce the results specified.
3. All systems shall be fully tested, adjusted, balanced, and commissioned.
4. The Contractor shall furnish written guarantee to replace all defective work, materials, and services furnished under this Section, at no additional cost to the Owner, for the warranty period
5. Contractor shall submit all manufacture's warranties with the Operations and Maintenance documentations.
6. The AOC reserves the right to make temporary repairs as necessary to keep equipment in operating condition without voiding the guarantees or relieving responsibility during the guarantee period.

B. General Requirements for BAS:

1. Provide all services, materials and equipment necessary to the successful operation of the entire BAS for a period of one year after completion of successful performance test and owner acceptance. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work.
2. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. The Owner's Representative shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
3. The Owner's Representative will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish The Owner's Representative with a telephone number where service representative can be reached at all times. Service personnel shall respond within 2 hours and be at the site within 24 hours after receiving a request for service.
4. Operation: Performance of scheduled adjustments and repairs shall include verification of operation of the system as demonstrated by system acceptance functional performance testing. At minimum the system will be adjusted at the start of the heating and cooling seasons.
5. Systems Modifications: Provide any recommendations for system modification in writing to The Owner's Representative. Do not make any system modifications, including operating parameters and control settings, without prior approval of The Owner's Representative. Any modifications made to the system shall be incorporated into the operations and maintenance manuals as well as any other documentation affected.
6. Software: The owner's representative shall be apprised of all software updates and provided an option to incorporate them into the system at no additional cost. The customer may elect not to install or to remove the updates at their discretion.

C. The warranty shall not include:

1. Standard maintenance items
2. Repairs or replacement of equipment damaged as a result of misuse, abuse, or lack of proper maintenance.
3. Existing equipment and materials not provided by this contract.

PART 2 PRODUCT – NOT USED

PART 3 EXECUTION – NOT USED

END OF SECTION 01 78 36

SECTION 01 79 00
DEMONSTRATION AND TRAINING

PART 1 GENERAL

1.01 TRAINING INSTRUCTIONS

A. On-Site Training: Provide services of controls contractor's qualified technical personnel for the training described in section C below. The AOC's representative shall notify contractor 1 week in advance of each day of requested training. The Contractor's designated training personnel shall meet with the Engineer and AOC's representative for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall generally be as follows:

1. Air Handling Units
    a. Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, and any other pertinent control operation.
    b. Review of installed components and how to install/replace, maintain, commission, and diagnose them.
    c. General review of sequence of operations for the controlled mechanical equipment, including stand alone and fail safe modes.
2. Operator Workstation (OWS) Training – For all potential users of the OWS:
    a. Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of portable and built-in operator interface device display capabilities.
    b. Brief overview of the various parts of the O&M Manuals, including hardware and software programming and operating publications, catalog data, controls installation drawings, and DDC programming documentation.
    c. Demonstration of workstation login/logout procedures, password setup, and exception reporting.
    d. Demonstration of workstation menu penetration and broad overview of the various workstation features.
    e. Overview of systems installed.
    f. Present all site-specific point naming conventions and points lists, open protocol information, configuration databases, back-up sequences, upload/download procedures, and other information as necessary to maintain the integrity of the Direct Digital Control.
    g. Overview of alarm and trending features.
    h. Overview of workstation reports.
    i. Review of installed components and how to install/replace, maintain, commission, and diagnose them.
    j. General review of sequence of operations and control logic for the project site, including stand alone and fail safe modes.
    k. Uploading /Downloading and backing up programs.

l. BAS Server Administration: facility lead engineers shall be trained on administrative privileges, including user account management and system server maintenance.

B. Submittals

1. Contractor shall submit a Training Plan for approval prior to System Readiness Checklist completion in the commissioning process. Training Plan shall include an agenda for each training session shall be included. A blank sign-in sheet shall also be included.

2. Completed Sign-in Sheets shall be submitted as final documentation for the Operation and Maintenance Manuals.

C. Training shall consist of a minimum of 32 hours at beneficial use, 8 hours at project acceptance, a 8 hour follow-up at 3 months, and a 8 hour follow-up at 6 months, and 8 hours prior to the expiration of the 1 year warranty

D. Customer shall be provided with the option of attending factory training courses at an additional cost. A complete list of available classes, costs, and schedules shall be included.

END OF SECTION 01 79 00

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SUMMARY

A. Air Balance
   1. All AHUs, VAV terminals, exhaust fans, and fan coils.

B. Water Balance
   1. Chilled Water systems.
   2. Hot Water systems

1.02 DESCRIPTION

A. Air and water balancing shall be performed by an Independent Test and Balance Agency retained under this Contract. Contractor shall provide all tests, inspections, and preparations specified herein to facilitate balancing activities of the Test and Balance Agency.

B. References:
   1. All referenced specification sections shall be adhered to as if the section was repeated herein
   2. Division 01- General Requirements
   3. All applicable sections of Division 23 – Heating, Ventilation, and Air Conditioning (HVAC)
   4. 23 08 00 Commissioning of HVAC

C. Quality Assurance:
   1. General:
      a. Prior to balancing, Contractor shall perform complete testing, checking, and adjusting of all systems and equipment existing, installed, or modified.
      b. System balancing shall be done by an AABC or NEBB certified agency regularly engaged and specializing in the field of air and water balancing. Testing and balancing shall be performed in complete accordance with the "National Standards for Total System Balance," as published by the Associated Air Balance Council.
      c. The Test and Balance Agency shall have experience in projects of similar type and scope. Submit a list of names and qualifications of all personnel proposed to do this work. A detailed description of the procedures and the instrumentation employed shall accompany the personnel list. Only experienced personnel and rational orderly procedures will be accepted.
   2. Requirements of Regulatory Agencies:
      a. Air balance between and within rooms shall be in accordance with California Mechanical Code.
   3. Referenced Standards:
      a. AABC - Associated Air Balance Council.

b. NEBB - National Environmental Balancing Bureau.

c. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.

D. Submittals

1. Statement from Test and Balance Agency indicating successful balancing of at least three (3) systems of comparable type and size.
2. Qualifications of testing and balancing personnel.
3. Procedure to be followed, including:
   a. Detailed procedures, specific to this project.
   b. Agenda for this project.
   c. Report forms.
   d. Project performance guarantee.
4. Descriptive data, including:
   a. Air flow measuring equipment.
   b. Pressure gauges.
   c. Thermometers.
   d. Other testing instruments.
   e. Certificates of calibration of test instruments.
5. One (1) copy of the field copy report submitted to the Commissioning Authority for review prior to submitting final report.
6. Six (6) copies of the final balance report typed in final form.
7. Written report, as necessary, describing any component, i.e., damper, valve, etc., which does not function properly.

PART 2 PRODUCTS

2.01 MATERIALS

A. Products and materials as specified in Part 3 of this Section and related sections.

PART 3 EXECUTION

3.01 PREBALANCE PREPARATION BY TEST AND BALANCE AGENCY

A. Study the Specifications and Drawings and prepare schedule to inspect, test, and balance air and water systems. Coordinate schedule requirements with the Contractor so that system testing and balancing is complete prior to functional testing of HVAC systems and final acceptance.

B. Within two (2) weeks of receiving authorization for projects notify the Owner in writing if the installation poses any potential balancing problems or if any additional balancing devices which are not shown or specified are necessary for a total system balance.

3.02 FINAL TEST AND BALANCE ACTIVITIES

A. Balancing Criteria

1. Air inlets and outlets of 200 CFM or less shall be balanced to within plus 10 percent to minus 0 percent of design; all other air system readings within plus 10 percent to minus 0 percent of design. Temperature readings shall be accurate to within 1/2 degree Fahrenheit. Water flow readings shall be accurate to within 5 percent. Pressure readings shall be accurate to within 1/2 psi for water systems and 0.01 inch W.G. for air systems.
2. Instruments shall have been calibrated within the last six (6) months and checked for accuracy prior to starting the balancing procedure. Make velocity readings with an instrument that does not require a separate timer.
3. All readings, measurements, and observations shall be recorded on printed data sheets and tabulated with appropriate calculations. Recorded data shall include the following:
   a. Fan speed and calculated fan delivery outlet velocity, inlet and outlet static pressures, drive motor nameplate amperes, and normal operating amperes. This data shall be taken for the existing and new air-handling unit and exhaust fans serving the project area.
   b. Velocities, air volume factors, and calculated air volumes of new air outlets and inlets and those designated during preconstruction tests.
   c. Room temperatures.

B. Air Balancing
1. Make allowance for air filter resistance at the time of the tests. The main air supplies shall be at design air quantities and at an air resistance across the filter banks at the listed pressure drops for dirty filters with the variable frequency drive at 60 Hz or less.
2. Final position of manual dampers shall be plainly marked after balancing is complete.
3. Take measurements with an airflow hood.
4. Record results of the air balancing on AABC or equivalent forms, including positive identification of points of measurements taken, shown on a plan such as a marked print, and include the following data:
   a. Air temperature.
   b. Size of outlet.
   c. Specified CFM.
   d. Specified velocity.
   e. Actual CFM.
   f. Actual velocity.
   g.

Fan Data	Actual	Specified
CFM		
RPM		
TOTAL S.P.		
AMP		
VOLTAGE		

5. Adjust main dampers and splitter dampers before adjusting individual branch dampers. In general, adjust splitter dampers first to obtain the proper proportion of air flow in each branch. Adjust main duct dampers second to obtain design air flows in each main duct. Adjust branch volume dampers last to obtain design air flows in each branch duct.

Dampers behind diffusers or registers shall be utilized only as a final adjustment and only at the Owner's Representative's direction.

6. Make adjustments at all diffusers and registers to prevent drafts at the occupant level in the space. Portions of the diffusers and registers shall be blanked behind these units as directed or required or blades shall be redirected in order to prevent or remove drafts.
7. Positive or negative pressure relationships between supply and exhaust CFM shall be achieved in spaces wherever required by Code. Required air pressure relationships are absolute and shall be met regardless of allowed tolerances for air flow adjustments. All other rooms which are both supplied and exhausted shall be in balance (no difference between supply and exhaust), unless otherwise shown or specified.
8. The balancing report shall include a tabulation for each room CFM as follows:

1	2	3	4	5
Rm. No.	Supply	Exhaust	Return	Difference: Col.2-(Col. 3+4)

9. Report shall include both design and measured values for Col. 2, 3, and 4. Report shall also indicate tabulations of total air flows for each fan system.

C. Hydronic System Balancing

1. Adjust heating hot water and chilled water mains and branches at locations with balancing valves to total flow rates (see locations shown on the Drawings). Adjust coil flow rates.
2. Use permanent flow measurement devices installed for balancing.
3. Repeat balancing procedures as required to arrive at fully balanced systems.
4. Balance report shall include design and measured flow rates and pressure drops at each point where design flow quantity is shown or scheduled on the Drawings, and water temperatures leaving and entering all coils when coils have had both air and water flows balanced.

D. Performance and Capacity Checks

1. Take readings as required to demonstrate that the following equipment is operating in accordance with scheduled performance criteria and the manufacturer's published ratings:
   a. Coils: Report complete coil performance data. Maintain scheduled entering water temperatures during tests. Where possible, control upstream heating coils to maintain scheduled entering air temperatures during tests. At zone heating coils, if excessive heat transfer is measured, reduce scheduled coil gpm to limit leaving air temperature (LAT) to the scheduled LAT + 5 degrees Fahrenheit.
   b. Spot Checking: After the Test and Balance Agency has submitted record of final readings, measurements, and test results for all systems, the Owner's Representative will make spot checks of each system. If spot check measurements differ materially from those submitted, the Owner's Representative will direct that the systems concerned be completely rebalanced at the Test and Balance Agency's expense and that new data be submitted.

3.03 COORDINATION WITH HVAC CONTROLS

A. Cooperate with Mechanical Contractor in making system adjustments necessary to accomplish required performance.

B. Become thoroughly familiar with HVAC Sequence of Operation.
   1. Where sequences require establishment of minimum and maximum air flows, multiple setpoints, reset schedules, or other variable conditions, furnish all testing and balancing necessary to establish required setpoints and fully balance systems under all possible operating conditions.
   2. Report measurements under all operating conditions as necessary to document proper system operation under all specified modes of operation.

C. Check the following:
   1. All devices are properly calibrated. Make temperature and pressure readings as necessary to verify calibration.
   2. Room temperature sensors and thermostats are installed to avoid erratic operation due to drafts or cold walls.
   3. Sensors are properly positioned to read intended temperatures.
   4. Simultaneous heating and cooling does not occur.
   5. Setpoints meet the intent of the Sequence of Operation.
   6. System interlocks operate properly.
   7. System components operate safely.

D. Submit written report to document control system coordination checking.

3.04 ACCEPTANCE TESTING

A. Cooperate as necessary and assist the temperature controls installer and Contractor in performing test runs of HVAC systems as specified in Section 01 00 00 General Requirements.

B. Comply with Section 23 08 00 Commissioning of HVAC

END OF SECTION 23 05 93

SECTION 23 08 00
COMMISSIONING OF HVAC

PART 1 GENERAL

1.01 DEFINITIONS

A. Acceptance Phase: Phase of construction after Startup and initial checkout when Functional Performance Tests, operation and maintenance documentation review, and training occurs.

B. Approval: Acceptance that a piece of equipment or system has been properly installed and is functioning in tested modes according to the Contract Documents and Cx Plan.

C. Building Automation System (BAS): The automated building system providing control and user interaction with select building systems.

D. Commissioning (Cx): Process by which an equipment, building, or plant (which is installed, or is complete or near completion) is tested to verify if it functions according to its design objectives or specifications.

E. Commissioning Authority (CxA): An independent agent hired directly by the Owner and not otherwise associated with the Architect / Design Engineer(s) or the Contractor. The CxA coordinates, witnesses, and approves the Cx activities on behalf of the Owner.

F. Cx Issue: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the requirements of the Contract Documents and/or effects, prevents, or inhibits commissioning, and must be resolved to finalize the Cx Process.

G. Commissioning Issues Log: A log maintained by the CxA listing all Deficiencies and Commissioning Issues documented during the commissioning process. All issues require action, correction, and closure, and shall be categorized as Open or Closed.

H. Cx Plan: The overall plan, developed before or after bidding, that provides structure, schedule and coordination planning for the Cx Process.

I. Contractor: The General Contractor directly contracted to the Owner with overall responsibility for project and all Cx activities described. The Contractor is responsible for all work within its contract scope, including that of the Trade Contractors.

J. Contractor's Commissioning Coordinator (CxC): Individual designated by the Contractor who plans, schedules, directs and coordinates all Cx activities and serves as the Cx Authority's single point of contact on behalf of the Contractor for all administrative and coordination issues.

K. Deferred Testing: Functional Performance Tests performed after Substantial Completion due to partial occupancy, equipment seasonal requirements, design or other site conditions that prevent the test from being performed during construction Acceptance Phase.

L. Factory Testing: Testing of equipment on-site or at the factory by factory personnel with an Owner's representative present if deemed necessary by the Owner.

M. Functional Performance Testing (FPT): A test of the dynamic function, operation, and control of equipment and systems (rather than just components) under various modes such as; during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, alarm, power failure, etc. The FPTs run through all the control system's sequences of operation and the system responses are verified to be responding as the sequences state. The FPTs also include Monitoring or Trending the system performance over time to verify integrated operation and system performance to the fullest extent of the design intent and specified control sequences.

N. Installation Verification: Field verification of proper installation of system components. Process is complete when systems are ready for startup.

O. Pre-Functional Checks & Tests: Various checks and tests performed on a piece of equipment or control system after installation is complete and prior to Functional Performance Testing, to prepare the equipment of system for initial operation. They are typically done to confirm that equipment and individual components are working properly, such as electrical spot measurements on motors, spot flow measurements, pressure testing, pipe flush-out and cleaning, control point-to-point checks, sensor calibration, actuator testing, etc., and include such things as mechanical system test and balance. Pre-Functional checks & tests are organized and recorded under the System Readiness Checklist (SRC) forms.

P. System Readiness Checklist (SRC): A checklist covering Installation Verification, Startup, and Pre-functional checks & tests to conduct and verify proper installation and Startup of the equipment prior to Functional Performance Testing. System Readiness Checklists are essentially a summary checklist, ideally a one-page cover sheet, governing all necessary static inspections and procedures to prepare the equipment of system for Functional Performance Testing. SRCs include simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor). Vendor standard installation, Startup and Pre-functional checklists shall be attached to the related SRC.

Q. Sampling: Inspecting or testing only a fraction of total number of identical or near-identical pieces of equipment.

R. Seasonal Tests: Functional tests that are deferred until environmental conditions closer to design conditions are experienced.

S. Startup: Initial starting or activating of dynamic equipment

T. Sub-Contractor: Typically a subcontractor to the Contractor who provides and installs specific building components and systems.

U. TAB: Testing, Adjusting, and Balancing or Test and Balance

V. Trending: Monitoring using the Building Automation systems (BAS) to aid in functional testing and verify system operation and performance under actual operating conditions.

W. Warranty Period: Warranty Period for the entire project, including components. Refer to General Conditions, Warranty, Guaranty, and Inspection of Work, for Warranty, Extended Guarantees, and Correction Period provisions.

1.02 CONTRACTOR RESPONSIBILITIES

A. Completely install and thoroughly inspect, startup, test, adjust, balance, and document all systems and equipment.

B. Assist Commissioning Authority (CxA) in performance verification and performance testing. This will generally include the following:

1. Attend Commissioning (Cx) progress and coordination meetings.
2. Prepare and submit required draft forms and systems information.
3. Establish trend logs of system operation as specified herein.
4. Demonstrate system operation.
5. Manipulate systems and equipment to facilitate testing.
6. Provide instrumentation necessary for verification and performance testing.

7. Manipulate control systems to facilitate verification and performance testing.
8. Train AOC's Representatives as specified in section 01 79 00 Demonstration - Training.

C. Provide a HVAC Technician to work with Commissioning Authority for installation verification, start-up, system readiness, and functional performance testing.

D. Compensation for Retesting: Contractor shall compensate AOC for site time necessitated by incompleteness of systems or equipment at time of functional performance testing. All testing failures which require on-site time for retesting will be considered actual damages to the AOC. All parties under contract with the AOC who are affected by the retesting shall be included in the contract modification.

1.03 SEQUENCING

A. The following list outlines the general sequence of events for submittals and commissioning:

1. Submit product data and shop drawings, and receive approval.
2. Submit Start-Up Checklists and manufacturer's start-up procedures for all HVAC equipment provided.
3. Submit Start-Up Test Agenda and Schedule for review.
4. Receive start up Test Agenda/schedule approval.
5. Submit Training Plan.
6. Place systems under automatic control where applicable during a scheduled outage.
7. Perform automatic control start up where applicable during a scheduled outage.
8. Prepare and initiate trend log data storage and format trend graphs if applicable.
9. Submit completed Start-Up Reports and initial draft of the O&M Manuals.
10. Receive Start Up Report approval and approval to schedule Demonstrations and Commissioning.
11. Demonstrate all HVAC systems to Commissioning Authority and AOC.
12. Receive demonstration approval and approval to schedule Acceptance Period.
13. Train AOC on HVAC and HVAC operation and maintenance.
14. Substantial Completion.
15. Begin Acceptance Phase.
16. Two week Operational Test.
17. Perform Functional Performance Testing.
18. Receive Acceptance Period approval, which is Functional Completion for the HVAC.
19. Train AOC on final sequences and modes of operation.
20. Install framed drawings.
21. Provide Top-Level BAS and computer platform password access to the AOC.
22. Revise and re-submit record drawings and O&M Manuals.
23. Final Acceptance.
24. Begin Warranty Phase.

25. Schedule and begin Opposite Season acceptance period.
26. Receive Opposite Season acceptance period approval.
27. Submit as-built drawings and O&M Manuals.
28. Update framed drawings as needed.
29. End-of-Warranty date/period.

PART 2 PRODUCTS

2.01 INSTRUMENTATION

A. Instrumentation required to verify readings and test the system and equipment performance shall be provided by Contractor and made available to Commissioning Authority. Generally, no testing equipment beyond that required to perform Contractors work under these Contract Documents will be required. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

PART 3 EXECUTION

3.01 COMMISSIONING SCHEDULE

A. Preliminary Cx Schedule: The CxA shall provide an initial schedule of Cx events to the CxC at the Cx kickoff meeting.

B. Cx Schedule: The Contractor shall integrate all Cx activities into the master construction schedule.

C. Cx Schedule Change: The Cx team and others involved in the Cx Process will address scheduling problems and make necessary notification in a timely manner in order to expedite the Cx Process.

D. Cx Activities Confirmation Notice: The CxC shall provide sufficient notice to the CxA and the Owner for scheduling and coordinating Cx activities. A minimum two-week's notice shall be provided to the CxA for final scheduling confirmation of witnessing equipment Start-ups, Pre-Functional checks & tests, and Functional Performance Testing.

E. Cx Coordination: CxC is to coordinate all function performance testing with the contractors and CxA. Provide a minimum of two weeks notice for each system.

F. Startup Schedule: Provide two weeks notice to the CxA of start-up activities, and coordinate witnessing of SRCs where required by the CxA.

3.02 SUBMITTALS

A. CxA Submittals Request: Provide Cx related submittals as they are available to the CxA for review. The CxA will review the submittal log/schedule and highlight which submittals shall have a Cx review. The CxA will review submittals and comment on Cx related issues. The CxA will also utilize the submittals in the developing Cx forms.

1. The CxA will review submittals
2. The CxA may request additional design, equipment, control sequences, or checkout forms as deemed necessary.
3. O & M manuals: Submittal Information does not constitute compliance for Operation and Maintenance Manual documentation. See specification section 01 78 23.

3.03 COMMISSIONING SUBMITTALS

A. Installation Verification and System Readiness Checklist documents
   1. Manufacture's standard written installation and startup checkout procedures report
   2. Contractor's Startup Report
   3. Contractor's Prefunctional Checklist Forms
   4. Factory Test Procedures
   5. Contractor Functional Performance Testing Procedures
   6. Program Report applicable to each system
   7. System Readiness Checkout Forms (CxA assist Contractor as required)

B. Functional Performance Test documents
   1. Contractor's Functional Performance Testing Report
   2. Training Plans
   3. Operation and Maintenance Manual

C. Reference trade specific for submittals requirements as applicable.

3.04 INSTALLATION VERIFICATION AND SYSTEM READINESS CHECKOUT

A. SRCs Utilization: Utilize and complete the System Readiness Checklist (SRC) to ensure the equipment and systems are connected, operational, and ready for functional testing.
   1. Installation Verification: Each piece of equipment shall receive a full installation verification inspection and startup and checkout (including pre-functional, component checks and tests) by the Contractor. Percentage Sampling may be used as directed by the CxA.
   2. SRC's sign off: System readiness testing for a given system must be successfully completed, and signed off by the CxA, prior to formal functional performance testing of equipment of subsystems or the given system.

B. Installation Verification (IV): Provide a complete package of Installation Verification documents as described herein and specific Cx specification for each division.
   1. Contractor Representation: Experienced and competent contractor personnel are responsible for completing System Readiness Checklists and equipment startup, assigned by the CxC.
   2. IVs / SRCs Contractor Responsibility: The Contractor shall be responsible for ensuring by completing the SRC Checklist Form and completing the installation verification described herein and the division specific Cx plan.
   3. CxA Assist: The CxA will assist the Cx team members responsible for startup of any equipment in their development of installation verification checks, detailed startup and checkout plans, and pre-functional, component level checks and tests.
   4. CxA Installation Verification Role: The primary role of the CxA in this process is to review these forms and to ensure that there is written documentation that each of the manufacturer-recommended procedures and factory and specified tests have been completed.

5. SRCs Checkout: SRCs are developed by the CxA with the input from the CxC and Contractors. The CxC shall submit to the CxA the full set of completed installation, startup and pre-functional checkout forms, based primarily on the manufacturer's detailed installation, startup and checkout sheets. Each SRC may have more than one responsible contractor for its execution.

C. Installation Verification (IV) issues: Clearly list any outstanding items of installation, startup and prefunctional checkout procedure that were not completed successfully, at the bottom of the SRC form or attached sheet. Submit this list to the CxA within two (2) days of discovery.

D. CxA I.V. Review: The CxA reviews all Contractor completed forms and documentation and submits either a non-compliance report (with deficiencies noted on the CxA's Issues List) or an approval form to the Contractor and the Owner.

E. Issues: Correct and retest issues in a timely manner and notify the CxA as soon as the issue has been corrected. Submit updated SRC forms with a Statement of Correction

3.05 FUNCTIONAL PERFORMANCE TESTING

A. CxA FPTs: The CxA will provide the functional performance test for the following systems:

1. HVAC Mechanical Systems controlled by the new BAS.

B. Contractor FPTs: Contractor's Functional Performance Testing Procedures not specified above shall be provided by the Contractor to the CxA for approval.

1. The following information shall be shown on the contractor FPTs:

a. System and equipment or component name(s)

b. Equipment location and identification number

c. Reference to unique system readiness checklist and start-up documentation identification numbers for the piece of equipment

d. Date

e. Project name

f. Participating parties

g. A copy of the specification section describing the test requirements

h. A copy of the specific sequence of operations or other specified parameters being verified

i. Points list

j. Formulas used in any calculations

k. Required pre-test field measurements

l. Instructions for setting up the test

m. Special cautions, alarm limits, etc.

n. Procedures Protocol: Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format, including any control system point value or setpoint overrides required to simulate a certain test condition or sequence mode.

o. System Response / Acceptance: The expected system response and acceptance criteria of proper performance with a Yes/No check boxes for initial test and rested to

allow for clearly marking whether or not proper performance of each part of the test was achieved

p. A section for recording actual system response, notes and comments

q. Signatures and date block for the CxA

C. FPTs Execution: Utilize and complete the Functional Performance Test (FPT) forms to demonstrate the correct operation and functionality of commissioned systems.

1. FTPs Execution Method: Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. Test are executed by the contractor prior to witness by the CxA to reduce the need for back checks.

2. Equipment FPT Execution: Each piece of equipment shall be subjected to a full Functional Performance Test by the Contractor.

3. Contractor FTPs Execution: The CxA will witness the contractors demonstrate the results of functional performance test. The contractor is to use the approved contractor FPT form to perform the test of the specified system. A final copy of testing report shall be submitted to the CxA.

4. CxA FTPs Witness: The CxA will witness and document as the contractor demonstrates the results of functional performance tests using the FPTs.

5. Set System To Normal Operation: At completion of the test, the Contractor shall return all effected building equipment and systems, due to these temporary modifications, to their pre-test and normal condition.

3.06 ISSUES LOG

A. Issue Log: The CxA will use the Issue Log to maintain record of the issues found during the construction phase of the project. The contractor is to provide resolutions of the issues found.

B. Problem Solving: The CxA will recommend solutions to problems found; however, the burden of responsibility to solve, correct and retest problems is with the CM, GC, Contractor, and the Architect and/or Design Engineer.

C. Immediate Correction: Immediate corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases, the issue and resolution will be documented on the FPT form.

D. FPTs delays: Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not overlook issues or loosen acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the written request of the Owner.

E. Record Issue Item Protocol: As tests progress and issues are identified, the CxA will discuss the issue with the executing Contractor and/or CxC.

1. Issue Accept: When there is no dispute on the Cx issue and the Contractor accepts responsibility to correct it:

a. Document: The CxA documents the issue and the Contractor’s response and intentions and they go on to another test or sequence.

b. Submit: The CxA submits the Issue Log to CxC and the Owner.

c. Correction: The Contractor corrects the issue, provides resolutions, comments, and signs off the issues item on the issue log.

d. Retest: The CxC schedules the re-test with the CxA and Contractor and the test is repeated.

2. Issue Dispute: If there is a dispute about a issue, regarding whether it is an issue or who is responsible:

a. Document: The issue shall be documented on the issues Log with the Contractor's response and a copy is given to the Owner, CxC and to the Contractor representative assumed to be responsible.

b. Accept Responsibility / Correct Issue: Resolutions are made at the lowest management level possible. Once the interpretation and resolution have been decided, the appropriate party corrects the issue, provides resolutions comment and sign off the issues item on the issue log.

c. Retest: The CxC schedules the retest with the CxA and Contractor and the test is repeated.

F. Cost Responsibility: The cost for the Contractor to retest a functional performance test, if they are responsible for the issue, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the Contractor.

G. Non SRC Issues / Startup Faults: For an issue identified, not related to any system readiness checklist or start-up fault, the following shall apply:

1. Test1 No Charge: The CxA and the Owner will require the retesting of the equipment once at no "charge" to the Contractor.

2. Test2 Charge:

a. SRC Equipment Failure during FPT Test1: The time for the CxA and the Owner to witness any retesting required because a specific System Readiness Checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be back-charged to the Contractor.

b. CxA and Owner witness Test2: The CxA and Owner's time for a second retest will be back-charged to the Contractor.

c. Retest CxA Cost: The Contractor shall cover the cost of back charges from the CxA for excessive retesting.

H. Issue Update: The Contractor shall respond in writing to the CxA and the Owner at least as often as Cx meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.

3.07 OWNER ACCEPTANCE AND PROJECT CLOSEOUT

A. Closeout Documents: Post-construction Contractor responsibilities include completion and submission of the Project Closeout Checklist for each commissioned system, to the CxA, for verification of completing contracted obligations for the Owner.

B. Require Items To Close: The CxA will detail items that were not closed out during the Cx phase of the project. The Owner's will require the Contractors to return and make repairs as of the systems as required. In some cases, the owner will accept the systems as-is and will make repairs after the occupancy of the building.

C. Final Completion Report: Upon completion of all Cx activities, the CxA will prepare and submit to the Owner Final Completion Report detailing the Cx Plan and all Cx activities and

recommending for acceptance of the Building. The CxC will support this effort by coordinating provided documentation.

3.08 WRITTEN WORK PRODUCTS

A. Documents: All checklists, startup documentation, test forms and other Cx related documentation required by contract shall be neatly and legibly completed and provided to the CxA via the CxC in a clear and easily readable condition.

B. Document Delivery: All required checklists, startup documentation, test forms and other Cx related documentation shall be provided to the CxA via the CxC in a timely fashion and according to the Cx and construction schedule.

C. Document Delivery Compliance: In every case where the Contractor is unable to comply with an item as listed on the checklist or form, the Contractor shall immediately notify the CxC, who shall in turn notify the CxA in writing as to the reasons for non-compliance.

D. Written Work Product: The Cx Process generates a number of written work products described in various parts of the Specifications. The Cx Plan will list all the formal written work products, will describe briefly their contents, who is responsible to create them, their due dates, who receives and approves them and the location of the specification to create them.

END OF SECTION 23 08 00

SECTION 23 09 13
INSTRUMENTATION AND CONTROL FIELD DEVICES DDC

PART 1 GENERAL

1.01 SECTION INCLUDES

A. General
B. Control Panels
C. Control Valves
D. Actuators
E. General Field Devices
F. Temperature Sensors
G. Temperature Transmitters
H. Differential Pressure Transmitters
I. Differential Pressure Switches
J. Pressure Switches
K. Current Switches
L. Current Transformers
M. CO_2 Sensors/Transmitters
N. Electric Control Components (Switches, EP Valves, Thermostats, Relays, Smoke Detectors, etc.)
O. Refrigerant Monitors
P. Nameplates
Q. Testing Equipment

1.02 DESCRIPTION OF WORK

1. The intent of this section is to provide a complete “turnkey” design-build replacement of the existing control systems. All required labor and materials to complete this work is to be provided by the Contractor.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. General: Provide electronic control products in appropriate sizes and capacities, consisting of valves, dampers, thermostats, clocks, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

B. New Control Panels:

1. Provide all panels and enclosures required for the scope and design intent of this project
2. Refer to 23 09 27 Field Panels

C. Control Valves

1. General: Provide factory fabricated control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as

determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Control valves shall be equipped with heavy-duty actuators, and with proper close-off rating for each individual application. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

2. Plug-Type Globe Pattern for Water Service:
    a. Valve Sizing: Where not specifically indicated on the control drawings, modulating valves shall be sized for maximum full flow pressure drop between 50% and 100% of the branch circuit it is controlling unless scheduled otherwise. Two-position valves shall be same size as connecting piping.
    b. Single Seated (Two-way) Valves: Valves shall have equal-percentage characteristic for typical heat exchanger service and linear characteristic for building loop connections to campus systems unless otherwise scheduled on the drawings. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on 'top-and-bottom' guided plugs.
    c. Double Seated (Three-way) Valves: Valves shall have linear characteristic. Valves shall be balanced-plug type, with cage-type trim providing seating and guiding surfaces on 'top-and-bottom' guided plugs.
    d. Temperature Rating: 25°F minimum, 250°F maximum
    e. Body: Bronze, screwed, 250 psi maximum working pressure for 1/2" to 2"; Cast Iron, flanged, 125 psi maximum working pressure for 2-1/2" and larger.
    f. Valve Trim: Bronze; Stem: Polished stainless steel.
    g. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting.
    h. Plug: Brass, bronze or stainless steel, Seat: Brass
    i. Disc: Replaceable Composition or Stainless Steel Filled PTFE.
    j. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)
    k. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:
        1) Belimo
3. Butterfly Type:
    a. General: Butterfly valves shall only be used for two position control. Butterfly valves for modulating control is not allowed.
    b. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class 125 or 250 bolt pattern to match specified flanges.
    c. Seat: EPDM, except in loop bypass applications where seat shall be metal to metal
    d. Disc: Bronze or stainless steel, pinned or mechanically locked to shaft
    e. Bearings: Bronze or stainless steel
    f. Shaft: 416 stainless steel
    g. Cold Service Pressure: 175 psi
    h. Close Off: Bubble-tight shutoff to 150 psi

i. Operation: Valve and actuator operation shall be smooth both seating and unseating. Should more that 2 psi deadband be required to seat/unseat the valve, valve shall be replaced at no cost to the Government.

j. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

1) Jamesbury WS815

2) Bray Series 31

3) Keystone AR2

4) Dezurik BGS

4. Ball Type

a. Body: Brass or bronze; one-, two-, or three-piece design; threaded ends.

b. Seat: Reinforced Teflon

c. Ball: Stainless steel.

d. Port: Standard or 'V' style.

e. Stem: Stainless steel, blow-out proof design, extended to match thickness of insulation.

f. Cold Service Pressure: 600 psi WOG

g. Steam working Pressure: 150 psi

h. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

1) Conbraco

2) Worcester

3) Nibco

4) Jamesbury

5) PBM

6) Delta

5. Segmented or Characterized Ball Type

a. Body: Carbon Steel (ASTM 216), one-piece design with wafer style ends.

b. Seat: Reinforced Teflon (PTFE).

c. Ball: Stainless steel ASTM A351

d. Port: Segmented design with equal-percentage characteristic.

e. Stem: Stainless steel.

f. Cold Service Pressure: 200 psi WOG

g. Cavitation Trim: Provide cavitation trim where indicated and/or required, designed to eliminate cavitation and noise while maintaining an equal percentage characteristic. Trim shall be a series of plates with orifices to break the pressure drop into multi-stages.

h. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

1) Jamesbury R-Series

2) Fisher

D. ACTUATORS

1. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.

2. Damper Actuators

a. Ambient Operating Temperature Limits: -10 to 150°F (-12.2 to 66 °C)

b. Two Position Electric Actuators: Line voltage with spring return

c. Electronic Actuators: Provide actuators with spring return for two-position (24v), 0-5 VDC, 0-10 VDC, 2-10VDC, 4-20 mA, or PWM input (subject to restrictions) as required. Actuators shall travel full stroke in less than 90 seconds. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel or in sequence provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override where indicated. Modulating actuators for valves shall have minimum rangeability of 40 to 1.

d. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off pressure for two-way water valve applications shall be the shutoff head of associated pump. Required close-off rating of steam valve applications shall be design inlet steam pressure plus 50 percent for low pressure steam, and 10 percent for high pressure steam. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent.

e. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

1) Belimo

3. Quarter-Turn Actuators (for ball and butterfly valves):

a. Electric

1) Motor: Suitable for 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.

2) Gear Train. Motor output shall be directed to a self locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.

3) Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure

4) Failsafe Positioning: Actuators shall be spring return type for failsafe positioning.

5) Enclosure: Actuator enclosure shall be NEMA-4 rated, and shall have a minimum of two threaded conduit entries. Provide an enclosure heater for actuators located outside of buildings.

6) Limit Switches: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.

7) Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.

8) Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared handwheel type. For larger valves, the override shall be a fixed geared handwheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the handwheel is engaged for manual operation.

9) Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.

10) Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.

11) Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 VDC, 2-10 VDC, and 135 Ohm potentiometer.

12) Ambient Conditions: Actuator shall be designed for operation from –140 to 150 °F ambient temperature with 0 to 100 percent relative humidity.

E. GENERAL FIELD DEVICES

1. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

2. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

3. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with ‘two-wire’ type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide ‘four-wire’ type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

4. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

5. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, nonrepeatability, and hysteresis.

F. TEMPERATURE SENSORS (TS)

1. Sensor range: When matched with A/D converter of BC, AAC/ASC, or SD, sensor range shall provide a resolution of no worse than 0.3°F (0.16 °C) (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.
2. Room sensors shall be an element contained within a ventilated cover, suitable for wall mounting. Provide insulated base. The following sensing elements are acceptable:
    a. Room temperature sensors are to be provided with a cover to prevent accidental damage.
    b. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.
    c. Provide setpoint adjustment where indicated. The setpoint adjustment shall be a warmer/cooler indication.
    d. Provide an occupancy override button on the room sensor enclosure where indicated. This shall be a momentary contact closure
    e. Provide current temperature indication via an LCD or LED readout where indicated.
3. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.
    a. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.2°F accuracy at calibration point
4. Liquid immersion temperature sensor shall include thermowell, sensor and connection head for wiring connections. Temperature range shall be as required for resolution of 0.15°F.
    a. Sensing element (chilled water/glycol systems) shall be platinum RTD +/- 0.2°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.15°F.
    b. Sensing element (other systems) shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.3°F.
5. Outside air sensors shall consist of a sensor, sun shield, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as require for resolution indicated in Paragraph A
    a. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

G. TEMPERATURE TRANSMITTERS

1. Where required by Controller, or where wiring runs are over 50 feet, sensors as specified above may be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1°F when applied to the sensor range.

H. DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

1. General Purpose - Water: Two-wire transmitter, 4-20 mA output with zero and span adjustments. Plus or minus 0.5% overall accuracy, 450 psig (3103 KPa) maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450

psid for 100 through 300 psid range. Acceptable units shall be Kele & Associates Model 360 C. Substitutions shall be allowed per AOC approval.

2. General Purpose Low Pressure Air: Generally for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.
    a. General: Loop powered two-wire differential capacitance cell-type transmitter.
    b. Output: two wire 4-20 mA output with zero adjustment.
    c. Overall Accuracy: Plus or minus 1%.
    d. Minimum Range: 0.1 in. w.c.
    e. Maximum Range: 10 inches w.c.
    f. Housing: Polymer housing suitable for surface mounting.
    g. Acceptable Manufacturers: Modus T30. Substitutions shall be allowed upon review.
    h. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
    i. Range: Select for specified setpoint to be between 25% and 75% full-scale.
3. VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS
    a. Provide a five valve bypass kit for protection of DP sensors where the static on the pipe can cause an over-pressure condition when connected to one port with the other at atmospheric pressure. Kit shall include high and low pressure isolation valves, high and low pressure vent valves, and a bypass valve contained in a NEMA-1 enclosure.

I. DIFFERENTIAL PRESSURE SWITCHES (DPS)

1. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

J. PRESSURE SWITCHES (PS)

1. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.
2. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Pennor, or approved equal

K. CURRENT SWITCHES (CS)

1. Clamp-On or Solid-Core Design Current Operated Switch (for Constant Speed Motor Status Indication)
    a. Range: 1.5 to 150 amps.
    b. Trip Point: Adjustable.
    c. Switch: Solid state, normally open, 1 to 135 VAC or VDC, 0.3 Amps. Zero off state leakage.
    d. Lower Frequency Limit: 6 Hz.
    e. Trip Indication: LED
    f. Approvals: UL, CSA

g. Max. Cable Size: 350 MCM

h. Acceptable Manufacturers: Veris Industries H-708/908; Inc., RE Technologies SCS1150A-LEDor approved equal

2. Clamp-on or Solid-Core Wire Through Current Switch (CS/CR) (for Constant Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 VAC resistive, 3A @ 240 VAC inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938/735; or RE Technologies RCS 1150or approved equal

   a. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to Kele RIBX or approved equal

3. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication

   a. Range: 1.5 to 135 Amps.

   b. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.

   c. Switch: Solid state, normally open, 1 to 135 VAC or VDC, 0.3 Amps. Zero off state leakage.

   d. Frequency Range: 5-75 Hz

   e. Trip Indication: LED

   f. Approvals: UL, CSA

   g. Max. Cable Size: 350 MCM

   h. Acceptable Manufacturers: Veris Industries, Inc. H-904.

4. Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 VAC resistive, 3A @ 240 VAC inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable manufacturer shall be Veris Industries, Inc., Model # H934.

5. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

L. CURRENT TRANSFORMERS (CT)

1. Clamp-On Design Current Transformer (for Motor Current Sensing)

   a. Range: 1-10 amps minimum, 20-200 amps maximum

   b. Trip Point: Adjustable

   c. Output: 0-5 VDC.

   d. Accuracy: ±0.2% from 20 to 100 Hz.

   e. Acceptable Manufacturers: KELE SA100 or approved equal

M. CO_2 SENSORS/TRANSMITTERS (CO2)

1. CO_2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
    a. Accuracy: ±36ppm at 800 ppm and 68°F.
    b. Stability: 5% over 5 years.
    c. Output: 4-20 mA, 0-10 VDC, or relay.
    d. Mounting: Duct or Wall as indicated.
    e. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW20 (wall).

N. ELECTRIC CONTROL COMPONENTS

1. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley or approved equal
2. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.
    a. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:
        1) AC coil pull-in voltage range of +10%, -15% or nominal voltage.
        2) Coil sealed volt-amperes (VA) not greater than four (4) VA.
        3) Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
        4) Pilot light indication of power-to-coil and coil retainer clips.
        5) Coil rated for 50 and 60 Hz service.
        6) Acceptable Manufacturers: Relays shall be Potter Brumfield, Model KRPA. Substitutions shall be approved by the AOC.
    b. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC or approved equal.
    c. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.
3. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1 enclosure. Manufacturer shall be Square 'D', Cutler-Hammer or Westinghouse.
4. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be UL and CSA listed. Primary and secondary sides shall be fused in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA-1 enclosure.
    a. Transformers shall be manufactured by Westinghouse, Square ‘D’, or Jefferson. Substitutions shall be approved by the AOC.
5. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the

application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.

a. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.

b. TDRs shall be UL and CSA listed, Crouzet type or approved equal

O. REFRIGERANT MONITOR (As Necessary, Dependent Upon Equipment Location)

1. General: Contractor shall provide a refrigerant sensitive infrared-based stationary refrigerant gas leak monitor system designed to continuously measure refrigerants. Refrigerant monitor shall be coordinated to detect refrigerants used in chiller equipment. The alarm system shall comply with ANSI/ASHRAE 15-1994 and local code requirements.

2. The refrigerant monitor shall be capable of monitoring multiple refrigerant gas compounds at multiple locations in concentrations of 0 PPM to a minimum of 1000 PPM. The Monitor shall have a low range resolution of 1 PPM in the range of 1 PPM through 100 PPM. Readings above 100 PPM must be accurate to within ±5% of reading. Accuracy shall be maintained within ambient environmental ranges of 0ºC through 50ºC, (32ºF. through 122ºF.) and 5% through 90% relative humidity, non-condensing.

3. The refrigerant monitor shall automatically and continuously monitor the areas through a sample draw type tubular pick up system with an internal pump and filter. The installation of the monitoring control and the tubing shall be in strict accordance with the manufacturer's instructions. The location, routing, and final position of the sample tubes shall be submitted to the engineer with all necessary shop drawings and monitor specifications and installation instructions. Tubing size, tubing material, and tube length limitations shall be within the specifications of the monitor manufacture. The location and method of tube support and hangers must be identified on the shop drawings. Each of the sampling tubes shall have end of line filters.

4. The analyzer will be based on infrared detection technology, and will be factory tested and calibrated for the specified refrigerant or refrigerants. Factory certification of the calibrations shall be provided with the O&M manuals. The analyzer shall provide a menu driven or automatic method of checking both zero, span calibration for each sensor, and allow for adjustment.

5. The monitor shall be equipped with 4 outputs. Three relays shall energize at an adjustable user defined set point based on refrigerant concentration levels. The relay threshold adjustment shall be protected by keyed or password access controls. Adjustments and observations shall be made at the front panel operator interface. The relay threshold values can be viewed without a password. The digital display will continuously display the refrigerant concentration level and alarm status. The fourth output shall indicate a monitor malfunction alarm. The monitor shall also have an analog output that will provide a liner scaled reference to the refrigerant concentration in parts per million. The analog output signal shall be an industry standard DC voltage, or mA current signal.

6. The monitor shall have a NEMA-4 moisture resistant enclosure with a gasket, hinged front cover. Conduits and tube connections shall be located on the bottom of the enclosure. The enclosure shall have a rust and corrosion resistant finish.

7. The following alarm modes will be provided by the refrigerant monitor:

a. ALARM LEVEL ONE – Low level of refrigerant concentration at one of the sampling points has detected the presence of a possible refrigerant leak. The initial alarm threshold shall be set to 5 PPM (adj.) and increased if there are nuisance alarms. This alarm level shall be displayed on the refrigerant monitor interface panel, indicating which sensor has triggered the alarm, and the associated concentration of refrigerant in PPM. This alarm will remain active until the refrigerant concentration is reduced below set point.

b. ALARM LEVEL TWO – This alarm shall indicate that one of the sensors has detected a refrigerant concentration that is approaching dangerous levels in the area being monitored. This alarm shall be set to 25% below the maximum calculated refrigerant level specified in ANSI/ASHRAE 15-1994 and ASHRAE 34-1992. This alarm will be displayed on the monitor interface, and will indicate which of the sensors has caused the alarm, and the highest concentration in PPM. This event will also activate the beacon and audible alarm mounted on the refrigerant monitoring enclosure. In this mode the audible alarm can be silenced, but the beacon shall remain active until the fault is cleared

c. ALARM LEVEL THREE – This alarm shall be set at the maximum calculated refrigerant level specified in ANSI/ASHRAE 15-1994 and ASHRAE 34-1992 whichever is the lowest concentration. The refrigerant monitor interface will display which sensor has caused the alarm, and the associated concentration in PPM. This event will also activate the beacon and audible alarm mounted on the refrigerant monitoring enclosure. If the audible alarm had been silenced by an earlier alarm, the activation of this level three alarm will cause the audible alarm to be activated again. The relay in the refrigerant monitoring panel shall activate the space ventilation system, and will disable all combustion or flame-producing equipment via hardwired control interlocks. In addition, this event and will de-energize the energy source for any hot surface (850°F or 454°C) located in the space. Interlocks must also be provided to close any normally open doors or openings to the space for proper ventilation and isolation during this alarm condition. In this mode, the audible alarm can be silenced, but the beacon shall remain active until the fault is cleared.

P. NAMEPLATES

1. Refer to 6 05 53 ID Elec Systems

Q. TESTING EQUIPMENT

1. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be NIST certified.

PART 3 EXECUTION

3.01 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes and Divisions 26 05 00.

B. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

C. Differential Pressure Transmitters: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

D. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.

E. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.

F. Supply Duct Pressure Transmitters:

1. General: Install pressure tips with at least 4 ‘round equivalent’ duct diameters of straight duct with no takeoffs upstream. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer’s installation instructions. Locate the transmitter at an accessible location to facilitate calibration.

2. Cutting and Patching Insulation: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

END OF SECTION 23 09 13

SECTION 23 09 23
DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 PART 1 - GENERAL

1.01 SCOPE OF WORK

A. A fully integrated building automation system (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control.

B. Complete temperature control system to be DDC as specified herein.

C. Supply and install all instrumentation and control devices as necessary to affect the sequence of operations and/or control diagrams as required for a complete and operating system, whether or not the instrumentation or control devices are explicitly called for.

D. All wiring, conduit, panels, and tubing for all DDC controls.

E. BAS Contractor shall be responsible for all electrical work associated with the BAS control system and as called for on the Drawings.

F. Installation of airflow control system, airflow measuring stations, and static pressure probes.

G. Contractor shall incorporate new sequence of operations and provide a fully operational system that meets the AOC's requirements and complies with all applicable codes.

H. Contractor shall work with the Commissioning Authority to establish a detailed sequence of operations in the submittal phase of the project and finalized prior to completion of functional performance testing.

1. Existing sequences are not to be re-used.

1.02 RELATED WORK

A. Division 00 General and Special Conditions

B. Division 23 All sections Mechanical

C. Division 26 Electrical

1.03 GENERAL PRODUCT DESCRIPTION:

A. Refer to section 23 09 27 and 23 09 13 for hardware devices

1.04 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design and revisions that complies with the specification requirements.

1.05 SUBMITTALS

A. Refer to Section 01 78 23

1.06 WARRANTY

A. Reference Section 01 78 36 Warranties for complete requirements.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Distech Controls, Inc., or approved equal, utilizing native BACnet® as specified herein.

2.02 NETWORKING COMMUNICATIONS

A. The system will consist of a flat, open architecture that utilizes the BACnet protocol as the common communication protocol between all controlled and controlling devices, and LNS architecture for the definition of the device database. No other device database structure will be permitted. When necessary or desired, BACnet packets shall be encapsulated into TCP/IP messages to take advantage of existing infrastructure or to increase network bandwidth. Any such encapsulation of the BACnet protocol into IP datagram's shall conform to existing BACnet specifications for such encapsulation. Systems that utilize non standard routing methods or hierarchal systems consisting of master or global controllers that poll and/or control less intelligent unitary controllers on a secondary bus will not be considered..

B. The system network shall be native BACnet. There will be no consideration given to any system that does not use BACnet as the communications network. System controllers shall be capable of sharing data with other BACnet based devices that utilize the same transceivers.

C. The system installed shall be able to seamlessly connect devices other than HVAC throughout the building regardless of subsystem type, i.e. HVAC and lighting shall coexist on the same network channel without the need for gateways. These components shall share common software for network communications, configuration, time scheduling, alarm handling, history logging, custom programming and monitoring.

D. Gateways shall not be used unless authorized in writing by the project engineer. Use of a gateway requires submittal of the documentation as required by the owner or owner's representative. It is the intent of this specification that gateways be limited to integrating legacy systems where applicable. Acceptance of gateways is at the sole written discretion of the owner and/or owner's representative.

2.03 DDC & HVAC MECHANICAL EQUIPMENT CONTROLLERS

A. Refer to section 23 09 27

2.04 FIELD DEVICES

A. Refer to Section 23 09 13

2.05 WORKSTATION AND SERVER HARDWARE

A. The operator workstation portion of the BAS shall consist of one or more BTL listed advanced operator workstations.

B. The programming and configuration workstation software shall allow any user with adequate permission to create and/or modify any or all parts of the BAS database.

C. All configuration workstations shall be personal computers operating under the Microsoft Windows operating system. The application software shall feature high-resolution color graphics, alarming, trend charting. It shall be user configurable for all data collection and data presentation functions.

D. Any user on the network can access the system, using the following software:

1. Windows 2000/XP and above

2. Internet Explorer 8 or above (32-bit)
3. Firefox 4.0 (32-bit) and above

E. Prior to ordering the computer, the contractor shall provide a specification to the AOC for approval.

F. Provide printers and other peripheral devices

2.06 NETWORK EQUIPMENT

A. Provide and install all required switches and routers to accomplish the scope of work.
1. Prior to ordering the hardware needed, the contractor shall provide a specification to the AOC for approval.
2. Connection to or use of AOC equipment and networks must be approved by the AOC.

B. Where appropriate, existing AOC equipment racks or other mounting devices and locations may be used with prior AOC approval

C.

2.07 COMMAND AND OPERATING SOFTWARE

A. Provide the operation system and all third party software and licenses (i.e. MS Office, SQL) required for system operation and usability.

B. One full licensed copy of all operational, programming, configuration, and balancing software shall be provided. Additional software licenses shall be provided as required to meet the design requirements.

C. As a minimum, the menu driven command and operating software shall permit the operator to perform the following tasks with a minimum knowledge of the HVAC Control System provided and basic computing skills.
1. Configure the network.
2. Create control sequences.
3. Graphical interface to systems.

D. Provide additional third party software to permit the operator to manage hard drive files such as access, delete, copy, modify, etc. The package shall be object oriented and permit the user to manage directories upon boot-up. The file management software shall organize directories and sub-directories using files, file folder objects.

E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.

F. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system supervisor shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

G. System Diagnostics. The system shall automatically monitor the operation of all HVAC control workstations, printers, modems, network connections, and nodes. The failure of these devices shall be annunciated to the operator.

H. Reports and Logs. Provide a reporting package that allows the operator to select, modify, or create reports. Each report shall be definable as to data content, format, interval, and date. Report data shall be archived on the hard disk for historical reporting. Provide the ability for the operator to obtain real time logs of designated lists of objects. Reports and logs shall be stored on the PC hard disk in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Reports and logs shall be readily printed to the system printer. Data shall be able to transferable to other software packages so as to create custom reports.

I. Web Browser Access: The DDC system shall provide total integration of the facility infrastructure systems with user access to all system data, either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet.

J. Graphical Object-Oriented Programming Software

1. The system shall include a graphical object-oriented programming function which shall be used to create all control sequences utilized in programmable nodes. The graphical object-oriented programming function shall provide programming elements to be connected together to create a logic diagram. The graphical object-oriented programming function shall include elements for mathematical, logical, timing, setpoint, display and input/output functions to create logic diagrams that represent sequences of operation for BAS nodes.

2. Program elements shall be able to be combined into a custom template that can then be used as a standard function.

3. Program checkout and debug tools shall include display of real time and/or simulated system variables and inter-object data on the programming screens. The user shall be able to assign fixed or variable values to inputs during the dynamic debugging of the control sequence.

4. The graphical programming tools shall provide the ability to print I/O lists, lists of standard network variables and lists of all parameters to be viewed by the HMI.

5. The programming software shall reside on each Portable Operating Terminal (POT) and Operator Workstation (OW) server for programming and/or configuring each model of BAS node on the project. The applications shall be downloaded and executed at the appropriate nodes. The software shall allow for updated applications via the network from the Operator Workstation.

6. All DDC setpoints, gains, and time constants associated with DDC programs shall be available to the operator for display and modification via the POT, Digital Display Unit (DDU) or OW interface.

7. Library of Applications: A library of control, application, and graphic objects shall be provided to enable the creation of applications and user interface screens. Provide the capability to cut & paste objects and libraries into applications for a node/system. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together, using a built-in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application

objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface display shall not be acceptable.

8. Provide integral trend-logging presentation in the programming screen.
9. Print capability, with page break reference tags to allow down to 8 ½"x 11" size paper
10. Off-line simulations (step function, continuous run function, simulation of external inputs)
11. Dynamic presentation of logic in on-line state (all intermediate values)
12. Text to logic screens
13. Memory monitoring
14. Power cycle restart function
15. Run-time capability
16. Programming Objects
17. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one (fan-in), or one-to-many (fan-out) relationships. Linked objects shall maintain their connections to other objects, regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.
18. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
19. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system (step function and run mode, integral trend logging).
20. The system shall support object duplication within the AOC database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

K. Object Libraries

1. A standard library of object function blocks shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The function blocks in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.

3. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.

L. Application Specific Controller (ASC) Configuration software Tools: Provide application specific controller configuration software tools that will permit the individual local ASC to be configured and commissioned with appropriate parameters. This software will reside on the POT. Functionality shall include:
   1. Translation capability for user defined configuration parameters
   2. Monitoring capability for inputs from the nodes
   3. Ability to set the values for outputs to the nodes

M. The software shall have Client/server capability to allow multiple users ability to manipulate the database simultaneously.

N. Human-Machine Interface - Operator Workstation Software (HMI – OWS)
   1. The HMI shall be a client/server architecture to allow multiple client access to an Ethernet connected server. The workstation shall operate also as a stand-alone workstation/server.
   2. The software shall enable an operator to interact with various devices including BACnet® nodes, recorders, input/output (I/O) systems, intelligent transmitters, and other field devices.
   3. It shall provide the following functions:
      a. Calendar.
      b. Scheduling.
      c. Trending.
      d. Alarm monitoring and routing.
      e. Time synchronization.
      f. Time zone handling
      g. Integration of BACnet® controller data
      h. Color graphic display
      i. On-line plots
      j. System documentation generation
      k. Dispatch of a single time schedule to all programmable nodes

O. System Configuration. At a minimum, the HMI shall permit the operator to perform the following tasks, with proper password access:
   1. Create, delete, upload, or modify control strategies.
   2. Add/delete objects to the system.
   3. Tune control loops through the adjustment of control loop parameters.
   4. Enable or disable systems

5. Generate text file reports to a networked printer.
6. Select points to be alarmable and define the alarm state.
7. Configure alarms to be sent to Microsoft windows mail client
8. Select points to be trended over a period of time and initiate the recording of values automatically.
9. Provide different levels of security to every object in the HMI database
10. Modify and create users with passwords and access levels and also be able to use currently logged on users and passwords

P. Event Alarm Notification and Actions

1. The HMI software shall provide alarm recognition, storage, routing, management, and analysis.
2. The HMI software shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:
    a. To alarm.
    b. Return to normal.
    c. To fault.
4. Provide for the creation of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
5. Provide timed (schedule) routing of alarms by class, object, group, or node.
6. Provide alarm generation from “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
7. Control equipment and network failures shall be treated as alarms and annunciated.
8. Alarms shall be annunciated in any of the following manners as defined by the user:
    a. Screen message text.
    b. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
        1) Day of week.
        2) Time of day.
        3) Recipient.
    c. Pagers via paging services that initiate a page on receipt of email message.
    d. Auto answer (at OWS) and auto dial (from node)
    e. Graphic with flashing alarm object(s).
    f. Printed message, routed directly to a dedicated alarm printer.
    g. Audio messages.

9. The following shall be recorded by the OWS HMI software for each alarm (at a minimum):
    a. Time and date.
    b. Location (building, floor, zone, office number, etc.).
    c. Equipment (air handler #, accessway, etc.).
    d. Acknowledge time, date, and user who issued acknowledgement.
    e. Number of occurrences
10. Alarm actions may be initiated by user defined programmable objects created for that purpose.
11. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
12. A log of all alarms shall be maintained by the OWS HMI and shall be available for review by the user.
13. Attach a graphic screen, text notes, and/or plant status report, to each alarm, as defined by user.
14. Repeat/nuisance alarms must have feature to be disabled, and a feature for monitoring disabled alarms.
15. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. An alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms.
16. The dedicated alarm window shall provide user selectable colors for each different priority of alarm.

Q. Data Collection and Storage Requirements
1. The OWS HMI shall have the ability to collect data for any property of any object and store this data for future use.
2. The data collection shall be performed by objects, resident in the node, and if desired OWS, shall have, at a minimum, the following configurable properties:
    a. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
    b. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
    c. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
    d. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
    e. All log data shall be stored in a database in the OWS HMI and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.

f. Systems that cannot provide log data in HTML formats at a minimum shall not be acceptable.

3. The OW shall have the ability to archive its log data either locally (to itself), or remotely to an OWS server. Provide the ability to configure the following archiving properties, at a minimum:

a. Archive on time of day.

b. Archive on user-defined number of data stores in the log (buffer size).

c. Archive when log has reached its user-defined capacity of data stores.

d. Provide ability to clear logs once archived.

R. Audit Log

1. Provide and maintain an Audit Log that tracks all activities performed on the OWS HMI. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally to OWS HMI or to a server. For each log entry, provide the following data:

a. Time and date.

b. User ID.

c. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

S. Database Backup And Storage

1. The OW shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.

2. Shall have the ability to automatically complete full or partial backups; and have the ability to full or partial restore. Partial is defined as only items that have changed in the database.

3. Copies of the current database and, at the most recently saved database shall be stored in the OW. The age of the most recently saved database is dependent on the user-defined database save interval.

T. Graphical Real-Time Displays. The HMI, shall at a minimum, support the following graphical features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating and importing a GIF, BMP, DWG, DXF, or JPG file format. In addition to, or in lieu of a graphic background, the HMI shall support the use of scanned pictures.

2. Graphic screens shall contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML, or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.

3. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.

4. Commands to start and stop binary objects shall be done by clicking the selected object and selecting the appropriate command from the pop-up menu. Data entry may be typed or mouse entered.

5. Adjustments to analog objects, such as set points, shall be done by clicking the selected object and entering value or using a graphical slider to adjust the value.

U. The OWS shall be able to support multiple graphic objects at the same time. If tiled, then each graphical object shall be fully scalable or aspect locked.

V. Trend Displays (variable versus time) - A trend display shall show the values of points plotted versus time similar to a strip chart recorder. Eight tags shall be trended per trend. The HMI software shall provide real-time and historical trending (for data which had been logged). This may be achieved by either color graphic page display or an Microsoft excel based display.

1. Real-Time Trends - shall contain real-time data without consuming hard disk space.
2. Historical Trends Logs - A historical trend log display presents data stored on the computer's hard disk.
3. X-Y Plots (variable versus variable) - An x-y plot shall dynamically represent the real-time or historical relationship one variable plotted against another variable.
4. Automatic Generation - All trends and plots shall be self-generated and not require any programming by the user.
5. The HMI software shall provide dialog boxes and menu picks for configuring trends and plots.
6. Any analog or binary data may be trended or plotted.
7. The software shall store pre-configured presentation of trends to facilitate operator call-up of trend log displays. It shall be possible to call up a trend log with pre-assigned data.

W. Graphics Builder - The HMI software shall provide a graphics builder.

1. Display Documentation - The graphics builder shall provide show, simulate, review, and document animation functions to allow the user to identify, diagnose, change, and document animation points on each display.
2. A library of vendor-supplied objects will be included. These objects, widgets, and symbols must be continuously scalable. These items shall be editable by the user.
3. A library of animated graphic objects shall be included.
4. Animation - The Graphics Builder will animate process graphics with real-time data from field devices.
5. Multi-State Color Animation shall be provided to change a graphic object's color from a palette of colors.
6. Alarm Color - Color animation for normal, alarm, and alarm acknowledged states for both analog and binary point tags shall be provided. The user shall define the foreground and background colors for each state.
7. Alarm Blink – Objects and text data shall blink based on alarm state and acknowledged state.
8. Text and Numeric Animation - The software shall display the numeric value of an analog point, text of a text point, and the descriptors of a binary point. Display Linking - The software shall provide a display linking function. Clicking the object associated with the link changes the display to a new user-defined display.
9. Pickable/Non-Pickable - The software shall enable active points to be selected with the mouse and accessed. It shall be possible to make a point non-pickable: the dynamic

information shall be displayed, but the operator will not be able to access a detail display, change the value, etc. based on security settings of the software.

10. Ability to open external executable files from button click
11. Ability to open HTML web pages from button click
12. Ability to view Microsoft Excel files from button click

X. On-Line Help. Provide a context sensitive help system to assist the operator in operation and editing of the system. Help screens shall be available for all applications and shall provide the relevant data for that particular screen.

Y. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data.

1. System security shall be selectable for each operator.
2. The system administrator shall have the ability to set passwords and security levels for all other operators.
3. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object.
4. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected.
5. All system security data shall be stored in an encrypted format.
6. Each object in the HMI database must be able to have a security policy applied to it.

Z. System Diagnostics. The system shall automatically monitor the operation of network connections and controllers. The failure of any device shall be annunciated to the operator.

AA. Microsoft Report Generation – The HMI software shall be able to seamlessly interact with Microsoft Office Products, including Excel, with no additional programming.

PART 3 EXECUTION

3.01 NETWORKING/SYSTEM ARCHITECTURE

A. Hardwired Network Communications – Provide network connections between all controllers and workstations. Install communications trunk in conduit. Install network termination resistors per manufacturers' best practices.

B. Devices will use BACnet protocols. Network wiring shall be a doubly terminated bus topology. Star, free, loop, or mixed topologies are not allowed.

C. Provide new network backbone for connecting the new controllers and devices.

3.02 SYSTEM INTEGRATION

A. In addition to the monitoring and control of HVAC systems, the following equipment will be integrated into the BAS using network communications (as able) for additional control and monitoring data:

1. Variable Frequency Drives
2. Chillers
3. Boilers
4. Miscellaneous Utility Systems Monitoring

5. Lighting Control Systems
6. Fire/Life Safety System (monitor only)
7. Garage Air Quality Monitoring

3.03 SEQUENCE OF OPERATION

A. Reference Section 23 09 93 Sequences of Operations for HVAC Equipment.

3.04 ELECTRICAL WIRING AND MATERIALS

A. Refer to section 26 05 00 Common Work for Electrical

3.05 TRAINING

A. Reference Section 01 79 00 Demonstration and Training.

3.06 GUARANTEE/WARRANTEE:

A. Reference Section 01 78 23 Warranties.

END OF SECTION 23 09 23

SECTION 23 09 27
FIELD EQUIPMENT PANELS

PART 1 GENERAL

1.01 SECTION INCLUDES:

A. Building Controller (BC)
B. Advanced Application Controller (AAC)
C. Application Generic Controller (AGC)
D. Application Specific Controller (ASC)

1.02 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions, apply to work of this section.

1.03 REFERENCE STANDARDS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions, apply to work of this section. All control components shall conform to ANSI/ASHRAE 135.1 standards

1.04 DESCRIPTION OF WORK:

A. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions. The intent of this section is to provide a complete "turnkey" design-build replacement of the existing control systems. All required labor and materials to complete this work is to be provided by the Contractor.

PART 2 PRODUCTS

2.01 PRODUCT CERTIFICATION

A. All controllers provided for this project shall have at least one BACnet Device Profile as listed by the BACnet Testing Lab (BTL).
B. All controllers provided for this project shall bear the BACnet® Testing Laboratories Mark.

2.02 STAND-ALONE FUNCTIONALITY

A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in Part 2. This item refers to acceptable paradigms for associating the points with the processor.
B. Functional Boundary: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally systems specified for the Application Category will dictate the boundary of the standalone control functionality. See related restrictions below. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.

C. The following configurations are considered acceptable with reference to a controller's standalone functionality:

1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).

2. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.

D. The following configurations are considered unacceptable with reference to a controller's standalone functionality:

1. Multiple controllers enclosed in the same control panel to accomplish the point requirement.

2.03 General Purpose Programmable Controller (BC)

A. General Requirements:

1. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device. Loss of Global Variables shall result in an operational mode that preserves occupant comfort. All control strategies performed by the BC(s) shall be both operator definable and modifiable through the Operator Interfaces.

2. GPPCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions. GPPCs shall share information with the entire network of GPPCs and AGCs/ASCs for full global control. Each controller shall permit multi-user operation from multiple workstations and portable operator terminals connected either locally or over the Primary Controller LAN. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure. GPPCs shall be programmable from an operator workstation, portable operator's terminal, or hand held operating device. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.

3. GPPCs shall be connected to a controller network that qualifies as a Primary Controlling LAN.

4. All GPPCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:

   a. Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. Self-diagnostic routine shall report an alarm for a low battery condition.

   b. Non-volatile memory

5. In addition GPPCs may provide intelligent, standalone control of HVAC functions. Each BC may be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar, and voltage transient and lightning protection devices. Refer to standalone functionality specified above.

6. The BC may provide for point mix flexibility and expandability. This requirement may be met via either a family of expander boards, modular input/output configuration, or a combination thereof. Refer to stand alone functionality specified above.
7. All BC point data, algorithms and application software shall be modifiable from the Operator Workstation.
8. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and will be able to upload/download to/from the OWS and/or CSS.
9. BC shall provide buffer for holding alarms, messages, trends etc.
10. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
11. Each BC shall contain software to perform full DDC/PID control loops.
12. For network wiring requiring end-of-line resistors, those resistors shall be located in the BC. MS/TP trunks to zone controllers may have one end terminated at the last device.
13. Input-Output Processing
    a. Digital/Binary Outputs (DO/BO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and a manual hand off or auto switch to allow for override. If these HOA switches are not provided on the main board they shall be provided via isolation relays within the control enclosure. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
    b. Analog Inputs (AI): AI shall be 0-5 VDC, 0-10 VDC, 0-20 VDC, 2-10 VDC, 4-20 mA, or 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
    c. Digital/Binary Inputs (DI/BI): Inputs may be used to monitor dry contact closures or accept pulsed inputs. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors may only be done in non-critical applications and only with prior approval of AOC.
    d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
    e. Electronic Analog Outputs (AO): Voltage mode: 0-5 VDC and 0-10 VDC; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO is acceptable only with AOC approval (Generally these will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.). Where these are allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate

manufacturer's board is unacceptable). D/A converters shall have a minimum resolution of 10 bits.

f. Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.

14. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.

15. All analog output points shall have a selectable failure setpoint. The BC shall be capable of maintaining this failure setpoint in the event of a system malfunction, which causes loss of BC control, or loss of output signal, as long as power is available at the BC. The failure setpoint shall be selectable on a per point basis.

16. Slope intercepts and gain adjustments shall be available on a per-point basis.

17. BC Power Loss:

    a. Upon a loss of power to any BC, the other units on the primary controlling network shall run in a default mode that maintains occupant comfort. Use of global variables shall be kept to a minimum.

    b. Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours. An alarm diagnostic message shall indicate that the BC is under battery power.

    c. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.

    d. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the AOC shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via the local area network, or to the laptop PC via the local service port.

18. BC Failure:

    a. Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer GPPCs shall recognize the loss, report alarm and reconfigure the LAN.

    b. BC Hardware Failure: BC shall cease operation and terminate communication with other devices. All outputs shall go to their specified fail position.

19. Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
20. A minimum of four levels of password protection shall be provided at each BC.
21. GPPCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 or weather tight enclosure as specified elsewhere.

2.04 APPLICATION SPECIFIC CONTROLLER (ASC)

A. Applications
   1. Application Specific Controller (ASC)
   2. Application Generic Controller (AGC)

B. General Requirements:
   1. AGCs and ASCs shall provide intelligent, standalone control of HVAC equipment. Each unit shall have its own internal RAM, non-volatile memory and will continue to operate all local control functions in the event of a loss of communications on the secondary LAN. Refer to standalone requirements by application specified in Part 3.03-E.3 of this section. In addition, it shall be able to share information with every other BC and AGC /ASC on the entire network.
   2. Each AGC and ASC shall include self-test diagnostics that allow the AGC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the AGC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.
   3. AGCs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
   4. Each AGC and ASC must be capable of: stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. Battery or super capacitor shall provide sufficient power to allow backup of critical data stored in RAM to non-volatile memory and perform an orderly shutdown in the event of sustained power loss.
   5. All point data; algorithms and application software within an AGC /ASC shall be modifiable from the Operator Workstation.
   6. AGC and ASC Input-Output Processing
      a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output. Each DO shall be discrete outputs from the AGC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
      b. Analog Inputs (AI): AI shall be 0-5 VDC, 0-10VDC, 2-10 VDC, 0-20Vdc, 4-20 mA, or 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 8-10 bits depending on application.

c. Digital Inputs (DI): Digital Inputs may be used to monitor dry contact closures or accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors may only be done in non-critical applications and only with prior approval of Architect/Engineer

d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.

e. Electronic Analog Outputs (AO) as required by application: voltage mode, 0-5VDC and 0-10VDC; current mode (4-20 mA). Provide zero and span calibration and circuit protection. Pulse Width Modulated (PWM) analog via a DO is acceptable only with government approval (Generally, PWM will not be allowed on loops with a short time constant such as discharge temperature loops, economizer loops, pressure control loops and the like. They are generally acceptable for standard room temperature control loops.). Where PWM is allowed, transducer/actuator shall be programmable for normally open, normally closed, or hold last position and shall allow adjustable timing. Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturers board is unacceptable). D/A converters shall have a minimum resolution of 8 bits.

C. Terminal Box Controllers:

1. Terminal box controllers controlling damper positions utilizing floating outputs to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total quantity of controllers in a building to perform this function at the same time. When possible the controllers shall perform this function when the supply air system is not operating or is unoccupied.

PART 3 EXECUTION

3.01 INSPECTION:

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF CONTROL SYSTEMS:

A. General: Install systems and materials in accordance with manufacturer's instructions, specifications roughing-in drawings and details shown on drawings. Contractor shall install all controllers in accordance with manufacturer's installation procedures and practices.

3.03 HARDWARE APPLICATION REQUIREMENTS:

A. General: The functional intent of this specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions. A Building Controller BC as specified above is generally fully featured and customizable whereas the AGC/ASC refers to a more cost-effective unit designed for lower-end applications. Specific requirements indicated below are required for the respective

application. Manufacturer may apply the most cost-effective unit that meets the requirement of that application.

B. Standalone Capability: Each Control Unit (CU) shall be capable of performing the required sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Refer to Item 2.01 above for physical limitations of standalone functionality. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs via LAN.

C. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

D. Application Category 0 (Distributed monitoring)

1. Applications in this category include the following:
    a. Monitoring of variables that are not used in a control loop, sequence logic, or safety.
2. Points on BCs, AGCs, and ASCs may be used in these applications as well as general-purpose I/O modules.
3. Where these points are trended, contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.

E. Application Category 1 (Application Specific Controller - ASC):

1. Applications in this category include the following:
    a. Fan Coil Units
    b. Airflow Control Boxes (VAV and Constant Volume Terminal Units)
    c. Misc. Heaters
    d. Unitary equipment <15 tons (Package Terminal AC Units, Package Terminal Heat Pumps, Split-System AC Units, Split-System Heat Pumps, Water-Source Heat Pumps)
    e. Variable Speed Drive (VSD) controllers not requiring safety shutdowns of the controlled device.
2. ASCs may be used in these applications.
3. Standalone Capability: Provide capability to execute control functions for the application for a given set point or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred except for conditions that may cause unsafe conditions or equipment damage (i.e. CO monitoring). If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter

Outdoor Air Temp	Last read state
Smoke Control	Normal Mode

4. Mounting:
   a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
   b. ASCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
5. Programmability: Operator shall be able to modify all set points (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, inter-stage timing parameters, and mode settings. Application-specific block control algorithms may be used to meet the sequence of operations.

F. Application Category 2 (Advanced Application Controllers - AAC)
1. Applications in this category include the following:
   a. Unitary Equipment >= 15 tons (Air Conditioners, Heat Pumps, Packaged Heating/Cooling Units, and the like)
   b. Small, Constant Volume Single Zone Air Handling Units
   c. Constant Volume Pump Start/Stop
   d. Misc. Equipment (Exhaust Fan) Start/Stop
   e. Misc. Monitoring (not directly associated with a control sequence and where trending is not critical)
   f. Steam Converter Control
   g. Large Constant Volume Air Handlers
   h. Small VAV Air Handlers
   i. Self Contained VAV Units
   j. Sequenced or Variable Speed Pump Control
   k. Local Chiller Control (unit specific)
   l. Local Free Cooling Heat Exchanger Control
   m. Air Handlers serving critical areas
2. AAC/AGC/ASCs may be used in these applications.
3. Standalone Capability: Provide capability to execute control functions for the application for a given set point or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred except for conditions that may cause unsafe conditions or equipment damage (i.e. CO monitoring). If such fault has not been

corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal
Morning Warm-Up	off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter
Outdoor Air Temp	Last read state
Smoke Control	Normal Mode

4. Mounting:
    a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
    b. ASCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
    c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
    d. Section 23 09 00 contractor may furnish ASCs to the terminal unit manufacturer for factory mounting.
5. Programmability: Operator shall be able to override outputs, modify all set points (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, inter-stage timing parameters, and mode settings. Application-specific block control algorithms may be used to meet the sequence of operations.
6. Applications in this category include the following:
    a. Large Built Up VAV Air Handlers
    b. Central Cooling Plant
    c. Central Heating Plant
    d. Cooling Towers

G. Application Category 3

1. Applications in this category include the following:
    a. Large Built Up VAV Air Handlers
    b. Central Cooling Plant
    c. Central Heating Plant
    d. Cooling Towers
2. BCs may be used in these applications.
3. Standalone Capability: Provide capability to execute control functions for the application for a given set point or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the

event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the BC shall use the last value obtained before the fault occurred except for conditions that may cause unsafe conditions or equipment damage (i.e. CO monitoring). If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter
Outdoor Air Temp	Last read state
Smoke Control	Normal Mode

4. Mounting:
   a. BCs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
   b. BCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
5. Programmability: Operator shall be able to modify all set points (temperature and airflow), scheduling parameters associated with the unit, tuning and set up parameters, inter-stage timing parameters, and mode settings.

END OF SECTION 23 09 27

SECTION 23 09 36
VARIABLE-FREQUENCY DRIVES
REFERENCE FOR ADD ALTERNATE #2

PART 1 GENERAL

1.01 DESCRIPTION

A. Section includes requirements for separately enclosed, pre-assembled, combination Variable Frequency Drives (VFD), rated 600V and less. These VFDs shall be used for speed control of any new or existing three phase motors on pumps.

1.02 REFERENCE CODES AND STANDARDS

A. References:

1. All referenced specification section shall be adhered to as if the section was repeated herein
2. Division 01- General Requirements
3. Section 23 08 00 – Commissioning of HVAC
4. Section 23 09 13 Instrumentation and Control Field Devices for DDC

B. All work specified herein shall conform to or exceed the applicable requirements of the referenced portions of the latest editions of the following publications to the extent that the provisions thereof are not in conflict with other provisions of these specifications:

C. Codes

1. NEC National Fire Protection Association (NFPA) –
   a. 70 National Electrical Code (NEC)
   b. NEC 430.120, Adjustable-Speed Drive Systems
2. CCR Title 8, Industrial Relations, Subchapter 5, Electrical Safety Orders, California Code of Regulations. National Electrical Code
3. Commercial Standards
4. ANSI/UL 467 Grounding and Bonding Equipment, Safety Standard For
5. IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
   a. IEEE 519-1992, Guide for Harmonic Content and Control.
6. IEEE 1100 Powering and Grounding Sensitive Electronic Equipment (Emerald Book)
7. NEMA MG-1998 Motors and Generators. Standard for
8. NEMA ICS7.1 1995 Construction and Guide to Selection, Installation, and Operation of Adjustable Frequency Drives Systems, Safety Standards for
9. UL 508A - Industrial Control Equipment, Standard for h. ISA 5.4 - Instrument Loop Diagrams, Standard for
10. UBC - Uniform Building Code

1.03 SUBMITTALS

A. Product Data for each type and rating of VFD indicated.

B. Submit statement guaranteeing compatibility of VFDs with existing motors.

C. Shop Drawings for each VFD:

1. Layout drawings of the VFD system that include all cabinet or enclosure dimensions, access details, and weights. Drawings shall include the physical arrangement of door mounted devices located on the VFD enclosure.

2. Complete single-line diagrams indicating all devices comprising the VFD system including, but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, and other equipment comprising the complete system. Electrical ratings of all equipment and devices shall be clearly indicated on these single-line diagrams.

3. Control diagrams, schematic and interconnection wiring diagrams of all electrical work, including terminal blocks and identification numbers, wire numbers and wire colors.

4. Logic diagrams identifying system control logic.

5. Manufacturer's drawings.

6. Manufacturer's operation instructions.

7. Performance, control and protection data with specified features clearly shown.

8. Operating and monitoring devices with specified features clearly indicated.

9. Start-up, operation and maintenance manuals; spare parts list and field testing procedures.

10. Other appropriate data.

D. Product certificates.

E. Field quality-control reports.

F. Operation and maintenance data.

1.04 ELECTRICAL NOISE CRITERIA:

A. Voltage and current distortion generated by VFD and attenuation devices, measured at the point of common coupling shall not exceed the criteria of IEEE Standard 519-1992.

B. Contractor is responsible for cost of all equipment required to meet IEEE-519-1992, General Category. Equipment which can be provided includes input line reactors, DC bus reactors and harmonic filters.

1.05 WARRANTY

A. Include 5 year parts and labor warranty beginning at start-up of the equipment.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. All drives shall be of like manufacturer.

1. Manufacturer: DanFoss, Yaskawa, ABB, or approved equivalent.

B. VFD Description: Factory packaged Variable Frequency Drive in a NEMA-1 enclosure (NEMA 3R outdoors), with integral disconnecting means and over-current and overload

protection; arranged to provide self-protection and variable-speed control of a three-phase motor by adjusting output voltage and frequency.

C. Fabrication:
   1. VFD shall be variable torque, solid state, microprocessor based control, modular design.
   2. VFD components shall be factory mounted and wired in NEMA 1 enclosure with lock.
   3. Circuitry shall be plug-in, plug-out modular. Printed circuit boards shall have protective coating to reduce corrosion.
   4. Unit shall conform to NEMA and NEC standards and be CSA, UL, or ETL listed. Control circuitry shall be electrically isolated from power circuitry.

D. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

E. Unit Operating Requirements:
   1. Voltage and power range: 3-phase, 208 to 480 V 2:·15% (0.75 to 355 kW)
   2. Frequency: 48 to 63 Hz
   3. Power factor: 0.98
   4. Rated currents: Current at ambient temperature of -15 to +40 deg C; rated output current, no de-rating needed. Current at ambient temperature of + 40 to + 50 deg C; de-rating of less than 1 %/deg C above 40 deg C.
   5. Ambient Temperature Rating: -15 to 50 deg C (no frost allowed)
   6. Ambient Storage Temperature Rating: -40 to 70 deg C
   7. Humidity Rating: Less than 95 percent (non-condensing).
   8. Altitude Rating: Rated current at 0 to 1000 m, reduce by 1% per 100 meters 1000 to 2000 m. Over 2000 m consult manufacturer.
   9. Overload Capability: 1.1 times the rated load current for 60 seconds every 10 minutes through the entire speed range.
   10. Protection classes: IP21 for wall mounted and free standing units or IP54 for wall mounted units
   11. 2 analog inputs: selectable both for current and voltage
   12. Voltage signal: 0(2) to 10 V, R_{in} > 312 k ohms single-ended
   13. Current signal: 0(4) to 20 mA, R_{in} = 100 ohms single-ended
   14. Potentiometer reference value: 10 V:1: 2% max. 10 mA, R < 10 k ohms
   15. Communication: Protocols as standard (RS 485); LonTalk, BACnet MS/TP, Modbus RTU, N2 and FLN. Available as plug-ins options: BACnet/IP router, LonTalk, Ethernet etc. Available as· external options: remote access and diagnostics module.

F. Internal Adjustability Capabilities:
   1. Minimum Speed: 5 to 25 percent of maximum rpm.
   2. Maximum Speed: 80 to 100 percent of maximum rpm.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal/line voltage.
2. Loss of Input Signal Protection.
3. Under- and overvoltage trips.
4. Inverter over-current trips
5. VFD and Motor Overload/Over-temperature Protection
6. Instantaneous line-to-line and line-to-ground over-current trips
7. Loss-of-phase protection.
8. Reverse-phase protection.
9. Short-circuit protection.

H. Protection Features: Power circuits shall be protected by electronic protection circuits. Electronic protection circuits shall provide orderly shutdown without blowing fuses and prevent component loss under the following abnormal conditions.
1. Inverter over-current and overvoltage
2. Loss of phase and low/loss of system voltage.
3. Ground fault.
4. Loss of DC link.
5. Motor overload
6. Over-temperature.

I. Integral Input Disconnecting Means and OCPD with pad-lockable, door-mounted handle mechanism.

J. Controls and Indication:
1. Provide capability for ~~LON~~ BACnet interface.
2. Status Lights: Station: Manufacturer's standard front-accessible.
3. Indicating Devices: Manufacturer's standard.
4. Provide adjustable minimum and maximum speed settings (0 - 100%) for both auto and manual mode. Initial minimum setting shall be 10%.
5. Provide adjustable automatic reset for fault trips, except overload and over-current. After selected number of unsuccessful restart attempts, drive shall be shut down. Number of restart attempts and time interval between resets shall be selectable.
6. When unit shuts down due to power outage, unit shall be capable of being restarted manually or automatically.
7. Provide critical frequency avoidance circuit with at least 2 field adjustable bands to avoid operation at speeds which cause excessive vibration in driven equipment.
8. Provide isolated ungrounded output signal to indicate drive percent of speed or drive frequency.

K. Operating and Monitoring Devices: Manufacturer's standard

L. Quality Assurance:

1. Drive assembly shall be subjected to factory heat stress test and run tested under load to verify functions specified. Test reports shall be available upon request.
2. VFDs and options shall be UL508 listed as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR without the need for external input fuses..
3. The entire VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the 2012 International Building Code (IBC):
   a. VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
   b. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.
   c. Seismic ratings based upon calculations alone are not acceptable. Certification of Seismic rating must be based on testing done in all three axis of motion.
   d. Special seismic certification of equipment and components shall be provided by OSHPD preapproval.

PART 3 EXECUTION

3.01 INSPECTION

A. Visually inspect equipment and components at time of delivery. Submit report to with list of items or deficiencies to be corrected.

B. Manufacturer's standard tests shall be performed.

3.02 INSTALLATION

A. Install VFD system in accordance with details, approved shop drawings and manufacturer's instructions and recommendations. Line, load, and control wiring shall be run in separate conduits.

B. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.

C. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

D. Provide field electrical wiring, both line and low voltage of VFD system components. Install wiring in metal conduit and in accordance with electrical sections of this specification and applicable electrical code.

E. Provide control wiring between interlocks in VFD control circuits and driven motor's disconnect switches, where such motor disconnect switches are provided.

F. Provide grounding conductor in addition to conduit ground for each motor circuit

G. Do not connect ground from one unit to another unit's cabinet.

H. Use separate conduits for incoming and outgoing power conductors from each unit.

I. Use separate conduit for control wiring for each unit. Control wiring shall not occupy same conduit as power wiring.

J. Use minimum 18 gauge shielded wiring with ground for control wiring.

K. Install fuses in control circuits if not factory installed. Provide set of spare fuses."

3.03 IDENTIFICATION

A. Identify VFDs, components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and associated control device with self adhesive label securely fastened. Indicate location of dP sensor with either floor plan or description of location.

3.04 START-UP

A. Perform tests and inspections.

1. Start-up shall be provided by a factory trained and certified manufacturer's representative. Certification shall be submitted and approved prior to start-up.
2. The VFD's and all associated points and control functionality shall be commissioned in accordance with Section 23 08 00 Commissioning of HVAC.
3. Inspect VFD, wiring, components, connections, and equipment installation.
4. Test insulation resistance for each VFD element, component, connecting motor supply, connected motor stator windings, feeder, and control circuits.
5. Test continuity of each circuit.
6. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify AOC before starting the motor.
7. Test each motor for proper phase rotation. Correct any phase rotation issues by correcting power connection wiring- changing the phase rotation/direction of motor rotation by configuring the VFD settings is prohibited.
8. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
9. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
10. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
11. VFDs will be considered defective if they do not pass tests and inspections.
12. Perform start-up of VFD in accordance with procedures as defined by manufacturer for proper operation.
13. Completion of the installation, final inspection, receipt of the test and as-built documentation, and successful performance of the system for a three week period shall constitute acceptance of the system.

END OF SECTION 23 09 36

SECTION 23 09 93
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.01 EXISTING CONDITIONS

A. As part of the BAS replacement project, all existing sequence of operation shall be replaced with new sequences that optimize comfort control and energy efficiency.

1.02 CONTRACTOR RESPONSIBILITIES

A. The Contractor is responsible for developing detailed design sequences of operation that expand upon the proposed (design intent) sequence of operations provided in part 3.01. The detailed design sequences shall be included in the design phase submittals for review by the Commissioning Authority (CxA) and the AOC. The CxA, along with the AOC, has final approval rights to the sequence of operations prior to implementation.

1. The proposed sequence of operations included in part 3.01 communicates the project design intent. The submitted design sequence of operations shall be an accurate narrative of how the sequences will be programmed, and shall include all necessary details, time delays, offsets, clarifications, and/or proposed enhancements of the proposed sequence of operation required to provide a complete and fully operational control program code. And with sufficient details that the CxA can develop the functional performance test procedures. The Contractor may provide enhancements and modifications to improve system performance and/or control stability. Verbatim duplication of the proposed sequence of operation on the submittals is discouraged and may result in rejection of the submittal.

2. Submitted sequence of operation shall be written with a logical and organized format with full outline numbering. Sequence of operation language shall be detailed, clear, and unambiguous. Point descriptors and point nomenclature referenced in the submitted sequence of operation shall match those on the design drawings.

3. Final sequence of operations shall be provided by the Contractor after completion of the commissioning functional performance testing.

B. Sequence of operation programming bugs (both due to programming misinterpretations and sequence errors) shall be corrected and any reasonable control sequence changes required to provide proper system operation or proposed design intent shall be provided at no additional cost to the project.

PART 2 PRODUCT – NOT USED

PART 3 EXECUTION

3.01 PROPOSED SEQUENCE OF OPERATIONS

A. Contractor shall review the proposed design intent sequence of operations with facility personnel, the AOC and CxA.

B. Contractor shall enhance the sequences of operations for improved building performance and energy efficiency.

C. All set points, reset values, and control loop parameters shall be operator adjustable from a graphic on the front-end user interface. Adjusting these values shall not require re-compiling or download of control programming and shall not require a controller reset of any kind.

D. Air Handling Unit Sequences:

1. Air handling unit (AHU) 5 is a single-duct, constant volume, 100% outside air unit with heating and cooling. AHU-5 serves the detention areas of the building.
2. AHU 1 and 2 share the same supply and return ductwork, but each unit has its own set of dampers, fans, and coils. Each unit is a single-duct, heating and cooling, variable air volume system with economizer. The heating and cooling sections on AHU-1/2 are equipped with a bypass damper.
3. AHUs 3 and 4 are single-duct, heating and cooling, variable air volume with economizer. AHU-4 heating and cooling section is equipped with a bypass damper.
4. Variable Volume AHU duct static pressure setpoint shall be reset based on the VAV zone demand for airflow using a trim and respond control algorithm. The intent of the reset is to maintain the duct static pressure setpoint at the lowest level possible to maintain all VAV zones satisfied with airflow.
    a. The algorithm shall allow the user to assign different weighting or importance factors to each zone via the operator workstation and shall allow the user to ostracize a zone from the trim and respond control algorithm.
    b. The algorithm shall have a separate trim amount and a separate respond amount.
5. Air handling unit enable/disable shall be via time schedule with optimal start to affect morning warmup as needed without operator intervention.
6. Variable Volume AHU economizer control shall utilize free cooling from outside air when available. The AHU shall enter the economizer mode at any time when outside air temperature (OAT) is less than return air temperature (RAT) over a minimum time delay, and disabled otherwise.
    a. In the economizer mode, the outdoor air damper (OAD) and return air damper (RAD) shall be sequenced (i.e., one is fully open while the other damper modulates) rather than complementary (as per most standard sequences) to reduce fan power at part loads.
    b. The chilled water valve shall remain closed until the OAD is fully open and the RAD is fully closed. If, after the OAD is fully open there is a persistent need for cooling, the return air damper (RAD) shall modulate closed and then once the RAD is fully closed, the chilled water valve (CHWV) shall modulate to maintain supply air temperature (SAT) equal to the SAT Setpoint. Upon lowering demand for cooling; the CHWV shall modulate shut. After the CHWV is shut and the demand for cooling continues to lower, the RAD shall modulate open. After the RAD is fully open and the demand for cooling continues to lower, the OAD shall modulate closed (not below the minimum position for ventilation). After the OAD has closed down to the minimum outside air position and the demand for cooling continues to lower, the heating water valve shall modulate to maintain SAT = SAT Setpoint.
    c. For a rising demand for cooling, this sequence shall operate in the reverse (HWV closes, then OAD opens, then RAD shuts, etc.).
7. The return fan (RF) speed shall maintain an offset from the supply fan speed (initially 10%) and the exhaust air damper shall modulate to maintain building static pressure equal to building static pressure set point (slightly positive).

8. Air handling unit supply air temperature setpoint reset to based on OAT from a minimum set point (55F) to a maximum set point (65F) for outside air temperature between a maximum (75F) to a minimum value (55F).
9. Minimum OAD position to be verified by the TAB contractor. Minimum outside airflows shall match design documents from the spring of 1995.

E. Chilled Water Plant Sequences:

1. The chilled water plant will be enabled and disabled based on demand for cooling. Demand for cooling is assessed by evaluating the command to each CHWV. The chilled water plant enable algorithm shall allow the user to assign different weighting or importance factors to each CHWV and shall allow the user to ostracize a CHWV from the chilled water plant enable algorithm. The chilled water plant shall initially be enabled when the most-open CHWV command reaches 80%. The chilled water plant shall initially be disabled when the most-open CHWV is 10%. These values shall be refined during the commissioning process. Once enabled, the plant shall remain enabled to run for a minimum time period (initially one hour). Once disabled, the plant shall remain disabled for a minimum time period (initially thirty minutes). These time periods will be user-adjustable and will be refined during the commissioning process.
2. The chilled water plant consists of three (3) chillers; an air-cooled chiller (50T), a small centrifugal chiller (200T), and a large centrifugal chiller (350T). A minimum of five (5) stages of cooling shall be provided:
    a. Stage 1: Air cooled liquid chiller only
    b. Stage 2: Small centrifugal chiller only
    c. Stage 3: Large centrifugal chiller only
    d. Stage 4: Both centrifugal chillers
    e. Stage 5: All chillers
3. The chilled water plant shall stage up when the chilled water supply temperature (CHWST) is greater than the chilled water supply temperature setpoint (CHWST StPt) plus an offset (adjustable, initially 5F) for the duration of a staging up time delay (adjustable, initially 30 minutes). The chilled water plant shall stage down when the computed building load is less than 80% capacity of the next lower stage for the duration of a staging down time delay (adjustable, initially 45 minutes). The staging delays shall be displayed on and adjustable from the chilled water plant graphic and shall display accumulated time when staging conditions are met.

Active Chilled Water Plant Stage	Computed Load to Start Stage Down Timer
Stage 5	< 440 Tons
Stage 4	< 280 Tons
Stage 3	< 160 Tons
Stage 2	< 40 Tons
Stage 1	(Not Applicable)

4. For chilled water plant stages 2 and above, the chilled water supply temperature (CHWST) setpoint shall be reset based on outside air temperature according to the table

below:

Outside Air Temperature	Chilled Water Supply Temperature Set Point
50F	55F
70F	45F

5. Chilled water plant staging shall occur automatically and without operator intervention. There shall be a graphical selector switch on the chilled water plant graphic allowing the operator to select a "Manual Stage Down" mode of operation. Adjacent to this selector switch, there shall be a graphical pushbutton to allow the operator to manually stage down the chilled water plant. In the Manual Stage Down mode of operation, chilled water plant stage down is manually initiated however, the plant will still stage up automatically if CHWST > CHWST StPt + Offset. If the chilled water flowmeter is determined to be unreliable or failed, an alarm shall be annunciated at the operator workstation and Manual Stage Down mode shall be initiated without operator intervention. Reliable operation of the chilled water flowmeter shall be determined by comparing the measured chilled water flow against the flow expected for the number of operating chilled water pumps. If chilled water flow is less than 60% of expected flow for the number of operating chilled water pumps, or over 110% of expected flow for a period of time, the flowmeter is failed.
6. For outside air temperature (OAT) between 70F and 85F, set Condenser Water Supply Temperature Setpoint (CWST StPt) equal to the outside air temperature. For OAT < 70F, set CWST StPt equal to 70F. For OAT > 85F, set CWST StPt equal to Cooling tower fans shall modulate speed in unison to maintain CWST = CWST setpoint.

F. Heating Water Plant Sequences:
1. The heating plant will be enabled and disabled based on demand for heat. Demand for heating is determined by Outside Air Temperature (OAT). The heating water plant is enabled any time OAT < an adjustable value- initially 70F. The heating water plant is disabled whenever OAT > the adjustable value plus a dead band (initially 2F). Modulate heating water pump VFD speed to maintain heating water loop differential pressure (dP) setpoint
2. Heating hot water supply temperature set point shall reset based on outside air temperature according to the following table:

Outside Air Temperature	Heating Hot Water Supply Temperature Set Point
40F	180F
70F (OAT Lockout Setting)	100F

G. ADD ALTERNATE #2: Variable Flow CHW with DP Reset (will require adding DP sensor)
1. If this add-alternative is selected, the CHW pump VFD speed shall be controlled to maintain a CHW Differential Pressure (DP) Setpoint.
2. Variable CHW Flow shall only be active when the plant is operating a single centrifugal chiller (Plant Stages 2 and 3).

a. Variable flow shall be achieved by closing the manual bypass line valves associated with the cooling coil three-way control valves. One or more bypass line valves shall be left partially open in order to maintain minimum chiller flow. As the number and location of manual bypass valves left in a throttled position shall be determined by the TAB Contractor.

b. Minimum CHW flow setting can be determined using the installed CHW flowmeter once it is 'qualified'. Qualify the flowmeter by comparing flow indicated with flow measured using chiller manufacturer dP/Flow curves for chiller OR compare against flow computed using manufacturer's pump curves and measured system dP OR other approved method (such as a calibrated flowmeter).

3. The DP Setpoint shall be reset based on CHW valve command position using a trim and response control strategy. The intent of the reset is to maintain the DP Setpoint near the lowest level possible without starving CHW coils, thereby reducing CHW pump energy consumption.

a. The algorithm shall allow the user to assign different weighting or importance factors to each chilled water valve via the operator workstation and shall allow the user to ostracize a chilled water valve from the trim and respond control algorithm. This algorithm and associated weighting factors shall be the same used for the CHW plant enable/disable algorithm.

b. The algorithm shall also have a separate trim amount and a separate respond amount. For example, the trim and respond shall adjust the DP setpoint at each polling time step setpoint (5 minutes) as follows. If the number of CHW valves (three, adjustable setpoint) are more than 90% open (adjustable setpoint), the DP setpoint shall be increased by a respond setpoint (1 psi). If all CHW valves are less than 80% open (adjustable setpoint), the DP setpoint shall be decreased by a trim setpoint (0.5 psi). In between both conditions, the DP setpoint remains unchanged.

c. Also, the DP setpoint shall not reset below a minimum DP setpoint (5 psi) and above a maximum setpoint (20 psi), after a time delay setpoint upon initial startup.

H. ADD ALTERNATE #4: Raise Space Temperature and Limit Supply Fan Speed

1. Program a demand response event so that the BAS can raise the temperature of non-critical zones 2°F for a level one event and 4°F for a level two event. In addition, the supply fan speed shall be lowered to 85%.

3.02 SUBMITTALS

A. Design Phase

1. Contractor shall include control sequences of operations in the drawings for the applicable systems for each page.

2. Contractor shall submit the same sequence of operations in a separate written format to be used later in the Building Operations Plan.

B. Construction Phase

1. If applicable, a revised sequence of operations shall be submitted for Owner approval prior to commissioning the systems during the Functional Performance Testing so that the test forms can be modified to fit as installed/programmed conditions.

C. Final Documentation

1. As-built drawings shall reflect the actual sequence of operations finalized in the Functional Performance Testing phase.
2. The final written format sequence of operations shall be incorporated into the Building Operations Plan and final documentation.

END OF SECTION 23 09 93

SECTION 25 05 00
COMMON WORK FOR INTEGRATED AUTOMATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Sleeves for raceways and cables.
2. Grout.
3. Common electrical installation requirements.

PART 2 PRODUCTS

2.01 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.02 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

F. Avoid sharp bends and kinks in wire.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wire ways, cable trays, or bus ways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Remove burrs and protect against sharp edges

E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestopping materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.03 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.04 CONTROL WIRING

A. The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of networks, panels, and control devices.

B. Ethernet wiring shall be CAT6 or better

C. BACnet wiring shall conform to ANSI/ASHRAE 135.1 requirements and controller manufacturers' recommendations.

D. Doubly terminated bus topology shall be used. Free, star, loop, single termination, or mixed topology are not allowed. Termination modules shall be installed within the control panels. For VAV and Fan Coil loops one termination module may be located at the last device. Locations of all termination modules shall be indicated on the control drawings.

E. Wiring System: Install complete wiring system for electric control systems. Existing wire and raceways may be reused provided it meets the project specifications.

F. Conceal wiring except in mechanical rooms and areas where other conduit and piping are exposed. Protect wiring to a minimum of 10' from equipment room floors.

G. Installation of wiring shall generally follow building lines.

H. Install in accordance with National Electrical Code, industry standards, manufacturer's recommendations, and local building codes.

I. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code.

J. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.

K. Wire shall be free or kinks and sharp bends.

L. High voltage wiring shall enter the panel in a location that is separate from all low voltage wiring by at least 12 inches. Power wiring shall be run in the panel separate from any wiring less than 100 volts. Where signal wiring must be near power wiring it shall be run at right angles to power wiring. A disconnect shall be provided in each panel for the 120 volt power wiring. In addition each transformer shall be provided with a separate fused disconnect of proper size.

M. A 120 VAC convenience outlet shall be provided within control panels and switched separately from panel wiring.

N. Use Velcro style tie wraps.

O. Panel wiring shall be run neatly in Panduit or similar raceway.

P. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

Q. Provide conduit and wiring between all control devices and the nearest standby power source.

R. Install all line voltage wiring in conduit.

S. Low voltage electrical wiring above accessible ceilings may be plenum run using appropriately rated cabling.

T. Supply/Install all necessary transformers/power supplies as required to power BAS instrumentation.

U. Provide and coordinate additional emergency power circuits if needed at no additional cost to contract.

END OF SECTION 25 05 00

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.04 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

PART 2 PRODUCTS

2.01 CONDUCTORS AND CABLES

A. Copper Conductors: Comply with NEMA WC 70.

B. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and XHHW.

C. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

2.02 CONNECTORS AND SPLICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC.
4. 3M; Electrical Products Division.
5. Tyco Electronics Corp.
6. Wago

C. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Feeders Type THHN-THWN, in raceway.

B. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.

C. Cord Drops : Type SJO, junior service cord with strain relief device at terminations to suit application.

D. Class 1 Control Circuits: Type THHN-THWN, in raceway.

E. Class 2 Control Circuits: Power-limited cable, concealed in building finishes.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

G. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

H. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.04 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.05 FIELD QUALITY CONTROL

A. Mechanical Systems

1. Verify that existing branch circuits that are modified, and new branch circuits, are installed without faults.

B. Lighting Systems

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
3. Test Reports: Prepare a written report to record the following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Grounding systems and equipment.

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.03 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 PRODUCTS

2.01 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or Authorities Having Jurisdiction (AHJ).

B. Bare Copper Conductors:

1. Mechanical Systems

    a. Copper conductor, stranded, sized per NEC.

2. Lighting Systems

    a. Solid Conductors: ASTM B 3.

    b. Stranded Conductors: ASTM B 8.

2.02 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Bolts, nuts and washers shall be made of non-corrosive material, approved for the purpose. Use pressure type connections with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

2.03 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel ¾ inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Conductor Terminations and Connections:

1. Mechanical Systems:

   a. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

   b. Connections to Ground Rods at Test Wells: Bolted connectors.

   c. Connections to Structural Steel: Bolted connectors.

3.02 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

B. Equipment ground conductor shall be electrically and mechanically continuous from the electrical circuit source to the equipment to be grounded. Size ground conductors per NEC unless larger conductors are shown on drawings.

C. Install metal raceway couplings, fittings and terminations secure and tight to insure good ground continuity. Provide grounding bushing and bonding jumper where metal raceway is not directly attached to equipment metal enclosure and at concentric knock-outs.

3.03 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed equipment grounding at each location. Perform point-to point test per NETA ATS Section 7.13.2 to determine the resistance between the main grounding system and all major electrical equipment frames.

B. Report measured point-to-point resistances that exceed 0.5 Ohm

END OF SECTION 26 05 26

SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.02 ACTION SUBMITTALS

A. Product Data: For steel slotted support systems.

B. Shop Drawings: Signed and sealed by qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

1.03 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

PART 2 PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.; a division of Cooper Industries.
   c. ERICO International Corporation.
   d. GS Metals Corp.
   e. Thomas & Betts Corporation.

f. Unistrut; Tyco International, Ltd.

g. Wesanco, Inc.

3. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-

5. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Hilti Inc.

2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

3) MKT Fastening, LLC.

4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Cooper B-Line, Inc.; a division of Cooper Industries.

2) Empire Tool and Manufacturing Co., Inc.

3) Hilti Inc.

4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.

5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-inch (25-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

2. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
3. To Existing Concrete: Expansion anchor fasteners.
4. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate By means that meet seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

B. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:

1. Section 260519 "Low Voltage electrical Power Conduit and Cables".

1.03 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. EMT: Electrical metallic tubing.

C. ER: Equipment room

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. MC: Main cross-connect (Telecommunications.)

H. RMC: Rigid metal conduit.

I. RNC: Rigid nonmetallic conduit.

J. TDMM: Telecommunications Distribution Methods Manual, published by BICSI.

K. TR: Telecommunications room.

1.04 QUALITY ASSURANCE

A. 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.

B. Comply with NFPA 70.

C. Voice and Data Communications Pathways: Install conduit, raceways, and boxes according to BICSI TDMM, "Horizontal Distribution Systems" Chapter, and comply with NECA 568.

1.05 COORDINATION

A. HVAC Control and Monitoring: Verify locations of temperature control panels with Building Automation System installer.

B. MC/ER and TR: Verify locations of backboards, cable trays, equipment cabinets and racks, and conduit stub-outs with Voice and Data Communications Cable installer

PART 2 PRODUCTS

2.01 METAL CONDUIT AND TUBING

A. RMC: ANSI C80.1.

B. IMC: ANSI C80.6.

C. EMT: ANSI C80.3.

D. FMC: Zinc-coated steel or aluminum.

E. LFMC: Flexible steel conduit with PVC jacket.

F. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Die-cast type, pot-metal type, and indenter type fittings are not permitted.
2. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
3. Fittings for EMT: Steel, compression type.

G. Joint Compound for RMC or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.02 NONMETALLIC CONDUIT

A. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

B. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

2.03 METAL WIREWAYS

A. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

C. Wireway Covers: Screw-cover type.

D. Finish: Manufacturer's standard enamel finish.

2.04 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect/Engineer.

2.05 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

1. Gangable boxes are not permitted.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.

C. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

D. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

E. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic.

F. Cabinets Indoors:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

G. Cabinets Outdoors:

1. NEMA 250, Type 4, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch, concealed hinge, and gasket.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: RMC or IMC.
2. Concealed Conduit, Aboveground: RNC, Type EPC-40-PVC.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Physical Damage: RMC. Includes raceways in the following locations:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Kitchens.
3. Concealed in Ceilings and Interior Walls and Partitions: Plenum Rated.
4. Concealed in Exterior Walls: Plenum Rated except where exterior wall is not sealed of external elements.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: RMC or IMC.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: EMT.

8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: EMT.
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum RMC, IMC, EMT, or RNC, Type EPC-40-PVC Size: 1/2-inch trade size, unless indicated otherwise.

D. Minimum FMC or LFMC Size: 1/2-inch trade size, unless indicated otherwise.

E. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. RMC or IMC: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.02 OUTLET AND DEVICE BOX APPLICATION

A. Flush Boxes in Masonry Walls and Partitions: Use masonry boxes at least 3.5 inches deep.

B. Flush Boxes in Gypsum-Board Partitions: Use square boxes at least 2.125 inches deep with raised box covers.

C. Flush Device Boxes in Ceilings: Use square boxes at least 2.125 inches deep with raised box covers.

D. Flush Outlet Boxes in Ceilings: Use 4-inch round or octagonal boxes at least 2.125 inches deep.

E. Surface Boxes: Use cast-metal type with matching cover. Provide knock-out plugs in unused openings.

3.03 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Conceal conduit and EMT within finished walls, ceilings, and below floors, unless otherwise indicated.

G. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

H. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

I. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

J. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

K. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet.
   1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
      a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
      b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change.
   3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

L. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
   1. Use LFMC in damp or wet locations.

M. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

N. Conduits less than 3-inch trade size may be field bent, unless indicated otherwise. Use factory 45 and 90 degree, and special radius elbows for conduits 3-inch and larger.

O. Conduits for Feeders: Electrically continuous, terminated with grounding and insulating bushings.

P. Conduits for Branch Circuits: Electrically continuous.

Q. Finished Spaces: Provide escutcheons where conduits penetrate surfaces of finished spaces. Match finish of adjacent surfaces.

R. Raceways for Optical Fiber and Voice and Data Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
   1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
   2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
   3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
   4. Elbows: Use factory elbows. Field bent elbows are not permitted for optical fiber and communications cables.
      a. Radii of Elbows for Conduits 1-1/2-inches and Larger: At least 10 times inside diameter of conduit.
   5. Conduit Bodies: Use telecommunications conduit bodies.

3.04 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:

1. Identification of power and control cables.
2. Identification for conductors.
3. Instruction signs.
4. Equipment identification labels.
5. Miscellaneous identification products.

1.02 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.03 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 PRODUCTS

2.01 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.02 CONDUCTOR IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.03 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 mm)."

2.04 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.05 EQUIPMENT IDENTIFICATION LABELS

A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

PART 3 EXECUTION

3.01 INSTALLATION

A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

C. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

3.02 IDENTIFICATION SCHEDULE

A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and hand holes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch circuit conductors.
    a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG.
    b. Colors for 208/120-V Circuits:
        1) Phase A: Black.
        2) Phase B: Red.
        3) Phase C: Blue.
    c. Colors for 480/277-V Circuits:
        1) Phase A: Brown.
        2) Phase B: Orange.
        3) Phase C: Yellow.
    d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

B. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

C. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

D. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.

E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels, Baked-enamel warning signs, Metal-backed, butyrate warning signs.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
   a. Power transfer switches.
   b. Controls with external control power connections.

F. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

G. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and load shedding.

H. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:
   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
   d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

END OF SECTION 26 05 53

Standard Points List Minimum Guideline																																				
	Water						Air																								General							
	Temp.		Valve				Temperature					Fans							Static					Damper													
			Chilled Water	Hot Water	Bypass	Iso.						Supply				Return																						
	Supply Water	Return Water	Signal (voltage)	Signal (voltage)	on/off	on/of	Outside Air (one per building)	Supply Air	Return Air	Mixed Air	Space	Start/stop	Signal (VFD)	Status	Smoke Alarm	Start/stop	Signal (VFD)	Status	Smoke Alarm	Filter	AFMS (air flow measuring station)	Hi-Static Alarm	Input (4-20ma)	Input (4-20ma)	Supply	Return	Mixed Air	Outside Air	Start/Stop	Signal (VFD)	Status	Runtime	BAS Communications (if applicable to equipment)				
AHU			X	X			X	X	X	X	X	X	X	X	X					X		X	X				X	X					X				
Exhaust Fans																													X		X					
Chiller	X	X																															X			
Cooling Tower	X	X																															X			
Boiler	X	X		X	X	X																							X		X	X	X			
Pumps	X	X																											X	X	X	X				
VAV				X				X			X													X								X				
Fan Coil Unit				X				X			X	X		X																		X				
Heat Pump								X	X		X	X		X														X		X	X	X				

Minimum Graphics Design for the AOC

Building Automation System

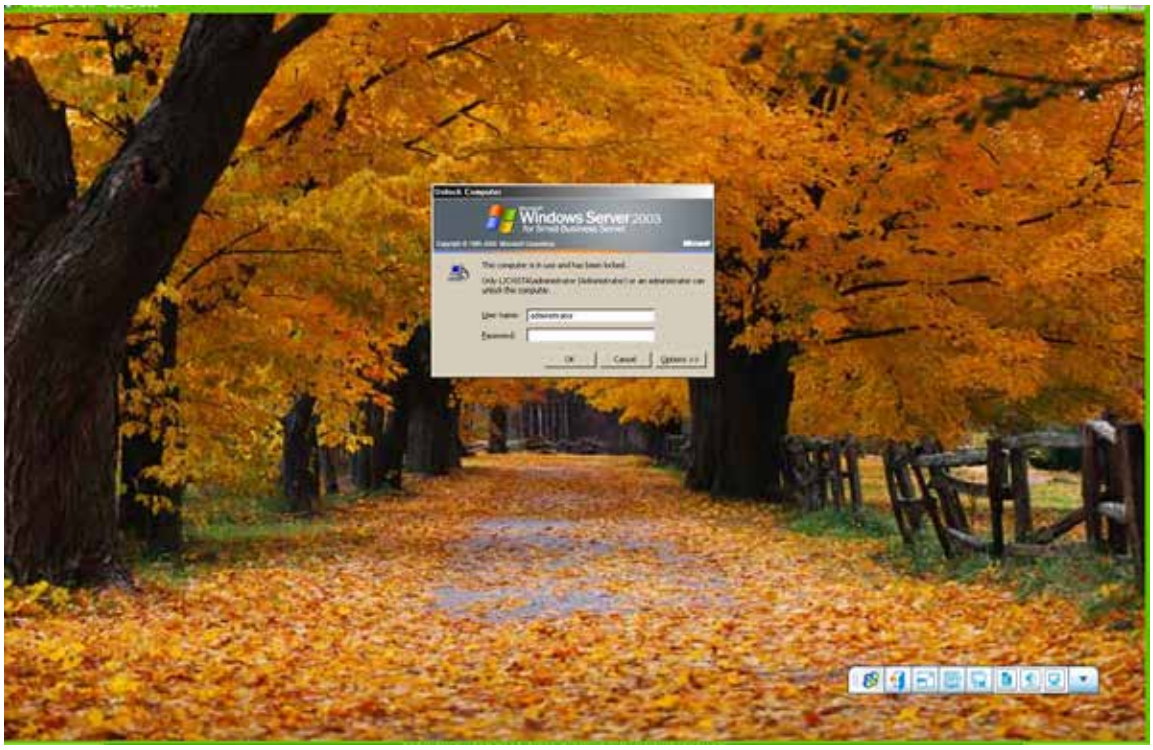
All graphics will be created and animated to represent the following examples enclosed. This document is a minimum requirement for all systems in any project, which will be displayed graphically and presented to the owner for their review and approval.

All physical equipment will be represented on or in a graphic.

Table of Contents

BAS Graphic Design

Logging Into the System

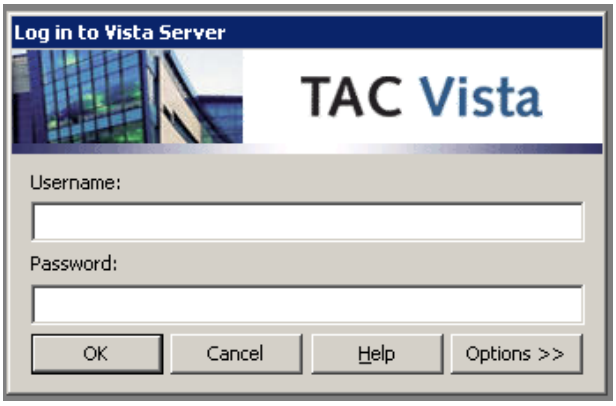


The AOC will supply you with the final configuration on how to set the domain, IP addresses and mail server to set-up the computer for the Enterprise software.

User Name-By AOC Password-By AOC

The Server will be set-up as a self loading service

Login in will be set-up as Windows domain login and the list of operators will be issued by the AOC with user name and access permissions. This is the same account used to login into the workstation/server.



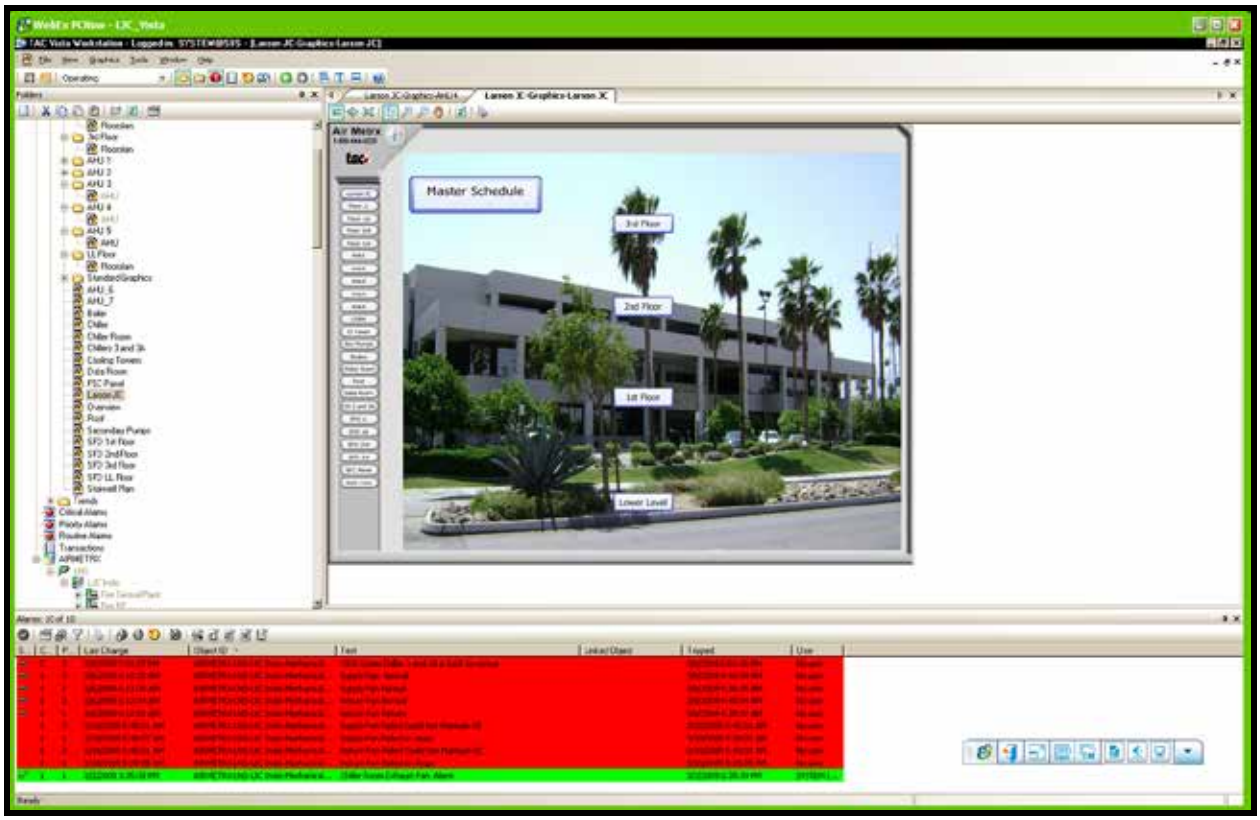
BAS Graphic Design

Home Page Screen Overview

Home Screen Links will have the ability to access all other main graphics. Note: the VAV's will be accessed through the thermal graphics page.

1. Master Schedule
2. The master schedule will control all start / stop functions on a global level
3. Review of Screen Links (left hand column of links on graphic)
4. The background graphic for the home page, will be a picture of the building. This will be submitted and approved by the AOC or it representatives.

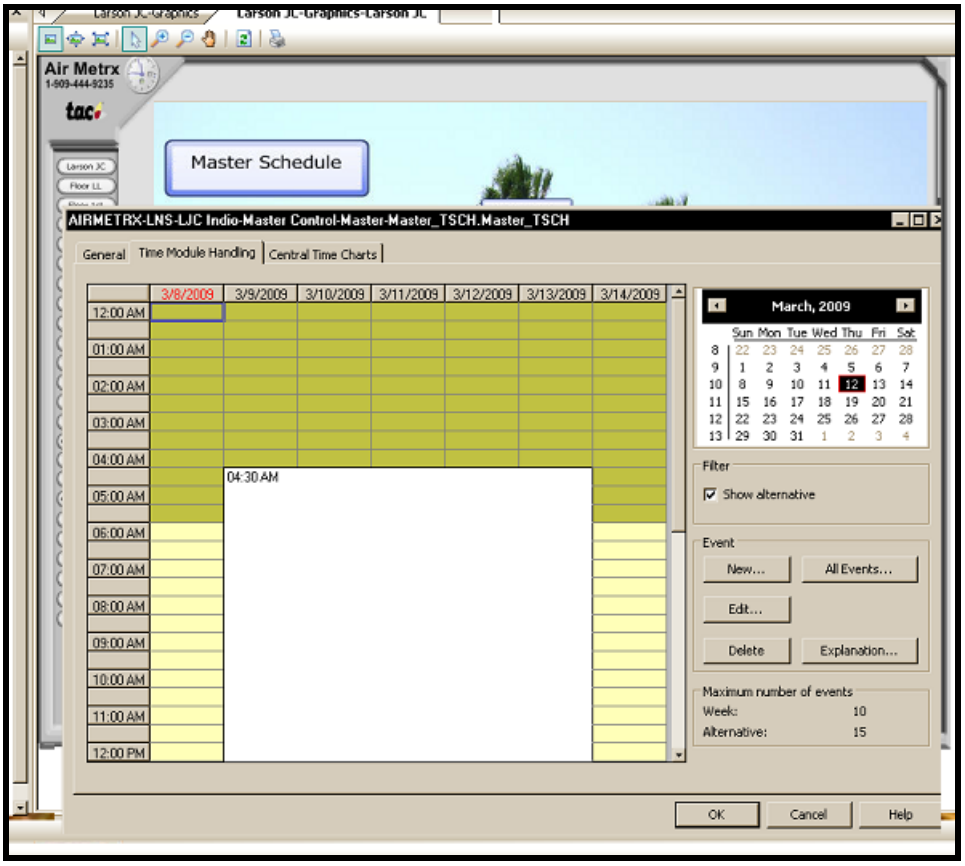
Home Page Graphic



Master Schedule

1. Master Schedule Graphic
2. The Master Schedule will be set-up with the occupied schedule for the facility.
3. All other events will be set-up for the first two years for the facility, ie: holiday and special events to be supplied by the AOC.

Master Schedule Graphic

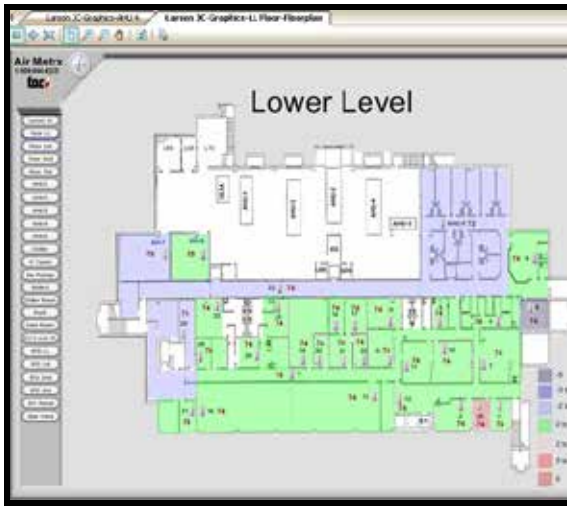


Thermal Graphic Floor Plans

All floors will be represented in a graphic form, (no less than one graphic per floor), which will be displayed with the minimum layers as described below.

1. The master set point for each VAV box, which will be a forcible set point. (See Figure 3)
2. A thermostat that displays the space temperature that will magnify when the curser goes over it. (See Figure 2) and (See Figure 3), for layer.
3. Hyper Link to each VAV box. (See Figure 3)
4. An (f) next to the space temperature will display the zone has been forced. (See Figure 3)
5. Zone # per engineering plan. (See Figure 3)
6. A color changing layer that represents the shape of the zone being supplied by the zone. It will change color based on deviation in space temperature. Note: If the space temperature is overrode or modified, the layer will track the change. (See Figure 1) Graphic Temperature Colors in figure 1. All scaling and color will be matched unless authorized by the AOC. (See Figure 3)
7. Hyper link to all VAV's and all other major parts of the system on this page.

Thermal Graphic Floor Plans



BAS Graphic Design

Graphic Temperature Colors

Figure 1

Reading Area Temperatures on the Floor Graphics

Figure 2

Layer Properties

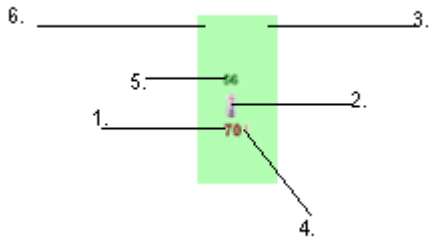


Figure 3

Variable Air Volume Box Review

Each type of VAV box will have its own graphical representation. (One graphic for each zone) The minimum graphical representation as seen in figures 4-6 below.

1. The damper and heating coil will be dynamic. The damper will open and close based on damper position and the hot water coil will go from blue to red using 6 distinct colors based on valve position.
2. Damper position display will magnify when the curser goes over it. (See Figure 6)
3. The following will be global set points to each VAV controller from the master controller. Application Mode (HVAC_Cool when heating is not available and auto all other times). Occupancy Zone space temperature set point and emergency command unless otherwise called out by the AOC or it representatives.
4. The VAV DAT will be tied into the OAT and have no effect on the control of the zone.
5. If a CO2 sensor is present the zone will reset based on CO2 level, 650 ppm and below normal operations. From 650 to 1100 the box will open to 100% of damper position unless otherwised called out by the AOC or it representatives.
6. The links are as follows: home screen, floor plan, AHU and Central Plant, if applies.
7. All zones for afterhours override will bring on the associated AHU and Central Plant if needed. The zone will be set-up for two hours intervals.

Variable Air Volume Box Graphics

BAS Graphic Design

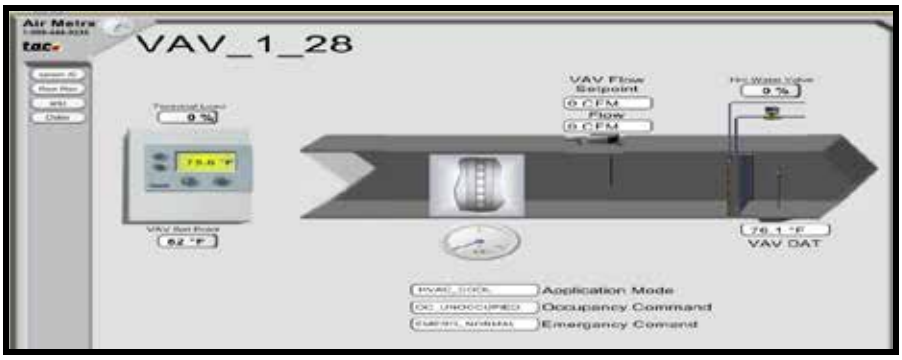


Figure 4

VAV Box with Re-Heat Coil

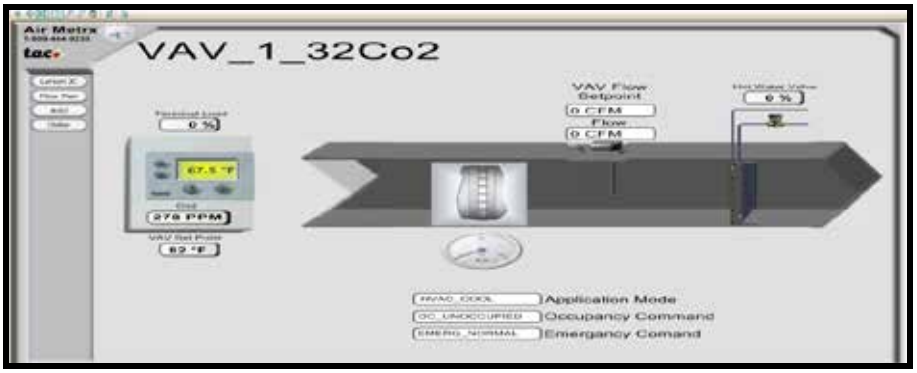


Figure 5

VAV Box with CO_2 Monitor

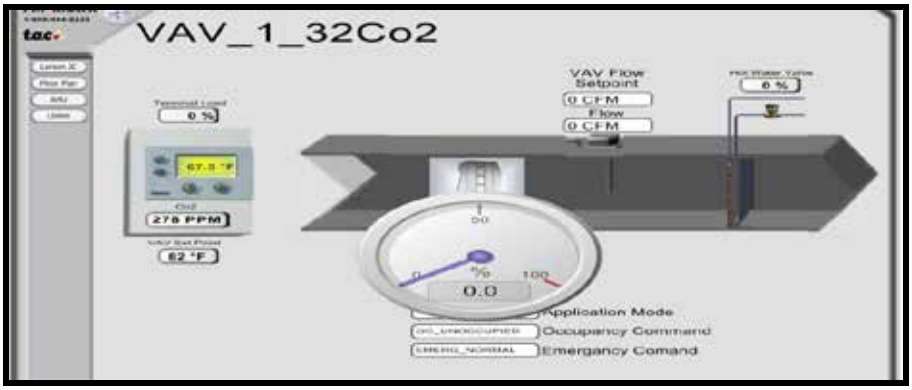


Figure 6

Air Handling Unit Graphics

The AHU's graphics will represent the actual layout of the unit it is controlling. The look and feel will be matched based on figures 7 through 10.

1. All dampers, fans, filters, cooling coils, reset buttons, alarming, forced by operator and heating coils will be dynamic.
    - The damper and indicator will open and close based on damper position.
    - The hot water coil will go from gray to red for hot water using 6 distinct colors based on valve position.
    - The chilled water coil will go from gray to blue for chilled water using 6 distinct colors based on valve position.
    - The filter will flash when it is dirty.
    - All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
    - An (f) next to the device and will display that the device has been forced.
    - The reset button will go from red to green when pressed and back to red after reset is released.(Auto)
2. All process variables will be displayed with the set points.
3. Emergency shutdown will be on each page for the unit represented.
4. A time schedule for that unit that will operate the AHU, the associated zones and the central plant.
5. Average thermal load will be displayed form the zone and will reset the discharge temperature based on load.

AHU's Graphics

BAS Graphic Design

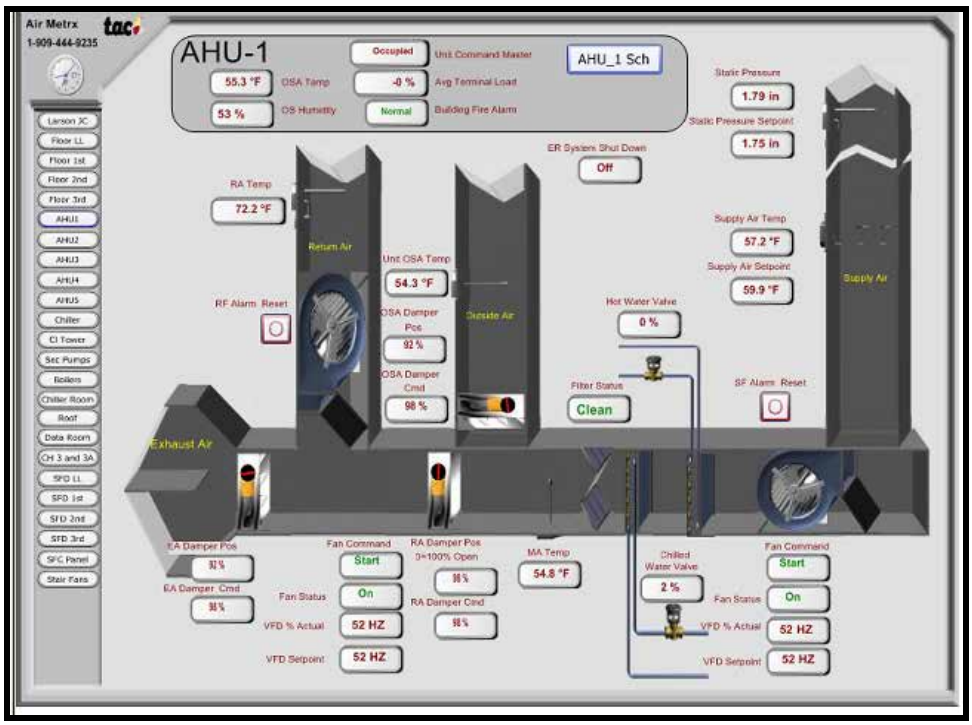


Figure 7

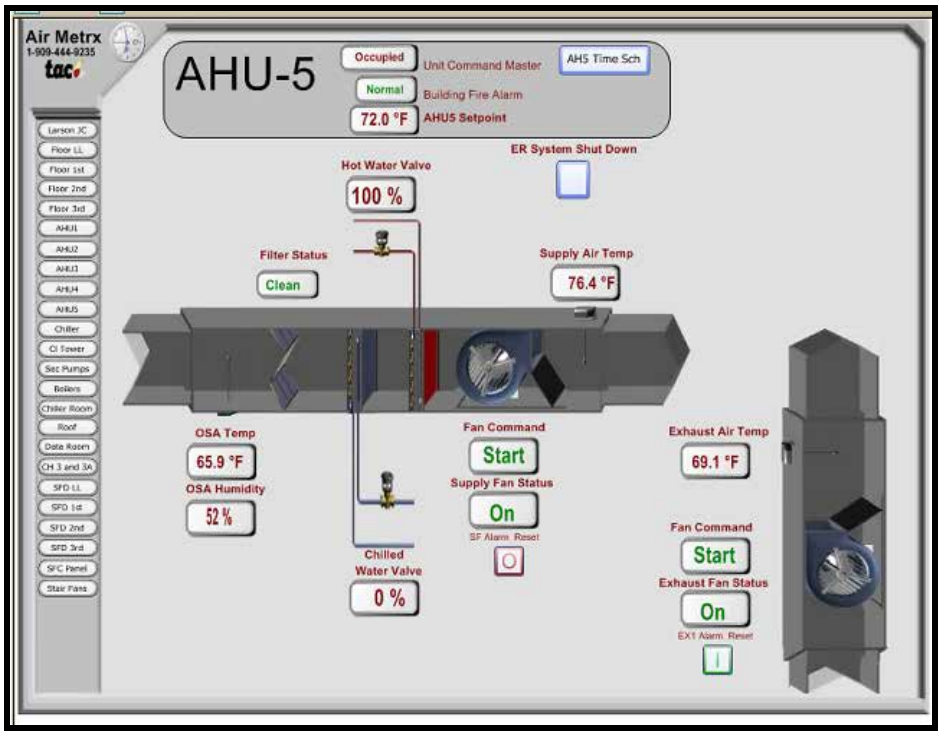


Figure 8

Room/Area Air Handling Units

BAS Graphic Design

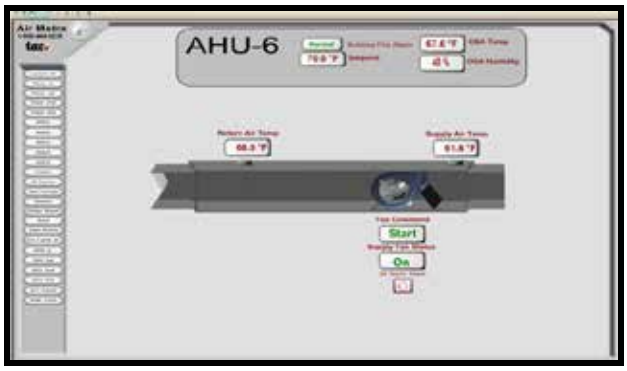


Figure 9

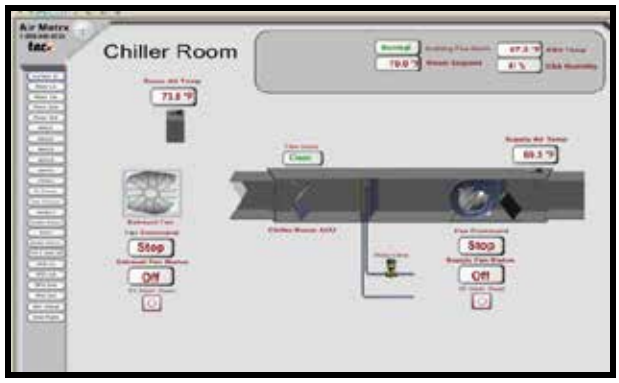


Figure 10

Chiller Room Graphics

The chiller room graphics will represent the actual layout of the central plant as it is controlling. The look and feel will be matched based on figure 11.

1. All chiller, pumps, valves, reset buttons, alarming, water flow arrows and forced by operator will be dynamic.
    - The chiller will display a change of state by showing the vanes moving.
    - The valves will go from 0-100% based on valve position.
    - All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
    - An (f) next to the device and will display that the device has been forced.
    - The reset button will go from red to green when pressed and back to red after reset is released. (Auto)
    - Water flow arrows will move in the direction of the water when the equipment is occupied.
2. All process variables will be displayed with the set points.
3. Emergency shutdown will be on each page for the unit represented.

Chiller Room Graphics

BAS Graphic Design

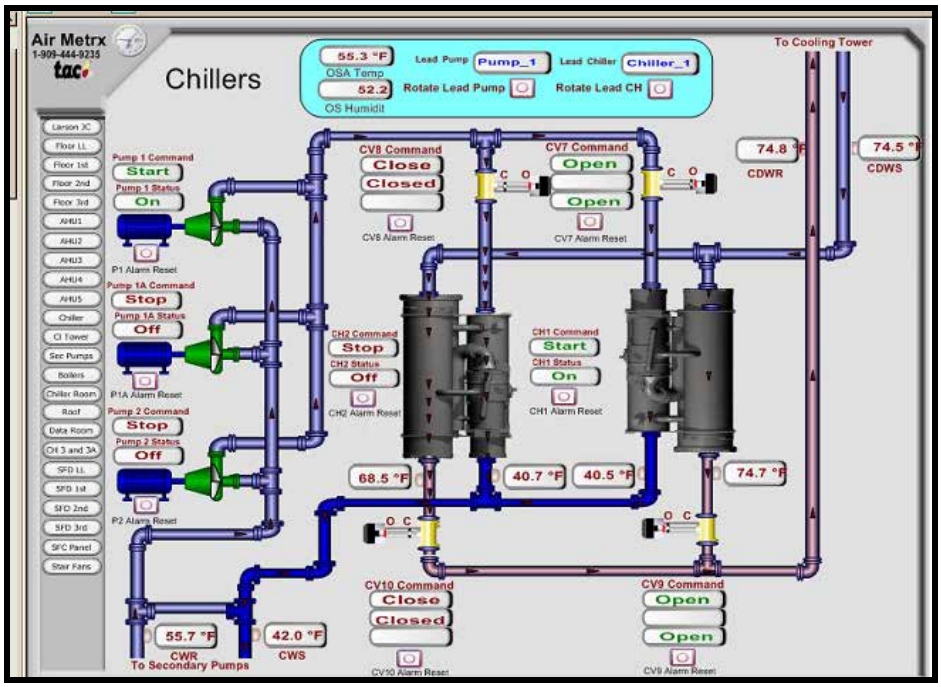


Figure 11

Cooling Tower Graphics

The cooling tower graphics will represent the actual layout of the central plant as it is controlling. The look and feel will be matched based on figure 12.

4. All cooling towers, pumps, valves, reset buttons, alarming, water flow arrows and forced by operator will be dynamic.
    - The cooling tower will display water flowing and fan moving in the change of state (on) for that piece of equipment.
    - The valves will go from 0-100% based on valve position.
    - All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
    - An (f) next to the device and will display that the device has been forced.
    - The reset button will go from red to green when pressed and back to red after reset is released. (Auto)
    - Water flow arrows will move in the direction of the water when the equipment is occupied.
5. All process variables will be displayed with the set points.
6. Emergency shutdown will be on each page for the unit represented.

Cooling Tower Graphics

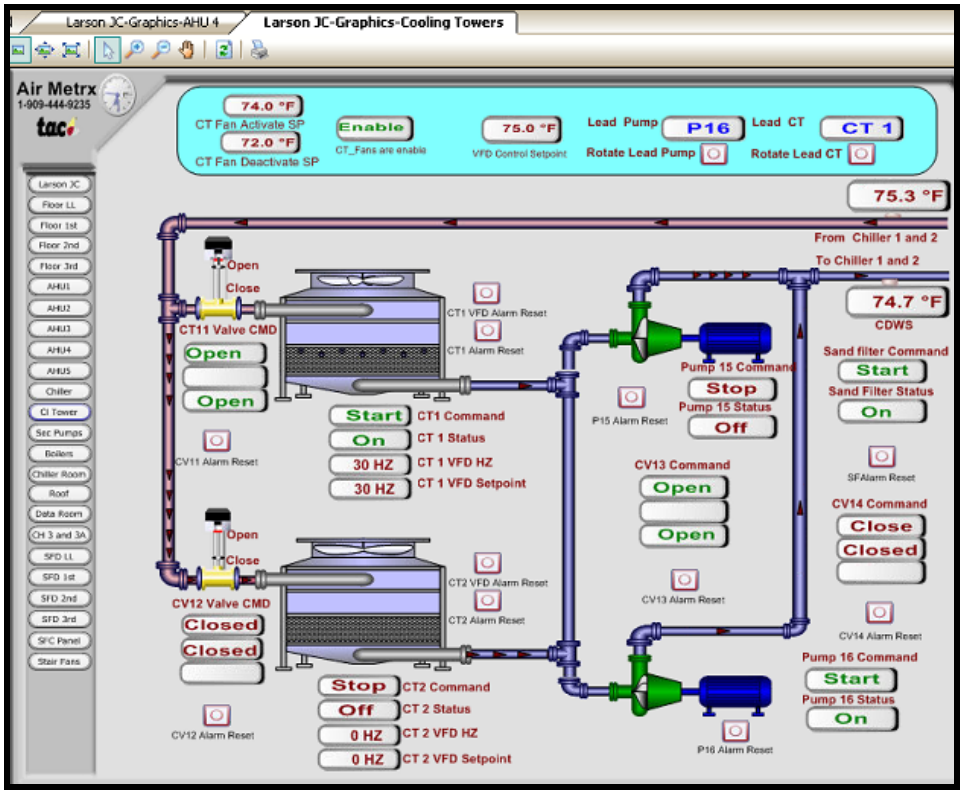


Figure 12

Secondary Pump Graphics

The secondary pump graphics will represent the actual layout of the central plant as it is controlling. The look and feel will be matched based on figure 13.

1. All pumps, valves, reset buttons, alarming, water flow arrows and forced by operator will be dynamic.
    - The cooling tower will display water flowing and fan moving in the change of state (on) for that piece of equipment.
    - The valves will go from 0-100% based on valve position.
    - All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
    - An (f) next to the device and will display that the device has been forced.
    - The reset button will go from red to green when pressed and back to red after reset is released. (Auto)
    - Water flow arrows will move in the direction of the water when the equipment is occupied.

2. All process variables will be displayed with the set points.
3. Emergency shutdown will be on each page for the unit represented.
4. The reset schedule will be displayed on the graphic if used.

Secondary Pump Graphics

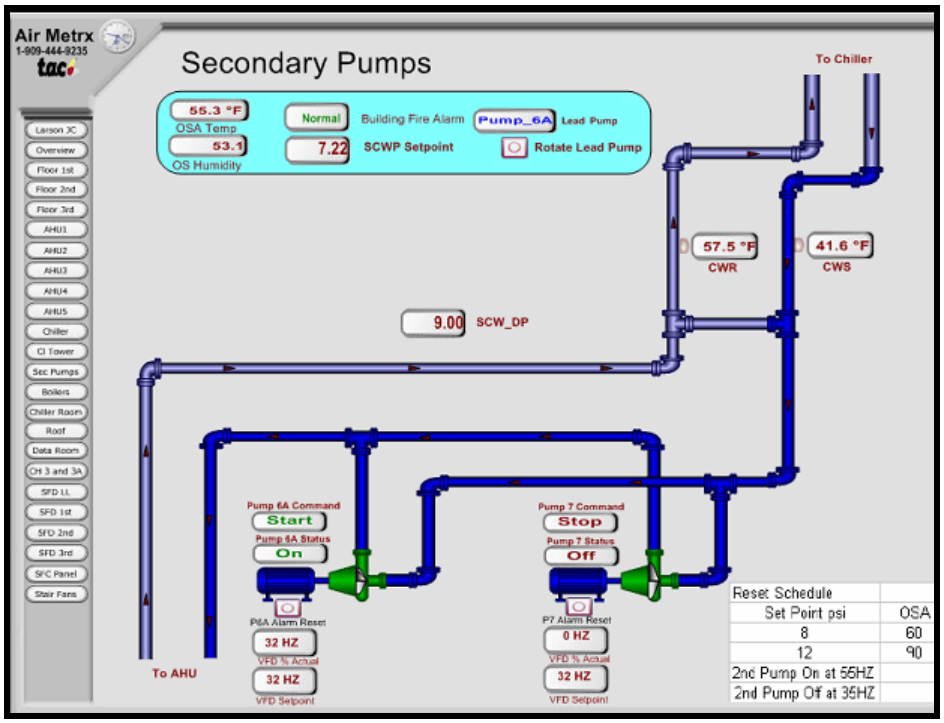


Figure 13

Boiler Room Graphics

The boiler room graphics will represent the actual layout of the central plant as it is controlling. The look and feel will be matched based on figure 14.

1. All boiler, pumps, valves, reset buttons, alarming, water flow arrows and forced by operator will be dynamic.

- The boiler will display the flames moving and the fan moving in the change of state (on) for that piece of equipment.
- The valves will go from 0-100% based on valve position.
- All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
- An (f) next to the device and will display that the device has been forced.
- The reset button will go from red to green when pressed and back to red after reset is released. (Auto)

- Water flow arrows will move in the direction of the water when the equipment is occupied.

2. All process variables will be displayed with the set points.
3. Emergency shutdown will be on each page for the unit represented.
4. The reset schedule will be displayed on the graphic if used.

Boiler Room Graphics

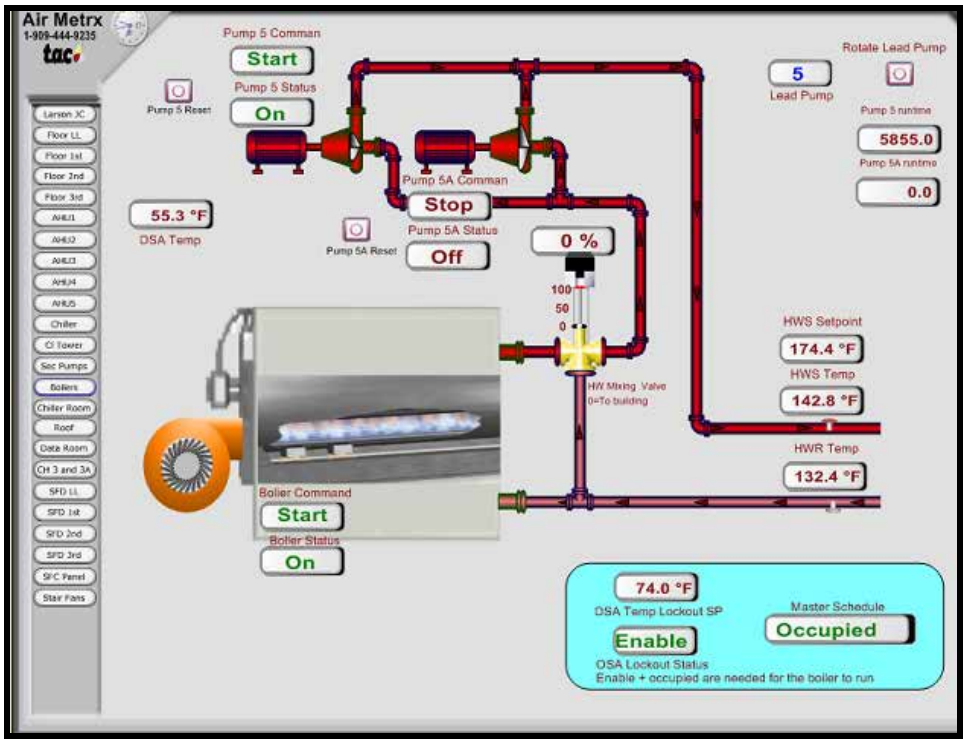


Figure 14

Roof Exhaust Fan Graphics

The exhaust fans graphics will represent the actual layout of the central plant as it is controlling. The look and feel will be matched based on figure 15.

1. All exhaust fans, reset buttons, alarming and forced by operator will be dynamic.

- The exhaust fans will display the color red for stop and green for run.
- All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
- An (f) next to the device and will display that the device has been forced.
- The reset button will go from red to green when pressed and back to red after reset is released. (Auto)

Roof Exhaust Fan Graphics

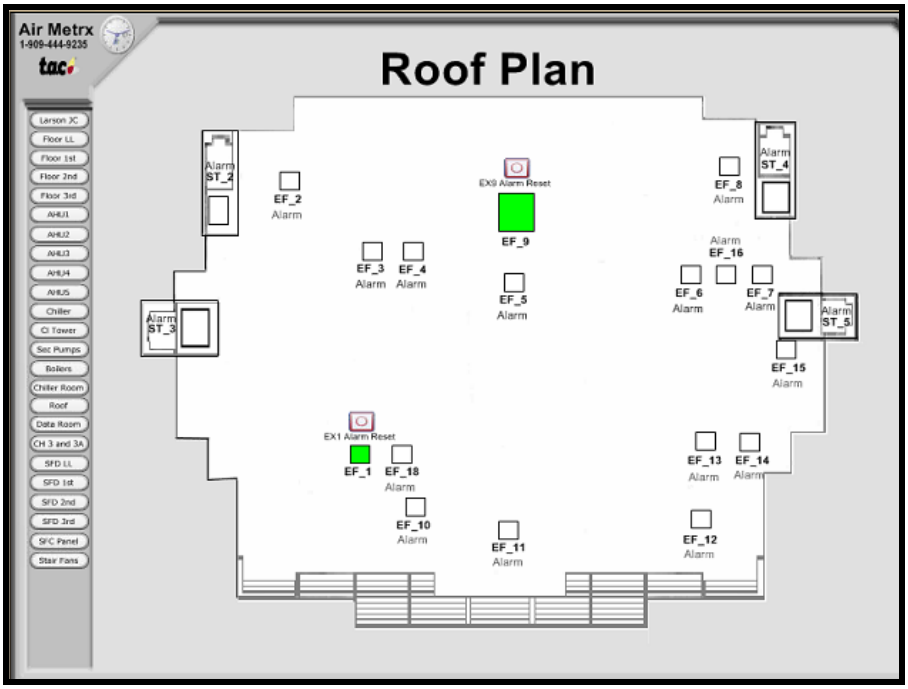


Figure 15

Smoke Fire Panel Graphics

The smoke fire panel graphics will represent the actual layout of the panel on multiple graphics. The look and feel will be matched based on figure 16-20.

1. All dampers, alarming, forced by operator will be dynamic.

   - All indication will be off if the panel is disabled. When enabled the indicators will display whether the dampers are in the open or closed position.
   - All equipment in alarm will flash (alarm) with a white background over the piece of equipment in alarm.
   - An (f) next to the device and will display that the device has been forced.

Smoke Fire Panel Graphics

BAS Graphic Design

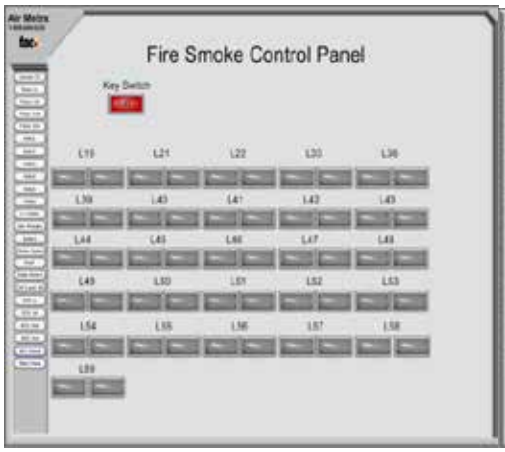


Figure 16

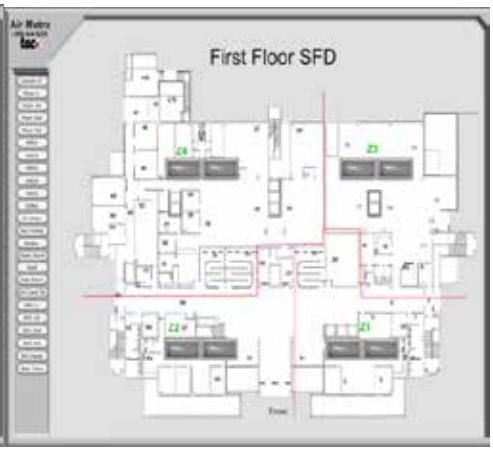


Figure 17

Figure 18

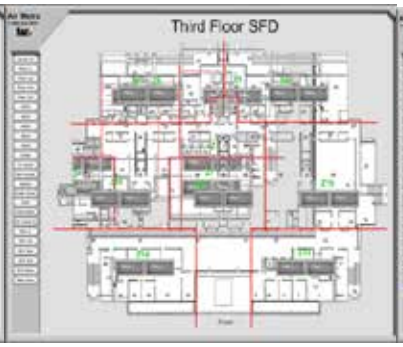


Figure 19

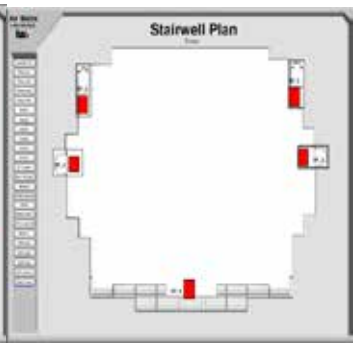


Figure 20

The graphics listed above are a general guideline and are the minimum design standards. All graphics need to be submitted and approved by the AOC before installing on the host as a final product.