DIVISION 25 – BUILDING AUTOMATION SYSTEMS (BAS)

Includes the following sections:
25 00 00 Building Automation System (BAS)

See Part II for additional information regarding Indoor Pollutant Reduction and Control, Energy Efficiency, etc.

Also refer to the following related Sections:
23 08 00 Commissioning of HVAC
23 09 00 Instrumentation and Control for HVAC
23 09 10 Instrumentation and Control for Lab HVAC
23 90 00 Mechanical Rooms

DESIGN REQUIREMENTS

DESIGN DOCUMENTS REQUIRED: BAS SYSTEMS STUDIES, SINGLE LINE DIAGRAMS, AND SEQUENCES OF OPERATIONS

The following shall be performed by the designer and submitted in addition to design drawings and specification documents for review:

1. Studies: Where new additional BAS controllers and points are being added to an existing BMS systems, the entire system shall be studied for existing JACE resource utilization performance, age, and suitability of continued use with the additional points. Designer shall confer with UC Engineering staff and Physical Plant BMS Shop for known limitations or problems associated with each existing JACE and temperature control panels that new points are being added to. Many older JACES are in poor shape (some are failing) and unsuitable for continued use and may be on a deferred maintenance list. All of these issues should discovered and documented during the design phase to ensure the new BMS systems are properly designed and budgeted for before going out to bid.

2. Coordination with Physical Plant BAS Shop: The service technicians have a lot of direct experience programming and maintaining existing BAS systems on Campus. They have design and equipment specification preferences that change regularly based on challenges encountered post construction on other projects, thus they should be engaged early in the design process to take advantage of lessons learned and identify designs and specifications of equipment they specifically don't want to have to maintain.

3. Controls Network Security: Any vendor provided devices must adhere to campus minimum network connectivity standards. Refer to https://policy.ucsc.edu/policies/its/it0004.html#appa

4. Single Line Diagrams Required:

    a) CONTROLS NETWORK ARCHITECTURE DIAGRAM: Diagram shall illustrate all DDC systems controls equipment including communications via internet web browser at remote location workstation, Ethernet cabling to routers and switches, operator workstation server (if used on site), JACE BMS control panel(s), LON cabling to field controllers, MODBUS RS-485 cables to equipment gateways (boiler managers, chiller managers, split system managers), communications wiring to remote XI/O) panels, and for each JACE indicate notated "120V power provided by Division 26" and ITS "Data cabling and hot jack provided by Division 27".

b) NETWORK RISER DIAGRAM FOR EVERY JACE: Diagram shall illustrate all DDC system controls equipment and communications cabling connected to the JACE via LON network (all local controllers for boilers, exhaust fans, air handlers, variable frequency drives, variable volume terminal devices, etc.), BACnet MS/TP for fume exhaust air valves, MODBUS for electrical meters, and BACnet IP for variable refrigerant gateways, etc.

c) Division 25 designer shall coordinate with the Division 26 and Division 27 designers to ensure these other designers are aware of the power and data requirements for each JACE and all terminal devices such as variable air volume boxes or lab air control valves.

d) Coordination of power requirements to each JACE: if the JACE controls any equipment that is on standby power, the JACE has to also be on standby power. If the JACE controls any equipment on emergency power, the JACE also has to be on emergency power. Note that JACES on emergency power are very rare (only special applications such as vivarium or seawater systems with livestock, otherwise the BMS system does not control life safety equipment) and should be discussed with UC Engineering staff.

5. Points Lists: Provide a list of all control points by name and signal type (AI, AO, DI, DO). Coordinate with Physical Plant for integration of specific equipment PLC read/write points to be mapped to the BAS.

6. Sequences of Operation: Provide sequences of operations for each controlled system including setpoints and alarms.

7. Zone Maps: provide a scaled zone map for each floor including what central equipment and terminal devices serve each zone. Indicate all BAS control panel locations.

8. Mechanical Rooms: Refer to 23 90 00 for BIM Modeling Requirements. BMS control panels with NEC clearances shall be shown and coordinated with other trades equipment and required access clearances.

9. Legacy of Single Line Diagrams: It is the University's intent for the Single Line Diagrams to be the building's perpetual living model documents that will be continuously modified and or updated for future building remodels, alterations, etc. For this reason, single line diagrams shall be updated and submitted by the Engineer of Record at the end of the project to reflect as-build conditions. In addition, as-built CAD and spreadsheet calculations shall be submitted in both native AutoCAD .DWG file format, Excel spreadsheet, and Acrobat PDF file formats. Before generating any single line diagrams or calculations, the Design Engineer should confer with Archives to determine if there are already AutoCAD single line diagrams and Excel spreadsheet files available to modify. The newer buildings on campus should have them, but the older ones won't. If Archives

does not have them, they will need to be generated from scratch. It is the Design Engineer's responsibility to ensure they have included the appropriate time and fees in their proposal to generate and deliver these as-built single line diagrams and calculations.

OTHER DESIGN RELATED SUGGESTIONS

The following is a list of Building Committee Suggestions compiled by Physical Plant BMS Shop based on many years of lessons learned on past projects on campus and is provided herein in order to help the designer not repeat these lessons. Please note most of these suggestions are mandatory and are somewhat redundant to the above design guidelines, but there may still be some pearls of design wisdom to mine. Also, this list will also grow over time.

Building energy management systems

- Adhere to Tridium resource management limitation guidelines
- Follow campus ITS security guidelines
- No Beta testing of software or equipment & SOO strategies
- Use Tridium BAS systems on Niagara network
- Fully utilize LON Modbus or BackNet devices on HVAC systems
- ITS infrastructure activated with emphasis on BAS data port connections for commissioning of systems.
- ITS switches and BAS equipment should be on standby power

BMS sequences of operation

- Always provide third party commissioning agent
- Use demand controlled ventilation strategies by measuring Co2 levels.
- Use motion occupancy detectors to reset VAV supply airflow & zone set points for DCV
- Use motion & Co2 detectors in lecture halls and classrooms to reduce operating hours for DCV
- Alarm filter bank Differential Pressure to front end
- Design building HVAC / BAS to meet LEED certification level
- Use supply air static set-point reset.
- Use chilled / heating water D.P set point reset.
- Provide start up commissioning and change of season retro commissioning
- Consider Skyspark or other persistent commissioning software
- Provide alarm if VAV can't meet supply air flow set-point
- Utilize VAV DAT sensor and alarm SAT to zone
- Utilize building optimum start stop
- Utilize building Night purge
- Utilize OSA free cooling

The following standard specification is intended to be edited according to the specifics of the project. Brackets [ ] and areas shaded in gray [e.g. format] indicate requirements that are optional depending upon the type of system being provided or per instructions associated with the [ ] and project requirements. Consult with University's Representative and campus stakeholders.

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SECTION 25 00 00 BUILDING AUTOMATION SYSTEM (BAS)

I. PART 1 GENERAL

A. SUMMARY

1. This section describes the scope of work for the Building Automation System that must be installed by a qualified BAS Contractor and integrated to the UCSC Campus Supervisor Server by the BAS Contractor Developer.
2. The Building Automation System (BAS) as provided in this Division shall be based on the NiagaraAx Framework (or "NiagaraAx"), a Java-based framework developed by Tridium.
3. Provide Building Automation System (BAS) incorporating Direct Digital Control (DDC), energy management and equipment monitoring consisting of the following elements:
4. Microprocessor based remote control panels interfacing directly with sensors, actuators, and environmental delivery systems to provide complete standalone DDC/EMS functionality. (i.e., HVAC equipment, lab monitoring, energy metering, etc.).
5. Communication network to allow data exchange between remote panels and central supervisors.
6. Associated operator station(s), and software functioning as the primary operator interface for BAS. System shall utilize a graphics front end.
7. Pneumatic, electric and electronic control for all items indicated including dampers, valves, panels and pneumatic and electrical installation.
8. Human Machine Interface (HMI) control:
   a) Controls installer shall interface the BAS systems with the BAS panel provided by the equipment manufacturer. Control installer shall provide integrator panel and all wiring from BAS to equipment panel and from equipment panel to other equipment. Equipment panel communications protocol shall be LONWORKS, BACnet MSTP or Modbus RTU to a JACE. BACNet/Modbus IP must be a separate network communicating through the JACE secondary IP port.
   b) Any vendor provided devices must adhere to campus minimum network connectivity standards. Refer to https://policy.ucsc.edu/policies/its/it0004.html#appa.
9. Provide submittals, installation, data entry, programming, startup, test and validation of BAS, instruction to UCSC PP&C representative on maintenance and operation of BAS, as-built documentation and system warranty.
10. Completely coordinate with work of other trades.

11. It is UCSC's goal to implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. University of California, Santa Cruz shall be the named license holder of all software associated with any and all incremental work on the project(s).
12. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to UCSC.

B. DEFINITIONS

a) BACnet:
   (1) An open communications protocol for building automation and ASHRAE 135 control networks. It is an ASHRAE, ANSI, and ISO standard protocol developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
b) FOX:
   (1) Tridium's TCP/IP-based protocol used for communication between network level controllers and supervisor servers.
c) LonTalk:
   (1) An open communications protocol for building automation and LonWorks control networks. It is a LonMark International, ANSI, and ISO standard protocol originally developed by Echelon Corporation.
d) Low Voltage:
   (1) As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
e) Modbus:
   (1) An open communications protocol for building automation and Modbus control networks. It is a standard protocol supported by the Modbus Organization, Inc.
f) Niagara-AX:
   (1) A software framework and development environment that solves the challenges associated with building Internet-enabled products, device-to-SupervisorAx applications and distributed Internet-enabled automation systems. Older version, phase-out started in 2015, still compatible with newer version, Niagara.
g) Niagara N4:
   (1) A software framework and development environment that solves the challenges associated with building Internet-enabled products, device-to-SupervisorAx applications, and distributed Internet-enabled automation systems. Current version, introduced in 2015, backward compatible with older version, Niagara-AX.
h) TCP/IP:
   (1) Short for Transmission Control Protocol/Internet Protocol. A protocol for communication between computers, used as a standard for transmitting data over networks and as the basis for standard Internet protocols.

C. SCOPE OF WORK

1. The Building Automation System (BAS) shall be comprised of Java Application Control Engine or Controllers (JACE) within each facility. Integration with the Tridium NiagaraAx Framework shall be accomplished through a BAS contractor-installed Tridium NiagaraAx JACE 8000. No legacy JACEs will be permitted.
2. Each copy of Tridium Niagara software shall include a 5 year Niagara Software Maintenance Agreement.

3. Niagara Supervisor software and JACE network controllers are required for the supervisor and network levels of the BAS. Communication at these levels shall be FOXS, Tridium's Secure TCP/IP-based protocol. The WEB Service (Port 80 and 443) on each JACE is to remain Disable. Access to the system, locally in each building, shall be accomplished using a technician's laptop with Workbench. Remote access to each JACE should be established using Tridium's Workbench over a FOXS connection, from a technician's laptop or pc through UCSCs VPN.
4. Field level controllers to be configured or programmed using wizards. Wizards shall be provided free of charge and be compatible with the current published versions of the network Automation tool that is provided as part of this project. The wizard software shall be available for public access from the manufacturer's web site. These wizard programming tools shall be compatible with at least 3 other manufactures network Automation tools.
5. Each JACE shall communicate directly to LonMark/LonTalk (LWC), BACnet MSTP (BNC), MODBUS RTU devices and other open and legacy protocol systems/devices provided under this Division. It is UCSC's goal to eliminate any gateway or redundant (redundant to the JACE functionality) device(s).
6. The work provided in this specification shall be performed by multiple entities. The BAS Contractor shall have overall responsibility for the Division work.
7. BAS Contractor's shall provide overall management, coordination and responsibility for delivering integrated BAS systems. The BAS Contractor shall review work performed by other Specialty Contractors such as low voltage, IT, security and control system subcontractors and coordinate the connection of these systems to UCSC's IT infrastructure in conjunction with UCSC IT staff.
8. All materials and equipment used shall be standard components. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
9. All wiring shall be done in accordance with all local and national codes.

D. DIVISION OF WORK

1. This section contains specifications pertaining to the (new/expansion of existing) Tridium based Building Automation System controls at "Project Name".
2. All work including provision of materials and installation is to be performed by the BAS Contractor with input from the UCSC BAS Department.
3. System programming [Designer to confer with Physical Plant BMS Shop to select one of the following Options]
   a) [Option #1] Contractor provides system programming and graphics per UCSC BAS Department Standards.
   b) [Option #2] UCSC BAS Department to provide system programming and graphics per UCSC BAS Department Standards.
4. Functional Acceptance Testing
   a) Contractor or Third Party Commissioning Agent will provide proof of point to point documentation for all hardware and terminations provided. The contractor and/or author of Sequence shall provide written Functional Acceptance Test Scripts based on the Sequence provided prior to the actual functional test date. (Provide a minimum of 16 hours assistance time by a qualified technician.)

5. The BAS Contractor shall be responsible for all communicating thermostats, any miscellaneous (LonWorks (LWC) and BACnet (BNC) controllers, control devices, control panels, controller programming, and controller programming software, controller input/output and power wiring and controller network wiring.
6. The BAS Contractor shall be responsible for the Java Application Control Engine(s) (JACE), software and programming, graphical user interface software (GUI), and connection of the JACE to the local or wide area network. BAS Contractor shall also be responsible for development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, and network management for all LWC or BNC devices.
7. LWC or BNC devices not provided by BAS Contractor shall be configured and commissioned by appropriate contractor and later managed in the JACE shall be integrated by BAS contractor.
8. For reasons of security and consistency, it is UCSCs intention to divide the work defined in this section into two sections:
   a) Work performed at the JACE level and below shall be performed by a qualified BAS Contractor Systems Integrator.
      (1) UCSC BAS Department will provide access to the Campus Construction Server for graphics development.
   b) All work provided at the Supervisor Server and between the Supervisor Server shall be provided by UCSC BAS Department. UCSC BAS Department shall also be responsible for all Security integration at the Supervisor Server level, if applicable.
9. All work pertaining to global strategies across sites and other intelligent building systems including between the JACE and other subsystems shall be by the BAS Contractor.

E. QUALITY ASSURANCE
1. DDC System Manufacturer Qualifications:
   a) Tridium Vykon, Distech Controls, Honeywell.
2. All new DDC controllers shall be Tridium based and programmed utilizing NiagaraAx Workbench as specified and shall be capable of communicating with the campus front end software (Honeywell WEBS Supervisor Version 3.8.111 at the time of this document) via the campus LAN using FOXS. Supervisor to JACE software version hierarchy must be followed.
3. Licensing of controllers must be open license allowing complete admin abilities to end user. Proprietary devices, licensing, and networks are not acceptable. All controllers/devices must adhere to “Tridium’s literature guidelines and Best Practices must be adhered too”.
4. For compatibility with existing systems all facets and units of data must be U.S. standard. Presented points as well as logic points found within the program.
5. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, and Governing Radio Frequency Electromagnetic Interference and be so labeled.
6. UPS to be installed for 120v feeding power supply to JACE and battery backup option for JACE to also be installed.
7. System to be installed by competent technicians, with full responsibility for proper operation of BAS, including debugging and proper calibration of each component in entire system.
8. Codes and approvals:

a) Complete BAS installation to be in strict accordance with national and local electrical codes. All devices designed for or used in line voltage applications to be UL listed.

9. All system components shall be fault tolerant.
   a) Provide satisfactory operation without damage at 110 percent and 85 percent of rated voltage, and at +/- 3 hertz variation in line frequency.
   b) Provide static, transient, short circuit, and surge protection on all inputs and outputs. Communication lines to be protected against incorrect wiring, static transients, and induced magnetic interference. Bus connected devices to be a.c. coupled, or equivalent so that any single device failure will not disrupt or halt bus communication.

F. QUALIFICATIONS

1. Detailed design, & installation of the Building Automation System shall be by a BAS Contractor that meets the following requirements:
   a) Contractor's primary personnel that will be working on this project will have successfully completed the Tridium NiagaraAx and Niagara N4 Certification training at the time of bid. Contractor to provide proof of mechanics / technicians having completed this training as part of submittals. These mechanics / technicians are to be designated as the primary designers / installers / integrators. They will be responsible parties to be on site during the installation. In addition they will be required to attend all pre-construction, construction, and post construction meetings, including acceptance testing and training.
   b) Experience installing at least three networked BAS systems utilizing NiagaraAx and Niagara N4 based control systems integrating controls utilizing either the LonWorks or BACnet communications protocol in the last 3 years. Minimum point count of these systems shall be 50 points. Submit information documenting this experience including contact information of client representative familiar with the contractors work on each project.

G. BASIC BAS REQUIREMENTS

1. Panel Locations:
   a) BAS panels should be under cover and centrally located relative to controlled equipment.
   b) BAS panels (including JACE and remote I/O) shall be protected from pipe leakage, dust, and other hazards and shall have a minimum 36" working clearance in front of each panel.
   c) BAS panels will be located as indicated on project mechanical drawings. The exact panel location will be determined by the Contractor and the University's Representative prior to the installation process.
   d) All panels shall be fully accessible without space restrictions to allow easy service and troubleshooting. Contractor shall obtain University approval of panel locations prior proceeding with the work.
2. DDC controllers and remote IO's shall provide the capability to manually override both digital and analog outputs at the BAS panel.
   a) Interface Relays: BAS output points shall not be used for direct switching of motor control circuits. Provide an interface relay at the BAS panel, between the DDC controller and motor starter or equipment.

b) Status Monitoring: Electric current sensor switches shall be used for BAS status monitoring. (As opposed to differential pressure switches or flow switches). These shall be located in the motor starter panel.

3. Start-Up Testing (Commissioning):

a) BAS Commissioning shall consist of 2 phases. The Contractor shall include BAS commissioning in the construction schedule. The BAS commissioning phases shall be:

(1) Pre-Functional Testing: Point to point testing of all points and controllers. UCSC BAS Department must receive and sign off on the Pre-Functional test script developed by the Contractor or Third Party Commissioning agent at least 14 days prior to Final Functional testing. This testing shall be completed in advance of program installation and Functional Acceptance Testing. The contractor shall submit signed off testing scripts verifying that this testing has been completed prior to the commencement of Functional Acceptance Testing.

(2) Functional Acceptance Testing: This will be a line by line testing of the sequences of operation. This testing shall be conducted by the BAS Contractor Systems Integrator and the author of the sequence, with equal support from both UCSC BAS Department and BAS Contractor.

H. SUBMITTALS

1. Shop Drawings: Provide individuals experienced with the installation and startup of equipment related to this type of integration.

a) One copy of shop drawings of the entire BAS shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions.

b) Complete system design information including:

(1) Data entry forms for initial parameters. All text and graphics to be approved prior to data entry.

(2) Valve, and damper schedules showing:

(a) Size.

(b) Configuration.

(c) Capacity.

(d) Location.

(3) Wiring and piping interconnection diagrams, including panel and device power and sources.

(4) Equipment lists (bill of materials) of all proposed devices and equipment.

(5) Software design data including:

(a) Flow chart of each DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.

(b) Sequence of operation relating to all flow chart functions.

(6) Control sequence.

(7) DDC installation, block diagrams, and wiring diagrams for each piece of equipment.

(8) DDC panel physical layout and schematics.

(9) The network topology diagram shall indicate the location and room number of all DDC controllers.

(10) The BAS Contractor shall submit an architecture layout that depicts devices from the JACE down to the device level.

(11) The BAS Contractor shall submit an architecture layout that depicts network diagrams for JACE to JACE communications as well as JACE to Server.

(12) BACnet specific designs:

(a) The BAS Contractor shall submit a network topology diagram that includes the following on all BACnet devices

(i) TCP/IP Address

(ii) MAC Address

(iii) Device instance number

(iv) BACnet Port

(v) Devices configured for BBMD

(vi) BACnet routers and subnets

(13) LonWorks specific designs:

(a) The BAS Contractor shall submit a network topology diagram that includes the following on all LON devices

(i) Neuron IDs

(ii) Routers

c) Sequence of Operations

(1) A complete written Sequence of Operation shall also be included with the submittal package. The BAS Contractor shall coordinate data from other contractors supplying products and systems, as part of their package and shall provide catalog data sheets, wiring diagrams and point lists to UCSC for proper coordination of work.

d) If a project is considered a renovation project the BAS Contractor shall update all existing master diagrams in order to keep as-built drawings completely accurate for the entire building.

(1) Digital Visio updateable drawings should be contained in JACE and Flashdrive.

e) A copy of all networks must be drawn on the actual physical daisy chain as installed. This is the actual blueprint showing the floorplan, equipment location and the route in which the network was run. The Niagara Network must also be included (i.e.: Communications Bldg. communicates to West Remote Parking, through JBEB connection on Rm. 252).

2. Product Data:

a) Complete list of product data including:

(1) Data sheets of all products.

(2) Valve, damper, and well and tap schedules showing size, configuration, capacity, and location of all equipment.

3. Project Information:

a) Certification of installer qualifications.

4. Submittal shall also include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 80% - 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or UCSC. It is expected that the successful BAS Contractor shall utilize the UC Santa Cruz graphic templates as much as possible. UCSC will provide an example of an acceptable graphic template. Where a particular graphic template does not exist, the Integrator shall create a similar template and gain approval during submittal process.
5. Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files.
6. Contract Closeout Information:
   a) Operating and maintenance manuals.
   b) UCSC instruction report.
   c) Certification that UCSC Training has been provided by BAS installer.
   d) As Built Instrumentation and Control Diagrams.
   e) Plan As-Builts at 1/8 inch scale showing:
      (1) Upon completion of the work, provide a complete set of ‘as-built’ drawings and application software on compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files.
      (2) Two copies of the ‘as-built’ drawings shall be provided in addition to the documents on compact disk.
      (3) Division 23, 25 and 26 contractors shall provide as-builts for their portions of work.
      (4) The BAS Contractor shall be responsible for as-builts pertaining to overall BAS architecture and network diagrams. All as built drawings shall also be installed into the BAS server in a dedicated directory.
      (5) Communication cable circuiting drawing with DDC panels and communication devices labeled.
      (6) Power wiring circuiting drawing showing 120 volt circuit source and low voltage transformer locations, identifications, and circuit to each controlled device per transformer for the DDC system.
7. Any software needed to program or calibrate controls system will be provided along with any setup, configurations and data files. Also, any hardware needed to communicate with the controllers and/or devices will also be included.

I. JOB CONDITIONS

1. Cooperation with other Trades:
   a) Coordinate the Work of this section with that of other Sections to ensure that the work will be carried out in an orderly fashion. It shall be the Systems Integrator’s responsibility to check the Contract documents for possible conflicts between his work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers and structural and architectural features.

J. SOFTWARE LICENSE AGREEMENT

1. It is the UCSC's express goal to implement an open system that will allow products from various suppliers to be integrated into a unified Tridium Niagara system in order to provide flexibility for expansion, maintenance, and service of the system. University of California, Santa Cruz shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the UCSC shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include:
   a) All custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the JACE, BAS Supervisor Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices.
   b) Any and all required IDs and passwords for access to any component or software program shall be provided to UCSC.
2. UCSC has signed a software and firmware licensing agreement for the BAS software. Such license shall grant use of all programs and application software to UCSC as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. Systems Integrators that participate in the integration of UC Santa Cruz direct digital control systems must:
   a) Be certified in the use, application and service of NiagaraAx and Niagara N4 software and shall provide documentation from the manufacturer's training center as such. However, certification in the above does not automatically qualify an integrator to bid on proposed UC Santa Cruz projects. Only approved integrators listed in this specification are eligible to participate in the project.
   b) Agree to use on any UC Santa Cruz project any application standards, html pages, graphics templates, etc. developed by or for UC Santa Cruz for the purpose of digital control, scheduling, alarming, graphics, etc.
   c) Agree that the application standards, html pages, graphics templates, etc. developed only for UC Santa Cruz are the property of UC Santa Cruz (subject to the manufacturer's license agreement) and shall not be reproduced, etc. for use on any other customer, project, etc. without the expressed written permission of the UC Santa Cruz facilities staff.
   d) Agree that certification on the manufacturer's software does not guarantee continued participation in UC Santa Cruz's BAS projects.
   e) Agree to provide UC Santa Cruz's staff with the highest level of administrative password.
   f) Agree that UC Santa Cruz staff and other Systems Integrators can use the onsite UC Santa Cruz software tools to modify JACE s, license files, and passwords, provide software maintenance, etc., after warranty period expires.
   g) UCSC requires that all NiagaraAx based software and hardware on this project have the following Niagara Information Compatibility Statement (NICS). The Existing NiagaraAx Server complies with the requirements below. Organizations without the NICS below shall not be allowed to bid.
      (1) Brand ID = Vykon or Distech Controls or Honeywell
      (2) Station Compatibility In = *
      (3) Station Compatibility Out = *

(4) Tool Compatibility In = *

K. WARRANTY

1. Provide all services, materials and equipment necessary for the successful operation of the entire BAS for a period of two years after acceptance by UCSC Project Manager and provide hardware and software upgrade support during that period that corresponds with any upgrades performed by the BAS Contractor Systems Integrator.
2. Within this period, upon notice by UCSC, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced systems or parts found defective at no cost to UCSC by the BAS Contractor including: but not limited to:
   a) Building Controls System Server software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies, as identified by the Contractor or UCSC, shall be provided and installed at no charge during the warranty period.
   b) Contractor to apply all software updates and security patches immediately (within 72 hours) as they become available, from the start of the project until the end of the warranty period.
   c) All corrective software modifications made during the warranty period shall be updated on all user documentation and on user and manufacturer archived software disks.
   d) Include parts, labor, and necessary travel during warranty.
   e) All parts should be replaced with the exact products. If exact parts are not available then the equivalency determination rests with UCSC.
   f) Troubleshooting service, preventative maintenance, and scheduled re-calibration of the system is the responsibility of UCSC. Such routine tasks shall not impact Contractor warranty obligations.
3. The adjustment, required testing, and repair of the system includes all computer equipment, transmission equipment and all sensors and control devices.
4. UCSC will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish UCSC with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 24 hours after receiving a request for service.
5. Provide vendor specific warranty information.
6. At the end of the warranty period, Contractor shall ensure every instance of Tridium Niagara software has the latest Tridium software maintenance release installed.
7. Expiration of the warranty period does not relieve Contractor of the responsibility for correcting all deficiencies identified during the warranty period. Expiration of the warranty period does not relieve Contractor of the responsibility for fulfilling all specified obligations during warranty period.

L. UCSC'S TRAINING

1. In no case shall training be scheduled until all graphics are approved and accepted by UCSC Physical Plant BAS Department.
2. Training shall not proceed until UCSC Physical Plant BAS Department has reviewed and approved the Training Submittal.

3. Provide a minimum of 32 hours of training, organized into 8 separate sessions of 4 hours each session.
4. Provide a factory-trained instructor or representative to give full instructions to designated personnel in the operation, maintenance, and programming of each piece of equipment or system. Instructors shall be thoroughly familiar with all aspects of the subject matter. The Contractor shall provide all equipment and material required for classroom training.
5. Qualifications of proposed training instructor are subject to UCSC approval.
6. The training shall be specifically oriented to the system and interfacing equipment installed.
7. Organize training per user group and into different training sessions. UCSC to provide user groups.
8. Include classroom instruction and field demonstration.
9. Classroom instruction should include at a minimum:
    a) Detailed review of as-built documentation and conditions with general equipment layout
    b) In depth discussion of theory of sequence of operations
    c) Review organization and usability of O&M documentation
    d) Maintenance (preventative, sensor calibration, etc.) procedures and schedules
    e) Pertinent safety requirements
    f) Operator control functions including graphic operation and navigation
    g) Explanation of adjustment, calibration and replacement procedures
    h) Explanation of procedures to restore any building level controller or building control system server database. Training manual shall include screen captures, including instructional annotation, of each step required to accomplish the task.
    i) Explanation of procedures to restore any local control unit database. Scenarios to explain include: restoring a database that is corrupted in an existing unit; restoring a database in a new unit that replaces an identical existing unit; and restoring a database in a new unit that is a different controller than the failed unit being replaced. Training manual shall include screen captures, including instructional annotation, of each step required to accomplish the task, for each type of DDC controller installed.
    j) Detailed review of all DDC logic, programming and programming documentation. Control logic shall be graphical and annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow UCSC's BAS Integrators to relate each program component block to corresponding portions of the specified Sequence of Operation. Training manual shall include screen captures, including instructional annotation, of all DDC logic, programming and programming documentation, for each type of DDC controller installed.
    k) Additional specific topics will be requested by UCSC in advance of Training session. Each custom topic/session will require the Contractor to prepare and submit training manual with the same level of detail (screen captures, annotation, and written instructions) as described above.
10. Field instruction, if determined by UCSC to be required for this project, should include at a minimum
    a) Normal maintenance procedures
    b) Demonstration of operation
    c) Demonstration of safeties and interlocks

d) Walk-through of the job to locate control components

M. PROJECT MANAGEMENT

Note: Edit the above training requirements for each project. Make sure each item is appropriate and coordinate with UCSC. Coordinate with Div. 1 requirement

Note: The following sections on Project Management and Scheduling contain additional details required for retrofit applications. These can be edited out for New Construction projects.

1. No later than the project kick-off meeting, Contractor shall identify in writing:
   a) One employee of the BAS Contractor who has the primary responsibility for managing the project. For purposes of scheduling and project management, this person shall be known as the BAS Contractor's Project Manager.
   b) One employee of the BAS Contractor who has the primary responsibility for supervising the control system physical installation. For purposes of scheduling and project management, this person shall be known as the BAS Contractor's Installation Supervisor.
   c) One employee of the BAS Contractor who has the primary responsibility for programming controllers, programming control system database and developing graphics. For purposes of scheduling and project management, this person shall be known as the BAS Contractor's Systems Integrator.
   d) Depending on size of project, the three above-listed roles may be performed by the same Contractor's employee.
2. For purposes of scheduling and project management, the project shall generally be divided into 3 phases.
   a) Installation Phase
      (1) Shall be the period from project start until physical installation of all controllers, appurtenant devices and computers is complete.
   b) Database/Graphics Finalizing Phase
      (1) Shall be the period from the completion of Installation Phase until Contractor has completed all system programming and graphics development.
   c) Project Closeout Phase
      (1) Shall be the period from the completion of the Database/Graphics Finalizing Phase until UCSC has accepted the project.
3. The Contractor shall attend all project meetings and provide meeting minutes and action items to all attendees within 3 working days of each meeting.
   a) During the Installation Phase, project meetings shall occur weekly at a regularly scheduled meeting time. BAS Contractor's Project Manager and BAS Contractor's Installation Supervisor shall attend all meetings during the Installation Phase. If requested by UCSC, BAS Contractor's Systems Integrator shall attend any meeting during the Installation Phase. BAS Contractor shall furnish updated project schedule, with all applicable milestones, at least 1 day prior to the meeting.

b) During the Database/Graphics Finalizing Phase, project meetings shall occur as determined by UCSC. UCSC will give 1 week advance notice of any project meetings during this phase. BAS Contractor’s Project Manager and BAS Contractor’s Systems Integrator shall attend all meetings during the Database/Graphics Finalizing Phase. If requested by UCSC, BAS Contractor’s Installation Supervisor shall attend any meeting during the Database/Graphics Finalizing Phase. BAS Contractor shall furnish updated project schedule, with all applicable milestones, at least 1 day prior to the meeting.

c) During the Project Close Out Phase, project meetings shall occur as determined by UCSC. UCSC will give 1 week advance notice of any project meetings during this phase. BAS Contractor’s Project Manager and BAS Contractor’s Systems Integrator shall attend all meetings during the Project Close Out Phase. If requested by UCSC, BAS Contractor’s Installation Supervisor shall attend any meeting during the Project Close Out Phase. BAS Contractor shall furnish updated project schedule, with all applicable milestones, at least 1 day prior to the meeting.

4. Meeting minutes shall represent a true and accurate record of the meeting. Corrections or clarifications to the meeting minutes shall be by a written request for correction within 7 days of the date of issuance of meeting minutes.
5. BAS Contractor accepts that during the Project Close Out Phase, UCSC may rely on third party consultants, i.e. Commissioning Authority, to complete independent test and review of project deliverables from BAS Contractor.
6. The BAS Contractor shall maintain a “red-lined” copy of the as-built drawings on-site at all times.
7. The BAS Contractor shall have Functional Performance Test and start up sheets available on-site at all times.

N. SCHEDULING

1. The BAS Contractor is required to provide a schedule of activities and continually update the schedule as the project progresses. Clearly distinguish between commissioning activities performed solely by BAS Contractor and commissioning activities involving the Commissioning Authority.
2. During Installation Phase, the BAS Contractor shall update schedule weekly, at least 1 day prior to the project meeting, to provide a 3-week look-ahead schedule with a list of construction impacts for occupants.
3. Project Schedule shall include, at a minimum, with at least 3 weeks advance notice, the following project milestones:

a) BAS Contractor starts physical installation.
b) Any Utility Shut Down required by project.
c) BAS Contractor ready to connect Building Automation System Server to UCSC Campus Controls Network.
d) BAS Contractor completes all physical installation.
e) BAS Contractor complete and ready for Commissioning (Cx) network points.
f) BAS Contractor ready for preliminary controller FPT and programming review (1 of each type of controller or controller application.
g) BAS Contractor ready for final zone terminal unit controller FPT and programming review (10% of each type of controller).

h) BAS Contractor ready for air handler FPT (Verifies AHU reset strategies and occupancy scheduling are functioning correctly).

i) BAS Contractor ready for building heating/cooling, central plant or whole building FPT (as applicable).

j) Controller programing and entire Niagara database ready for UCSC Physical Plant BAS Department review.

k) Graphics ready for UCSC Physical Plant BAS Department review.

l) BAS Contractor ready for Cx trend review.

m) Contractor submits Training Agenda and Training Binder for UCSC Physical Plant BAS Department review. Note: Graphics, Training Agenda and Training Binder must be reviewed and approved by UCSC Physical Plant BAS Department before training can be scheduled.

n) Training sessions.

4. Included in this project are connections to equipment provided by others. Coordinate deliveries, final locations, factory mounting, and various connections required.

5. Coordinate activities with contract project schedule.

   a) Ensure integration activities are incorporated into project schedule.

   b) Communicate requirements to prevent potential damage from paint, dust, water, weather, etc. Monitor and take measures to assure protection for all equipment.

6. Coordinate all IT requirements with UCSC and contract project schedule.

O. SYSTEM ARCHITECTURE

1. GENERAL

   a) The Facility Management Control System (BAS) shall be comprised of a network of interoperable, stand-alone digital controllers, a computer system, graphical user interface software, network devices and other devices as specified herein.

   b) The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate the most current ANSI/ASHRAE Standard BACnet, LonWorks technology, MODBUS, existing OPC if applicable, and other existing open and proprietary communication protocols if applicable in one open, interoperable system.

   c) The supplied Building Automation System shall employ component-based technology for representation of all data and control devices within the system. In addition, adherence to industry standards including the most current ANSI / ASHRAE™ Standard, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file and a resource file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via RS-485 (BACnet MSTP) or Ethernet (BACnet Ethernet/IP,) only by exception with prior UCSC BAS Department approval and only through the JACE's secondary IP port.

   d) All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.

e) The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.

f) A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.

(1) Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.

g) The installed system shall provide secure passwords access to all features, functions and data contained in the overall BAS.

h) System architecture shall consist of no more than two levels of LAN and/or communication busses.

(1) Level one – Campus Supervisor level

(a) Consists of JACE 8000 controllers acting as gateway devices to share data between buildings and supervisor server, where Campus NiagaraAx Supervisor software resides. The Supervisor Server is overseen by UCSC BAS Department. All modifications must be pre-approved and coordinated. BAS Department System Integrators access supervisor using Client provided workstations, connected to the Client LAN/WAN using preferred web browser software. JACE controllers to be installed throughout Client buildings connected to Client LAN/WAN for communication between supervisor server and the specific building controls, according to the Niagara Product Model. The communication protocol between supervisor and JACE controllers shall be FOXS, Tridium's Secure TCP/IP-based protocol.

(2) Level two - Field level

(a) Consists of general purpose programmable controllers to provide stand-alone control of terminal units. Examples of terminal units include VAV boxes, fan coil units, heat pumps, induction units, unit heaters, smaller rooftop units serving a single zone, etc. Field level controllers to be configured or programmed using the programmable controller tool made available by the manufacturer. Programmable controller tool shall be capable of connection to field controllers via Client LAN/WAN routed through the JACE controllers. Communication at the field level shall be open protocol; BACnet MS/TP or LonWorks.

P. NETWORK ACCESS AND SECURITY

1. Remote Access

a) For Local Area Network installations UCSC shall provide a connection to the Internet to enable access via the customer's Intranet to a corporate server. BAS Contractor shall connect to IP drop provided by UCSC IT utilizing a minimum of Category 6 grade of patch cabling.

2. JACE IP communications

a) BAS Contractor will use DHCP and DNS for IP communications.

(1) No static IPs or "hardcoded" IP addresses (except for secondary port, see below) in the JACE will be accepted.

(2) The BAS Contractor shall request from UCSC IT Department all required primary port TCP/IP network configuration settings for all JACEs via standard RFI. The BAS Contractor shall not assign any of the following configuration settings without UCSC BAS Department approval.

(a) Domain name

(b) Host name

(c) Station Name

(d) Secondary port

(i) For troubleshooting purpose, The BAS Contractor shall configure the JACE's secondary port to a static IP address of 192.168.1.12X, where X is equal to last digit of JACE's serial number.

(ii) The subnet mask shall be configured to 255. 255. 255.0

b) SSL requirements

(1) All communications between Niagara devices and the Supervisor server or user interface software, i.e., IDE, shall be secured using SSL encryption.

(2) The following ports shall be used for SSL communications

Software Interface	Protocol	Specified Port
Browser	HTTPS	443
Niagara Station IDE	FOXS	4911
Niagara Platform IDE	TLSv1	5011

Q. JAVA APPLICATION CONTROL ENGINE (JACE)

1. The BAS Contractors Systems Integrator shall supply one or more Java Application Control Engine (JACE) as part of this contract to manage devices/points in all specification sections. The number of JACEs provided by the BAS Contractor is dependent on the type/quantity of devices and points. It is the responsibility of the BAS Contractor to coordinate with all Division contractors to determine the quantity and type of JACEs needed to fulfill the operating sequences.

2. Java Application Control Engine (JACE) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the JACE. It shall be capable of executing application control programs to provide:

a) Calendar functions

b) Scheduling

c) Trending

d) Alarm monitoring and routing

e) Time synchronization

f) Integration of LonWorks controller data and BACnet controller data

g) Network Management functions for all LonWorks based devices.

3. The Java Application Control Engine must provide the following hardware features as a minimum:

a) TI AM3352: 1000MHz ARM® Cortex™-A8

b) 1GB DDR3 SDRAM

c) Removable micro-SD card with 4GB flash total storage/ 2GB user storage

d) Wi-Fi (Client or WAP)

(1) IEEE802.11a/b/g/n

(2) IEEE802.11n HT20 @ 2.4GHz

(3) IEEE802.11n HT20/HT40 @ 5GHz

(4) Configurable radio (Off, WAP, or Client)

(5) WPAPSK/WPA2PSK supported

e) USB type A connector

(1) Back-up and restore support

f) (2) Isolated RS-485 with selectable bias and termination

g) (2) 10/100MB Ethernet ports

h) Secure boot 24VAC/DC power supply

i) Runs Niagara-4.1 and later

j) Real time clock

k) Battery-less

l) Any Expansion Modules and IO Configurations needed for the project.

m) The JACE must be capable of operation over a temperature range of -22 to 140°F

n) The JACE must be capable of withstanding storage temperatures of between -40 and 185°F

o) The JACE must be capable of operation over a humidity range of 5 to 95% RH, noncondensing.

4. The JACE shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 32 simultaneous users.

5. JACE Data Collection and Storage.

a) The JACE shall have the ability to collect data for any property of any object and store this data for future use. The maximum records stored should be 250. See points list for required logs.

b) The data collection shall be performed by log objects, resident in the JACE that shall have, at a minimum, the following configurable properties:

(1) Designating the log as interval or deviation.

(2) For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.

(3) 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.

(4) 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.

c) Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action. All log data shall be archived to a database in the SupervisorAx Server and the data shall be accessed from a standard Web browser and the Periscope Dashboard.

d) All log data, when accessed from a server, shall be capable of being manipulated using standard SQL, BQL & NQL statements.

e) All log data shall be available to the user in the following data formats:
   (1) HTML
   (2) XML
   (3) Plain Text
   (4) Comma or tab separated values.
f) Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
g) The JACE shall have the ability to archive its log data remotely to a server on the network. Provide the ability to configure the following archiving properties, at a minimum:
   (1) Archive on time of day
   (2) Archive on user-defined number of data stores in the log (buffer size)
   (3) Archive when log has reached its user-defined capacity of data stores
   (4) Provide ability to clear logs once archive.

6. JACE Audit Log
   a) Provide and maintain an Audit Log that tracks all activities performed on the JACE. 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 to a server. For each log entry, provide the following data:
      (1) Time and date
      (2) User ID
      (3) Change or activity: i.e., Change set point, add or delete objects, commands, etc.
7. JACE Database Backup & Storage
   a) The JACE shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
   b) Copies of the current database and, at the most recently saved database shall be stored in the JACE. The age of the most recently saved database is dependent on the user-defined database save interval.
   c) The JACE database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.
8. JACE Time Sync
   a) Use the NtpPlatformServiceQnx in the Station/Services/PlatformServices/ NtpPlatformServiceQnx. Use Time Servers ntp1.ucsc.edu: 128.114.129.77, ntp2.ucsc.edu: 128.114.1.77, ntp3.ucsc.edu: 128.114.103.81
9. JACE Weather Station/OA Temperature
   a) The Web Supervisor has a dedicated weather station that will be available through the Niagara Network. While the JACE is not on the UCSC Network and for backup purposes all buildings are required to have their own Outdoor Air Temperature sensor to be used for economizer and other requirements but also is able to be overridden by the Web Supervisor Outdoor Air Temperature.
   b) Also available from the Web Supervisor is Outdoor Humidity, Dew point and Wet Bulb.
   c) The weather station in the Services of the Station should also be enabled and set for KWVI Watsonville Municipal Airport.

d) At this time Air Quality is not enabled due to conditions beyond our control. Therefor this property should be set to False.

10. JACE Loading

a) The Systems Integrator is to design the system to properly be load balance across multiple JACEs. I.e.; UCSC does not want 1 JACE operating at 80% and another is operating at 20%

11. JACE Mounting

a) The manufacturers recommended environmental and mount requirements shall be followed. In addition, a minimum clearance of 6 inches all around the JACE shall be maintained for local connections to the JACE.

R. INTEGRATED DEVELOPMENT ENVIRONMENT (IDE)

1. It is the intent of UCSC to manage and maintain all Niagara devices on the BAS network to the same Niagara approved version. It is the BAS Systems Contractor's responsibility to check the currently installed/approved version of Niagara on campus and to attain and perform any deployment with the current UCSC approved version.
2. An integrated development environment for development of graphic screens, control logic, security, alarm notification and data storage has been established using the Niagara Workbench Tool and currently resides on the EnergyAx Construction Server. The successful BAS Contractor shall utilize its own laptop for all programming. All graphical development will be done on UCSC's EnergyAx Construction Server. The server and JACE IDE tools shall be identical; however, it shall be possible to limit views and commands via a unique user profile and password in either. The system shall automatically monitor the operation of all workstations, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

S. INTEGRATED DEVELOPMENT ENVIRONMENT (IDE)

1. It is the intent of UCSC to manage and maintain all Niagara devices on the BAS network to the same Niagara approved version. It is the BAS Systems Contractor's responsibility to check the currently installed/approved version of Niagara on campus and to attain and perform any deployment with the current UCSC approved version.
2. An integrated development environment for development of graphic screens, control logic, security, alarm notification and data storage has been established using the Niagara Workbench Tool and currently resides on the EnergyAx Construction Server. The successful BAS Contractor shall utilize its own laptop for all programming. All graphical development will be done on UCSC's EnergyAx Construction Server. The server and JACE IDE tools shall be identical; however, it shall be possible to limit views and commands via a unique user profile and password in either. The system shall automatically monitor the operation of all workstations, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.

T. WEB BROWSER CLIENTS

1. The system shall also allow use of an unlimited number of clients using a standard Web browser including Chrome and Firefox™ (preferred). The system shall be capable of providing a rich user experience (including full use of the engineering toolset) through the use of java applets or a simple user interface using only HTML, CSS and JavaScript. Refer to Sequence of Operations for the client side display types that are required on this project.
2. The Web browser shall provide the same view of the graphics, schedules, calendars, logs, etc. as is provided by the Graphical User Interface and match the look and feel of graphics in the Web Supervisor. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
   a) The Web browser client shall support at a minimum, the following functions:
      (1) User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
      (2) Graphical screens developed for the GUI shall be the same screens used for the Web browser client (unless clearly stated in the sequence of operation). Any animated graphical objects supported by the GUI shall be supported by the Web browser interface. SupervisorAx Developer shall provide a BAS Contractor with a basis of performance/expectation for GUI. BAS Contractor shall use this standard graphic template or modify the graphics slightly to achieve the desired specification requirement/outcome.
      (3) Storage of the graphical screens shall be in the UCSC EnergyAx Construction Server and these graphics shall be “learned” by the SupervisorAx Server and EnergyAx Server via Export tagging.
      (4) Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
   b) UCSC shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
      (1) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
      (2) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
      (3) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
      (4) Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
      (5) View logs and charts
      (6) View and acknowledge alarms
      (7) Setup and execute SQL queries on log and archive information.
   c) Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.
   d) Navigation page will follow this layout:

(1) Home page – Main landing page with menu and a picture of the building.

(2) Floor Plans, under floor plans folder are the individual floor plans and under them the individual VAV's (meters and lighting to be shown on floor plan with layers and a legend.)

(3) Systems

(4) Equipment

(5) Meters

(a) Power

(b) Water

(c) Gas

(6) Miscellaneous

(a) Schedules

(b) Sequences

(c) Network Arc

(d) Notes

(e) Histories

(f) NCS 17 Equip Info

e) Tagging required on all projects. Points shall be tagged appropriately with Haystack and Niagara tag libraries.

f) All PID set point adjustments on a secure/hidden graphic. This file will be restricted by the system administrator

(1) Autotune is not acceptable and will be disabled

g) Legends to show what the different colors are

h) All floorplans are to be in a SVG or Scalable Vector Format.

i) VAV summary Page - Room Temp, Act temp, set point, damp position, reheat valve position, supply air temp, override color

j) Page for Max Terminal Box used for Set Point Calculation to allow for step up or step down of air flow. Ability to disable and enable VAV boxes in calculation

k) Show what points are in override, down, stale, in Alarm, and fault

l) Label units (AHU) to show what they feed

m) Network diagram to show JACE network inter-connectivity

n) JACEs to use outside air temp and campus weather station for temperatures

o) Valves need to be labeled and position shown

p) All flow meters and temperatures need to be trended

q) Page definitions with standards - AHU, CHW, Floorplan, VAV pages, DHW summary page, VAV summary page, water and gas meter page, electric meter

r) Insert maps (key plan) when zoomed in floor plans

s) Thermostat box on VAV page

t) Show where meters are in the building, show icon on floor plan and link back to summary page.

u) Floorplan zones - don't use conflicting colors

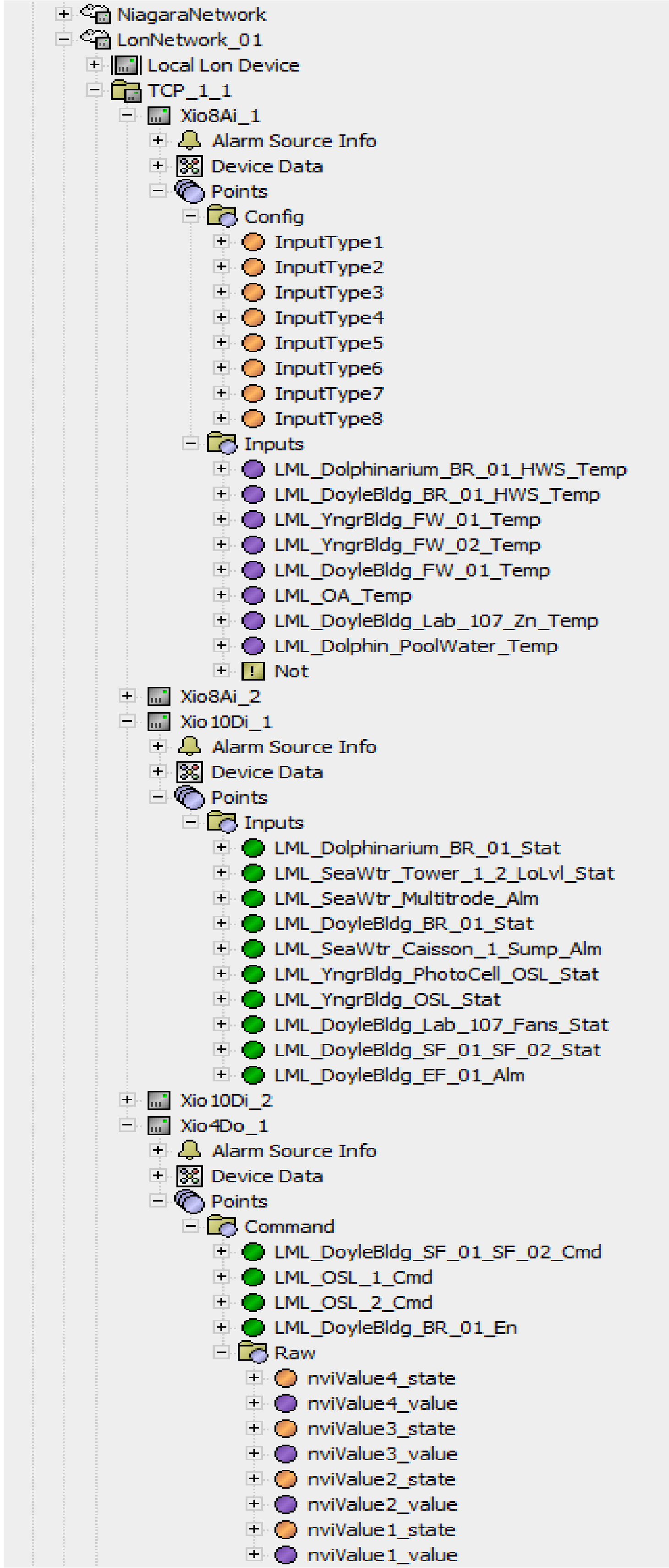
v) Control diagram show network addresses for each device

w) Control valve Tuning required on the graphics

3. Campus Navigation Bar on left side of page
4. JACEs shall be on Niagara 4.3 at a minimum or at the latest version Niagara that UCSC is running on the web supervisor. Check with UCSC BAS Department.

U. PROGRAMMING

1. Renovation work will require contractor to have direct communication with the UCSC BAS Department to coordinate access for system programming and interface to existing building system operation. Remote access to Construction AX Supervisor will be approved once contractor provides proof of understanding of system complexity. Project requirements may require programming and graphic generation be completed on site.
2. UCSC has a general programming standard. For programming file structure NavTree layout see below. Folder naming and location should follow the naming standard used by the UCSC BAS Department. All logic should live in folders named “Equipment Name_Logic”, under Config. Folder location and naming should follow the same format used on all UCSC jobs. Examples provided upon request.


NiagaraNetwork
LonNetwork_01
Local Lon Device
TCP_1_1
Xio8Ai_1
Alarm Source Info
Device Data
Points
Config
InputType1
InputType2
InputType3
InputType4
InputType5
InputType6
InputType7
InputType8
Inputs
LML_Dolphinarium_BR_01_HWS_Temp
LML_DoyleBldg_BR_01_HWS_Temp
LML_YngrBldg_FW_01_Temp
LML_YngrBldg_FW_02_Temp
LML_DoyleBldg_FW_01_Temp
LML_OA_Temp
LML_DoyleBldg_Lab_107_Zn_Temp
LML_Dolphin_PoolWater_Temp
Not
Xio8Ai_2
Xio10Di_1
Alarm Source Info
Device Data
Points
Inputs
LML_Dolphinarium_BR_01_Stat
LML_SeaWtr_Tower_1_2_LoLvl_Stat
LML_SeaWtr_Multitrode_Alm
LML_DoyleBldg_BR_01_Stat
LML_SeaWtr_Caisson_1_Sump_Alm
LML_YngrBldg_PhotoCell_OSL_Stat
LML_YngrBldg_OSL_Stat
LML_DoyleBldg_Lab_107_Fans_Stat
LML_DoyleBldg_SF_01_SF_02_Stat
LML_DoyleBldg_EF_01_Alm
Xio10Di_2
Xio4Do_1
Alarm Source Info
Device Data
Points
Command
LML_DoyleBldg_SF_01_SF_02_Cmd
LML_OSL_1_Cmd
LML_OSL_2_Cmd
LML_DoyleBldg_BR_01_En
Raw
nviValue4_state
nviValue4_value
nviValue3_state
nviValue3_value
nviValue2_state
nviValue2_value
nviValue1_state
nviValue1_value

3. Network architecture (Lon, Modbus, BACnet).
4. Programming Methods:
   a) Power Fail Protection - All System set points, proportional band, control algorithms and any other programming parameters shall be stored such that a power failure of any duration does not necessitated reprogramming the ASC (Application Specific Controller) JACE.
   b) Provide the capability to copy components from the supplied libraries, or from a user-defined library to the user's application. Component shall be linked by a graphical linking scheme by dragging a link from one component to another. Component links will support one-to-one, many-to-one, or one- to-many relationships. Linked components shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to components on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
   c) Configuration of each component will be done through the component's property sheet using fill-in the blank fields, list boxes, and selection buttons requiring the use of custom programming, scripting language, or a manufacturer-specific procedural language for every component configuration will not be accepted.
   d) 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.
   e) The system shall support component duplication within a customer's 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.
   f) All PIDs shall have adjustable set point exposed to the graphics in a secure/hidden page.
5. Network and Device Naming Conventions.
   a) All Network names will not have spaces or underscores. I.e.; BacnetNetwork is acceptable. Bacnet Network is not acceptable.
   b) Device names will not have spaces, underscores are acceptable. VAVs must have a room name associated with it. I.e.; VAV1_1_Rm126. The #1 attached to the VAV corresponds with the VAV Number; the second #1 corresponds with the floor it is on.
   c) All Network and Device names must be kept to a minimum and subject to UCSC BAS Department acceptance.

V. COMPONENTS LIBRARIES

1. A standard library of components shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The components 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 components created in their application and store the new instances of these components in a user-defined library.

3. Contractor will use the Niagara template station file as provided by UCSC BAS Department. The template station will be made available to the BAS Contractor upon request via standard RFI.
4. Contractor shall not use any “non-standard” or OEM JAR files unless approved by UCSC BAS Department. A JAR is considered “non-standard” if it is not included in Tridium’s “Niagara AX Developer” release made available to developers and to OEM partners. An example of a non-standard JAR is “jcigrahicssmall.jar”. A current list of approved JARs will be made available to the BAS Contractor upon request via standard RFI. Source codes made available to UCSC BAS Department to store and use.
5. Any approved non-standard JAR files become property of UCSC with a copy of the source code to store and use
6. All control components shall conform to the control component specified in the BACnet specification.
7. The component library shall include components to support the integration of devices connected to the Java Application Control Engine (JACE). At a minimum, provide the following as part of the standard library included with the programming software:
   a) LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific components to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.
   b) For devices not conforming to the LonMark standard, provide a dynamic component that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file and documentation for the device to facilitate device integration.
   c) For BACnet devices, provide the following components at a minimum:
      (1) Analog In
      (2) Analog Out
      (3) Analog Value
      (4) Binary
      (5) Binary In
      (6) Binary Out
      (7) Binary Value
      (8) Multi-State In
      (9) Multi-State Out
      (10) Multi-State Value
      (11) Schedule Export
      (12) Calendar Export
      (13) Trend Export
      (14) Device
   d) For each BACnet component, provide the ability to assign the component a BACnet device and component instance number.
   e) For BACnet devices, provide the following support at a minimum:
      (1) Segmentation

(2) Segmented Request
(3) Segmented Response
(4) Application Services
(5) Read Property
(6) Read Property Multiple Write Property
(7) Write Property Multiple
(8) Confirmed Event Notification
(9) Unconfirmed Event Notification
(10) Acknowledge Alarm
(11) Get Alarm Summary
(12) Who-has
(13) I-have
(14) Who-is
(15) I-am
(16) Subscribe COV
(17) Confirmed COV notification
(18) Unconfirmed COV notification
(19) Media Types
(20) Ethernet
(21) BACnet IP Annex J
(22) MSTP
(23) BACnet Broadcast Management Device (BBMD) function
(24) Routing

W. LONWORKS NETWORK MANAGEMENT

1. The Graphical User Interface software (GUI) shall provide a complete set of integrated LonWorks network management tools for working with LonWorks Networks. These tools shall manage a database for all LonWorks devices by type and revision, and shall provide a software mechanism for identifying each device on the network. These tools shall also be capable of defining network data connections between LonWorks devices, known as “binding”. Systems requiring the use of third party LonWorks network management tools shall not be accepted.
2. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
3. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
4. These tools shall provide the ability to “learn” an existing LonWorks network, regardless of what network management tool(s) were used to install the existing network, so that existing LonWorks devices and newly added devices are part of a single network management database.
5. The network management database shall be resident in the Java Application Control Engine (JACE), ensuring that anyone with proper authorization has access to the network management database at all times. Systems employing network management databases that are not resident, at all times, within the control system, shall not be accepted.

6. All LonNetworks must be installed to industry standards and are not exceed a max length of 3500 ft. Wire is to be installed in separate conduit if non-plenum and installed in accordance with proper LON specifications, no more than 60 devices and no LON repeaters, point and trend counts to assure proper polling of devices and points. Plenum cable is allowed without conduit with University approval. All points and devices are required to update correctly and not go into fault, stale or offline. Proof of network reliability by means of but not limited to LonNetwork Scan tool, Oscilloscope and Polling Service. Copies of these operations are to be submitted to UCSC before warranty period begins.

X. BACNET/MSTP NETWORK MANAGEMENT

1. The Java Application Control Engine shall support the integration of device data from BACnet TCP/IP or BACnet MSTP system devices. The connection to the BACnet system shall be via an RS485, or Ethernet IP as required by the device prior UCSC approval is required for IP/Ethernet controls and only through the secondary IP port of the JACE.
2. Provide the required components in the library, included with the Graphical User Interface programming software, to support the integration of the BACnet system data into the BAS. Components provided shall include at a minimum:
   a) Read/Write BACnet AI Points
   b) Read/Write BACnet AO Points
   c) Read/Write BACnet AV Points
   d) Read/Write BACnet BI Points
   e) Read/Write BACnet BO Points
3. Read/Write BACnet BV Points, All scheduling, alarming, logging and global supervisory control functions, of the BACnet system devices, shall be performed by the Java Application Control Engine.
4. The BAS supplier shall provide a BACnet system communications driver. The equipment system vendor that provided the equipment utilizing BACnet shall provide documentation of the system’s interface and shall provide factory support at no charge during system commissioning
5. BACnet Conformance:
   a) Logic controllers shall as a minimum support MS/TP BACnet LAN type. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as native BACnet devices. Logic controllers shall be of BACnet conformance class 3 and support all BACnet services necessary to provide the following BACnet functional groups:
      (1) Files Functional Group
      (2) Reinitialize Functional Group
      (3) Device Communications Functional Group
      (4) All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

6. All BacNetworks must be installed to BacnetNetwork industry standards with attention to number of devices, routers, and overall length, point and trend counts to assure proper polling of devices and points. All points and devices are required to update correctly and not go into fault, stale or offline. Proof of network reliability by means of but not limited to BacnetNetwork Scan tool, Oscilloscope and Polling Service. Copies of these operations are to be submitted to UNCC before warranty period begins.

Y. ALARM MANAGEMENT

1. It is required that a logical and consistent alarm strategy be used. The alarm strategy described here must be used. The typical alarms listed here show common situations, it is expected that additional alarms be added when applicable.
2. Additional, non-typical alarm extensions shall be added for specific situations described within the control sequences in drawing set.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Full point name shall be included in every alarm message, refer to “Point Naming” this specification section.
5. These steps must be taken to prevent nuisance alarming. False alarms can quickly fill alarms logs causing real alarms to get overlooked.
6. All indicated alarm threshold, limit, and time delay values to be user adjustable.
7. End-users shall be able to define additional alarms for any point in the system.
   a) Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
      (1) To alarm
      (2) Return to normal
      (3) To fault
   b) Provide for the creation of a minimum of eight of alarm classes (Must contain building name) for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
   c) Provide timed (scheduled) routing of alarms by building name and class, object, group or node.
   d) Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
   e) Control equipment and network failures shall be treated as alarms and annunciated.
   f) Alarms shall be annunciated in any of the following manners as defined by the user:
      (1) Screen message text
      (2) Email of the complete alarm message to multiple recipients. Provide the ability to route email alarms based on:
         (a) Day of week
         (b) Time of day
         (c) Recipient
      (3) Graphic with flashing alarm object(s).
   g) The following shall be recorded by the JACE for each alarm (at a minimum):
      (1) Time and date

(2) Location (building, floor, zone, office number, etc.)

(3) Equipment (air handler #, access way, etc.)

(4) Acknowledge time, date, and user who issued acknowledgement.

(5) Number of occurrences since last acknowledgement.

h) Alarm actions may be initiated by user defined programmable objects created for that purpose.

i) Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.

j) A log of all alarms with a maximum setting of 250 records shall be maintained by the JACE and shall be available for review by the user.

8. There will be 8 Alarm Classes:

a) Emergency_Alarm_Class - Class for Life Safety equipment such as Fume Hood Exhaust Fans.

b) High_Priority_Alarm_Class - Class for critical equipment.

c) Low_Priority_Alarm_Class - Class for most of the alarms. Anything that does not fall in High Priority or Emergency.

d) Notification_Alarm_Class – Class for Notifications. Non urgent notifications such as, OccSensor Occupied for more than 24 hrs.

e) BMS_Comm_Fail_Alarm_Class – Class for devices or network ping failures.

f) Battery_Alarm – Class specific for JACE battery failures.

g) EnergyAx_Comm_Fail_Alarm – Class for any JACE ping fails to EnergyAx Supervisor.

h) SupervisorAx_Comm_Fail_Alarm - Class for any JACE ping fails to SupervisorsAx.

9. Alarm Message Library:

Alarm Message Library

Alarm #	Message
1	Monitor and log necessary actions taken to ensure normal system operation. Document what steps you have taken to resolve the alarm. Are the systems operational? Can the Power Plant Operator resolve the issue? Document your observations/actions taken. If a call out is necessary, provide steps taken to resolve the issue to the responding technician. Request Work Order, Include all response information.
2	Call BMS Technician during normal hours after point/device has been in alarm for more than 30 minutes.
3	Call BMS Technician during normal hours after point/device has been in alarm for more than 30 mins. The BMS System is monitoring the Outside Lights Status. After hours, make a site visit and make sure the OSL are ON.
4	Call BMS Technician at any hour after point/device has been in alarm for more than 30 minutes. Critical Equipment!
5	Call Electrician at any hour.
6	If this point is in alarm for more than 30 minutes, then the Plant Operator should make a Site visit to verify that at least one Sump Pump is functioning correctly. If unable to make a quick repair or if unable to leave the plant, then call an

	HVAC Mechanic at any hour.
7	Life Safety Hazard! Call Dispatch; have them contact Users & Mechanic Immediately!
8	Make Site visit immediately!
9	Call Facilities Manager at 212-7005. If no response after 30 minutes, call Mechanic at any hour.
10	Call Laird at 831-212-7665. If no response after 30 minutes, call Mechanic at any hour, and call Randolph at 818-2071.
11	Call Laird at 831-212-7665. If no response after 30 minutes, call Mechanic at any hour, and call Randolph at 818-2071.
12	Call Laird at 831-212-7665. If no response after 30 minutes, call Mechanic at any hour.
13	Contact Vivarium staff @ 459-2793.
PB Sci (14)	EQUIPMENT (Freezers/Refrigerators/Incubators) ACTION MESSAGE (PB Sci ONLY) DAY SHIFT PROCEDURE (8am - 5pm M-F): 1. Plant Operator calls PBSci Facilities WODesk at 9-3498. 2. If PBSci Facilities WODesk not available, leave message and then call 9-4468 (PBSci Facilities Asst Mgr). 3. PBSci Facilities WODesk notifies users (using PBSci Call-Out List). NIGHT SHIFT PROCEDURE (evenings, weekends, holidays, and closures): 1. Plant Operator calls Dispatch at 9-4861. Dispatch calls users (using PBSci Call-Out List). 2. Plant Operator also leaves message with PBSci Facilities WODesk at 9-3498.
PB Sci (15)	ENVIRONMENTAL ROOM "24/7" ACTION MESSAGE (PB Sci ONLY) DAY SHIFT PROCEDURE (8am - 5pm M-F): 1. Plant Operator calls PBSci Facilities WODesk at 9-3498. 2. If PBSci Facilities WODesk not available, leave message and then call 9-4468 (PBSci Facilities Asst Mgr). 3. PBSci Facilities WODesk notifies users (using PBSci Call-Out List). 4. Call HVAC Mechanic at any hour. NIGHT SHIFT PROCEDURE (evenings, weekends, holidays, and closures): 1. Plant Operator calls Dispatch at 9-4861. Dispatch calls users (using PBSci Call-Out List). 2. Plant Operator also leaves message with PBSci Facilities WODesk at 9-3498. 3. Call HVAC Mechanic at any hour.

PB Sci (16)	ENVIRONMENTAL ROOM "Normal" ACTION MESSAGE (PB Sci ONLY) DAY SHIFT PROCEDURE (8am - 5pm M-F): 1. Plant Operator calls PBSci Facilities WODesk at 9-3498. 2. If PBSci Facilities WODesk not available, leave message and then call 9-4468 (PBSci Facilities Asst Mgr). 3. PBSci Facilities WODesk notifies users (using PBSci Call-Out List). 4. Call HVAC Mechanic during normal hours. NIGHT SHIFT PROCEDURE (evenings, weekends, holidays, and closures): 1. Plant Operator calls Dispatch at 9-4861. Dispatch calls users (using PBSci Call-Out List). 2. Plant Operator also leaves message with PBSci Facilities WODesk at 9-3498. 3. Call HVAC Mechanic during normal hours.
SOE (17)	FREEZER ACTION MESSAGE (SOE ONLY) *DAY Shift (8am – 5pm M-F) Procedure* 1. Heat Plant notifies SOE: Jeff Duncan 9-5710, Bob Vitale 9-3794, Al McGuire 9-4878. 2. SOE notifies users. 3. If SOE is not available, leave message. Heat Plant notifies Dispatch: 9-4861 4. Dispatch follows Evening Procedure. *EVENING Procedure (includes weekends and holidays)* 1. Heat Plant notifies Dispatch: 9-4861 2. Dispatch calls users as follows: a: In Labs first. b: At Home second. 3. If no answer, leave message. Dispatch calls Department Rep(s). Jeff Duncan, Bob Vitale, Al McGuire. 4. Dept Rep. contacts users.

10. Niagara Bformatting shall be utilized in all To offNormal Text, To Fault Text and To Normal Text. For example, instead of “Space Temp Too High”, use the following Formatting:
    a) %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%.
11. For alarms not listed in this schedule, use the following guidelines. The device name(s), present value(s) and alarm threshold(s) or condition(s), shall be expressed in Bformatting. Hard coded values shall not be acceptable.
12. All Bformatting subject to approval of UCSC BAS Department.
13. On each Alarm Extension, the Alarm Source Name shall be correctly BFormatted to automatically prepend the Point Display Name, with JACE Name (Station Name if alarm extension resides in Supervisor) and Controller Name, in the format: JACEName_ControllerName_PointName, in both the Source and Message Text fields of each alarm record as it appears in any alarm console.
14. Use of Boolean Alarm extensions, on analog (Numeric) values, is not acceptable.
15. Provide alarms per project I/O table. Coordinate with UCSC points requiring DDC alarming and include the following:
    a) Point Name and Description
    b) Alarm differentials (automatically adjust with setpoints)
    c) Units
    d) Coordinate settings (limits or state) with UCSC
    e) Instrument tag
    f) Priority
    g) Message
16. Include the following Communication alarms:

Point Description	Alarm if:	Delay Time	Inhibit Time	Priority Level	Alarm Class	Alarm Text	To Normal Text
Niagara Network Heath Alarm	Any Niagara Station Offline > 5 min. (WBJ-Adj.)	5 min		10	BMS_Comm_Fail_Alarm	Prepend with bFormatting: BuildingName_StationName:	Prepend with bFormatting: BuildingName_StationName:
LON Network Heath Alarm	Any LON Device Offline > 5 min. (WBJ-Adj.)	5 min		10	BMS_Comm_Fail_Alarm	Prepend with bFormatting: JACEName_DeviceName: if multiple LON trunks on JACE JACEName_LONtrunkID_DeviceName:	Prepend with bFormatting: JACEName_DeviceName:

Modbus Network Health Alarm	Modbus missing timing pulse > 5 min. (WBJ-Adj.)	5 min		10	BMS_Comm_Fail_Alarm	Prepend with bFormatting: BuildingName_StationName:	Prepend with bFormatting: BuildingName_StationName:

17. Include the following alarms for all VAV boxes with Reheat Coil:

Point Description	Alarm if:	Delay Time	Inhibit Time	Priority Level	Alarm Class	Alarm Text	To Normal Text
Space Temperature	>4°F (WBJ-Adj.) Above Cooling SP	20 min	2 hrs	200	Low_Priority_Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
	>4°F (WBJ-Adj.) Below Heating SP	20 min	2 hrs	200	Low_Priority_Alarm	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

	>95°F (WBJ-Adj.)			150	High_Priority_Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
	<55°F (WBJ-Adj.)			150	High_Priority_Alarm	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Special Space Temperature	>3°F (WBJ-Adj.) Above setpoint over 4 hours (WB-Adj.)			150	Low_Priority_Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Special Space Temperature	Adj.) below			150	Low_Priority_Alarm	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

Special Space Temperature	>82°F (WBJ-Adj.)	5 min		150	High_Priority_Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Special Space Temperature	<63°F (WBJ-Adj.)	5 min		150	High_Priority_Alarm	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Critical Airflow	Actual Airflow <80% (WBJ-Adj.) of Minimum Airflow SP in Lab Zone	20 min		30	Emergency_Priority_Alarm	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit%
Terminal Load	100% (WBJ-Adj.)	4 hrs.		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.

Terminal Load	-100% (WBJ-Adj.)	4 hrs.		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Damper Position	100% (WBJ-Adj.)	4 hrs.		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%
Discharge Air Temperature (DAT)		20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Discharge Air Temperature (DAT)	< DAT SP –5°F (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

Valve Alarm	DAT > AHU SAT + 8°F (WBJ-Adj.); While reheat valve position = 0% (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit% while the HW Valve is Closed	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit% while the HW Valve is Fully Closed
Valve Alarm	DAT < 72°F (WBJ-Adj.); While reheat valve position = 100% (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit% while the HW Valve is 100% Open	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit% while the HW Valve is 100% Open
Reheat Valve Position	100% (WBJ-Adj.)	4 hrs.	2 hrs.	200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%

Actual Air Flow	>120% (WBJ-Adj.) Of Air Flow SP	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Actual Air Flow	<80% (WBJ-Adj.) of Air Flow SP			200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Damper Position	Damper Position = 0% (WBJ-Adj.); While airflow is greater than 50 (WBJ-Adj.) CFM	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, while airflow is greater than 50 CFM.	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit%, while airflow is greater than 50 CFM.
Damper Position	Damper position = 100% (WBJ-Adj.); while airflow is less than 50 CFM (WBJ-Adj.)	5 min		200	Low_Priority_Alarm_Class	%alarmData.sourceName% is at %alarmData.presentValue%, while airflow is less than 50 CFM. Check Damper Position.	

CO2 (1)	> 1000 ppm (WBJ-Adj.)	30 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
CO2 (2)	< 300 ppm (WBJ-Adj.)	30 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
CO2 (3)	>2,500 ppm (WBJ-Adj.)			20	Life_Safety_Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the Unsafe High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Safe Level of %alarmData.presentValue%, which is below the Unsafe High Limit of %alarmData.highLimit%

18. Include the following alarms for all Cooling Only VAV boxes:

Point Description	Alarm if:	Delay Time	Inhibit Time	Priority Level	Alarm Class	Alarm Text	To Normal Text
Space Temperature	>4°F (WBJ-Adj.) Above Cooling SP	20 min	2 hrs	200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
	>4°F (WBJ-Adj.) Below Heating SP	20 min	2 hrs	200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
	>95°F (WBJ-Adj.)			150	High_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
	<55°F (WBJ-Adj.)			150	High_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

Special Space Temperature	>3°F (WBJ-Adj.) Above setpoint over 4 hours (WB-Adj.)			150	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Special Space Temperature	Adj.)			150	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Special Space Temperature	>82°F (WBJ-Adj.)	5 min		150	High_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Special Space Temperature	<63°F (WBJ-Adj.)	5 min		150	High_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

Critical Airflow	Actual Airflow <80% (WBJ-Adj.) Of Minimum Airflow SP in Lab Zone	20 min		30	High_Priority_Alarm	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit%
Terminal Load	100% (WBJ-Adj.)	4 hrs.		200	Low_Priority Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Damper Position	100% (WBJ-Adj.)	4 hrs.		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%
Discharge Air Temperature (DAT)		20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.

Discharge Air Temperature (DAT)	< DAT SP – 5°F (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Actual Air Flow	>120% (WBJ-Adj.) of Air Flow SP	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Actual Air Flow	<80% (WBJ-Adj.) Of Air Flow SP			200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Damper Position	Damper Position = 0% (WBJ-Adj.); While airflow is greater than 50 (WBJ-Adj.) CFM	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, while airflow is greater than 50 CFM.	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit%, while airflow is greater than 50 CFM. Check Damper Position.

Damper Position	Damper position = 100% (WBJ-Adj.); while airflow is less than 50 (WBJ-Adj.) CFM	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, while airflow is less than 50 CFM.	%alarmData.sourceName% is at %alarmData.presentValue%, while airflow is less than 50 CFM. Check Damper Position.
CO2 (1)	> 1000 ppm (WBJ-Adj.)	30 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
CO2 (2)	< 300 ppm (WBJ-Adj.)	30 min			Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
CO2 (3)	>2,500 ppm (WBJ-Adj.)				Life_Safety_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the Unsafe High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Safe Level of %alarmData.presentValue%, which is below the Unsafe High Limit of %alarmData.highLimit%

19. Include the following alarms for all FCU's.

Point Description	Alarm if:	Delay Time	Inhibit Time	Priority Level	Alarm Class	Alarm Text	To Normal Text
Heating Control Signal	100% (WBJ-Adj.)	4 hrs.	2 hrs.	200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%
Valve Position	100% (WBJ-Adj.)	4 hrs.	2 hrs.	200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%
Discharge air temperature (DAT)	>110°F (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%

DAT Leaking Valve	DAT > Zone Temperature + 5°F (WBJ-Adj.); while valve position = 0% and fan status is on. (For hot water fan coil units only)	30 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue% (VAV DAT), which is above the High Limit of %alarmData.highLimit%, while the Reheat Valve Position is at 0 %, and the Fan Status is ON. Leaking Valve?	%alarmData.sourceName% has returned to a normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%, while the Reheat Valve Position is at 0 %, and the Fan Status is ON.
DAT No Heating	DAT < Zone Temperature + 5° (WBJ-Adj.) F; while the valve position is greater than 30% (WBJ-Adj.) and the fan status is on and the heating hot water pump is on. (For hot water fan coil units only)	30 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the low Limit of %alarmData.lowLimit%, while the valve position is greater than 30% and the fan status is on and the heating hot water pump is on. No Heating?	%alarmData.sourceName% has returned to a normal value of %alarmData.presentValue% which is above the low Limit of %alarmData.lowLimit%, while the valve position is greater than 30% and the fan status is on and the heating hot water pump is on.
Fan Fail Alarm	Status is off while Command is on.	5 min		200	Low_Priority_Alarm_Class	To Offnormal Text: %alarmData.sourceName% is %alarmData.presentValue%, while the Fan Command) is ON - Fan Failure? Check Belts and HOA Switch.	%alarmData.sourceName% has returned to Normal %alarmData.presentValue%, while the Fan Command is ON.

Fan In Hand Alarm	Status is on while Command is off.	5 min		200	Low_Priority_Alarm_Class	To Offnormal Text: %alarmData.sourceName% is II. %alarmData.presentValue%, while the Fan Command is OFF - Return to Automatic	%alarmData.sourceName% has returned to a Normal Status, %alarmData.presentValue%, while the Fan Command is OFF.

a) Include the following alarms for all Lab Supply Air Valves / Exhaust Valves / Hoods:

Point Description	Alarm if:	Delay Time	Inhibit Time	Priority Level	Alarm Class	Alarm Text	To Normal Text
Space Temperature	>4°F (WBJ-Adj.) Above Cooling SP	20 min	2 hrs.	200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
	>4°F (WBJ-Adj.) Below Heating SP	20 min	2 hrs.	200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

	>95°F (WBJ-Adj.)			150	High_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
	<55°F (WBJ-Adj.)			150	High_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Special Space Temperature	>3°F (WBJ-Adj.) Above setpoint over 4 hours (WB-Adj.)			150	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Special Space Temperature	Adj.) below setpoint			150	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

Special Space Temperature	>82°F (WBJ-Adj.)	5 min		150	High_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Special Space Temperature	<63°F (WBJ-Adj.)	5 min		150	High_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Critical Airflow	Actual Airflow <80% (WBJ-Adj.) Of Minimum Airflow SP in Lab Zone	20 min		30	High_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit%
Terminal Load	100% (WBJ-Adj.)	4 hrs		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.

Terminal Load	-100% (WBJ-Adj.)	4 hrs		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Damper Position	100% (WBJ-Adj.)	4 hrs		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%
Discharge Air Temperature (DAT)		20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Discharge Air Temperature (DAT)	< DAT SP – 5°F (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%

Valve Alarm	DAT > AHU SAT + 8°F (WBJ-Adj.); While reheat valve position = 0% (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit% while the HW Valve is Closed	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit% while the HW Valve is Fully Closed
Valve Alarm	DAT < 72°F (WBJ-Adj.); While reheat valve position = 100% (WBJ-Adj.)	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit% while the HW Valve is 100% Open	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit% while the HW Valve is 100% Open
Reheat Valve Position	100% (WBJ-Adj.)	4 hrs	2 hrs	200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is below the High Limit of %alarmData.highLimit%

Actual Air Flow	>120% (WBJ-Adj.) Of Air Flow SP	20 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Actual Air Flow	<80% (WBJ-Adj.) Of Air Flow SP			200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Damper Position	Damper Position = 0% (WBJ-Adj.); while airflow is greater than 50 (WBJ-Adj.) CFM	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, while airflow is greater than 50 CFM.	%alarmData.sourceName% has returned to a Normal value of %alarmData.presentValue%, which is above the Low Limit of %alarmData.lowLimit%, while airflow is greater than 50 CFM.
Damper Position	Damper position = 100% (WBJ-Adj.); while airflow is less than 50 CFM (WBJ-Adj.)	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, while airflow is less than 50 CFM.	%alarmData.sourceName% is at %alarmData.presentValue%, while airflow is less than 50 CFM. Check Damper Position.

Exhaust Air Terminal CFM Reading	>115% (WBJ-Adj.) Of CFM SP	15 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
ExhaustAir Terminal CFM Reading	<90% (WBJ-Adj.) Of CFM SP	15 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
User Override Push Button	Out of Status	1 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the Unsafe High Limit of %alarmData.highLimit%	%alarmData.sourceName% has returned to a Safe Level of %alarmData.presentValue%, which is below the Unsafe High Limit of %alarmData.highLimit%
Air Flow Differential	>110% (WBJ-Adj.) Of Scheduled Differential SP	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.

Air Flow Differential	<95% (WBJ-Adj.) Of Scheduled Differential SP	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Fume Hood Face Velocity	>115% (WBJ-Adj.) of Scheduled SP 100 FPM During Normal Operation. 60 FPM during Not In Use Periods	5 min		30	High_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Fume Hood Face Velocity	<85% (WBJ-Adj.) Of Scheduled SP 100 FPM During Normal Operation. 60 FPM during Not In Use Periods	5 min		30	High_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Sash Height	Above Maximum Sash Position	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.

Sash Height	At Maximum Sash Position For >24 Hours	24 hour		30	High_Priority_Alarm_Class	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.
Sash Height	Below Minimum Sash Position	5 min		200	Low_Priority_Alarm_Class	Offnormal Algorithm, Low Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is below the Low Limit of %alarmData.lowLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is above the Low Limit of %alarmData.lowLimit%
Hood Alarms	Hood in Alarm			30	High_Priority_Alarm_Class	%alarmData.sourceName% is in Alarm	%alarmData.sourceName% has returned to Normal

21. Include the following alarms for all Generator Rooms:

Point Description	Alarm if:	Delay Time	Inhibit Time	Priority Level	Alarm Class	Alarm Text	To Normal Text
CO level in Engine Room	>35 PPM (WBJ-Adj.)	1 min		20	Life_Safety_Alarm	Offnormal Algorithm, High Limit Text: %alarmData.sourceName% is at %alarmData.presentValue%, which is above the High Limit of %alarmData.highLimit%	%alarmData.sourceName% is at %alarmData.presentValue% which is below the High Limit of %alarmData.highLimit%.

22. All VAV box alarms shall be inhibited while the AHU serving those boxes is non-functional.
23. Configure the following priority level scheme:

Type	Priority Level	Niagara Alarm Class Name	Local Supervisor Station Alarm Console	Local Supervisor Station Critical Alarms Console	Campus DDC Alarm Servers
Communication (Not Ping Alarms)	10	BMS_Comm_Fail_Alarm_Class	Yes	Yes	Yes
Life Safety	20	Emergency_Alarm_Class	Yes	Yes	Yes
Critical	30	High_Priotrity_Alarm_Class	Yes	Yes	Yes
Central Plant, Main AHU	40	CentralPlants	Yes	No	Yes
Building Hydronics	100	Low_Priotrity_Alarm_Class	Yes	No	Yes
HVAC General	120	HVAC_General	Yes	No	No
Important Temperatures	150	Critical_Temps	Yes	No	Yes
Troubleshooting	200	Troubleshooting	Yes	No	No
Remainder, including all Ping	254	Default Alarm Class	Yes	No	No

24. Coordinate and implement alarm notifications and routing with UCSC BAS Department. Include:
    a) Paging
    b) Email
    c) Text Messaging
    d) Group and network notifications
    e) Alarm acknowledgement.
    f) Filter and route alarms based on user log in.
    g) Alarm reports and messages will be directed to a user defined list of operator devices
25. Provide hardware or interface required to implement alarm notification and routing.
26. Provide state-based alarming to prevent alarms during specific equipment states.
    a) Interlock equipment status and/or modes to lock out associated alarms during shutdowns.
    b) Interlock acknowledgement to lock out associated alarm for limited adjustable time period.
27. Provide continuous monitoring of network connectivity for the all networks. Generate alarm upon any communication failure.
28. Alarms shall be inhibited for a specified time period after a change in occupancy or for AHUs that are off.
29. Contractor shall ensure that alarms passed to any remote Station Recipient shall retain alarm class and priority level.
30. Contractor shall use only the exact Niagara alarm class names listed above to ensure compatibility with remote station recipients. Alarm Class Mapping is not acceptable. Note: Niagara object naming conventions do not permit spaces.

31. Alarms report to LocalHost Alarm Console on building control systems server. If project scope does not include a building control systems server, alarms report to Alarm Console in building level controller.
32. Alarm Source Name shall prepend with the following B-Formatting:
    a) %parent.parent.parent.displayName%_%parent.displayName% or as required to produce the format: StationName_ControllerName_PointName
33. Alarm Types
    a) At least four alarm types as described here shall be programmed.
34. Examples are shown here to set the level of expectation to apply these types of alarms to each of these typical situations.
    (1) Supervisory Alarms
        (a) Where the BAS system monitors itself. Programming to issue an alarm when a predicted result is not achieved as the result of a programmed control action, typically applies to outputs.
        (b) Command fail alarm shall be sent to the BAS any time the fan start/stop and status don't match for 60 seconds (adjustable).
        (c) Cooling alarm shall be sent to the BAS anytime a cooling valve is full open or cooling stage is active for 5 minutes (adjustable) and there is not a temperature drop across coil of at least 5 degrees F (adjustable).
        (d) Cooling alarm shall be sent to the BAS anytime an outside air damper is full open while economizer is active for 5 minutes (adjustable) and there is not a temperature drop from return air to mixed air of at least 5 Degrees F (adjustable).
        (e) Heating alarm shall be sent to the BAS anytime a heating valve is full open or heating stage is active for 5 minutes (adjustable) and there is not a temperature rise across coil of at least 5 degrees F (adjustable).
        (f) Setpoint alarms, only active when control is active. For example, RmTemp alarms shall only alarm when area is occupied, and has been occupied long enough for the temperatures to be normal. Setpoint alarms shall be sent to the BAS anytime a sensed value is not within tolerance of setpoint value within 15 minutes (adjustable).
    (2) Range Alarms
        (a) Where an input sensor is outside of its operating range. Indicates when a sensor has failed, power to the sensor has failed, wiring has be shorted or opened, etc. It is required to determine how every controller reads both an open and short for every input and program a specific range alarm for each.
        (b) Hi limit alarm shall be sent to the BAS anytime an input sensor reads near the top of its range, and this value is above its normal control range. For example, outside air temperature reading of 150 Degrees F.
        (c) Lo limit alarm shall be sent to the BAS anytime an input sensor reads near the bottom of its range, and this value is below its normal control range. For example, outside air temperature reading of -60 Degrees F.
    (3) Absolute Alarms,
        (a) Where an input sensor is above or below a fixed threshold. Or where an alarm contact closes.

(b) Hi limit alarm shall be sent to the BAS anytime an input sensor reads above the high limit threshold. For example, when freezer temperature is greater than 0°F (adjustable) for a minimum of 10 minutes (adjustable). Or when kitchen cooler temperature is greater than 37°F (adjustable) for a minimum of 10 minutes (adjustable).

(c) Lo limit alarm shall be sent to the BAS anytime an input sensor reads below the low limit threshold. For example, any room temperature less than 40 Degrees F.

(d) Discrete alarms shall be sent to the BAS anytime a monitored contact changes to an alarm state. For example, freezestat device trips or inhibitor chemical running low contact remains closed for 10 minutes (adjustable).

(4) Communication Alarms

(a) Here a controller is offline.

(b) Any controller communication alarm shall be sent to the BAS anytime communication is lost to a controller for 10 minutes (adjustable).

X. HARDWARE

a) Environmental Conditions for Controllers, Gateways, Instruments and Actuators:

(1) Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

(2) If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

(3) Products shall be protected with enclosures satisfying the minimum requirements specified later in this section unless more stringent requirements are indicated.

b) DDC System Reliability and Redundancy:

(1) Design, install, and configure DDC control system, to match mechanical/electrical systems and equipment reliability and redundancy design.

(a) For example; if two chillers are installed, one being a back-up, it is expected that the back-up chiller will automatically start when the primary chiller fails. Two chillers were installed to ensure cooling remains active if a single device fails. The DDC control system must match this design intent, where the single failure of one DDC controller or DDC component does not prevent cooling of the building.

c) Electric Power Quality:

(1) When building is equipped with UPS or emergency power, these sources, in respective order should be used to power all DDC system products if capacity is available.

(2) Power Conditioning:

(a) When building UPS power is used to power DDC system products, no additional power conditioning is required.

(b) Provide an UPS with Surge Protection inside the enclosure at each panel requiring 120 Volt power. The UPS shall have a minimum capacity of 500 VA and 300W, and have the ability to digitally monitor normal power and battery condition. (SOLA SDU500 w/relay card or equal). Upsize UPS as required to provide a minimum of 2 minutes battery backup time at actual load. Provide plug outlet and pigtail as required to condition the incoming power on the line side of all panel devices.

(3) Ground Fault:

(a) Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition. Install grounding wires as shown in manufacturer's instructions.

d) Backup Power Source:

(1) Design, install and configure DDC control system, to match mechanical/electrical systems and equipment reliability and redundancy design.

(a) For example; if two chillers are installed, one being a back-up, and each powered from separate power panels, it is expected that one chiller will run when power is cut to one power panel. Two power panels were utilized to ensure cooling remains active if a single device fails. Power to the DDC control system must match this design intent, where the single failure of one power source does not prevent cooling to the building.

(2) Mechanical/electrical systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from the same or equivalent backup power source.

e) Continuity of Operation after Electric Power Interruption:

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

PART 3 – GRAPHICS

B. SUMMARY

1. Section includes the general requirements for graphic generation and end-user interface with the Building Automation System.

C. SYSTEM DESCRIPTION

1. Provide software and labor for graphical representation of all systems specified.
2. Show all hardware points, setpoints, integrated points as shown in drawings and as needed to properly control and monitor systems.

D. SUBMITTALS

1. University of California Santa Cruz has developed campus standards including detailed graphics templates (Px Graphic) contact University of California Santa Cruz Physical Plant BAS Department for latest examples.
2. Submit for Review:

a) Each graphic page shall be submitted for review and requires approval by UCSC BAS Department.

E. GRAPHICS QUALITY ASSURANCE

1. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Mozilla Firefox™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
2. Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BMS, shall not be acceptable.
3. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface (if used). Systems that require different graphic views, different means of graphic generation, or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
4. The Web browser client shall support at a minimum, the following functions:
5. User log-on identification and password shall be required. If and unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
6. Graphical screens developed for the BCA shall be the same screens used for the Web browser client.
7. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
8. Storage of the graphical screens shall be in the web based server application.

9. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
10. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    a) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
        (1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
11. Text fields, column header labels, button labels, etc. must be a text string. Mapping text strings, from Niagara string objects, is acceptable; mapping Niagara object names to text fields is not acceptable.
12. Decimal precision. Unless indicated otherwise, point values shall use the following decimal precision:
    a) Temperatures and temperature setpoints:
        (1) 1 decimal place.
    b) Airflow (CFM) and airflow setpoints:
        (1) No decimal places.
    c) Water flow (GPM) and water flow setpoints:
        (1) 1 decimal place.
    d) Duct static pressure (Inches Water Column) and duct static pressure setpoints:
        (1) 2 decimal places.
    e) Building static pressure (Inches Water Column) and building static pressure setpoints:
        (1) 3 decimal places.
    f) Humidity (%RH) and humidity setpoints:
        (1) 1 decimal place.
13. All valve and damper output positions should be denoted as %OPEN
14. Provide consistency in measurement units.
15. Graphics for identical mechanical systems shall utilize relative ORD's to minimize number of graphics. Graphics for identical mechanical systems that utilize absolute ORD's are not acceptable.
16. Vendor names, logos, hyperlinks to vendor site, or other vendor identification or promotion, are not permitted on graphics.
17. UCSC shall furnish sample UCSC Standard Graphics to ensure consistency of look and feel across all Niagara sites.
    a) UCSC Standard Graphics, furnished to Contractor, are dynamic with programming code embedded in the graphics. Contractor may not modify embedded programming code, variable ORD schemes, color schemes, spectrum binding weighting values, BQL queries, etc., in graphics, unless approved by UCSC.
    b) Screen captures of example UCSC Standard Graphics are depicted below.

XI. GRAPHIC GENERATION

A. COMMON FOR ALL GRAPHICS

1. Tridium's kitPxGraphics.jar should be the primary source for images and gifs.
2. Custom non-Tridium jars are not to be used.
3. Each graphic shall include all control points, devices and user adjustable setpoints/parameters associated with the system.
4. All points, as specified in point's list table, shall be displayed and adjustable in graphics.
5. User adjustable points, displayed on any graphic page, shall be identifiable by highlighting (turn blue) upon mouse over.
6. Provide links, in a "breadcrumb trail" navigation menu bar, that allow a user to logically navigate all graphics in a hierarchical manner.
7. There shall be only one graphic header file that shall be used as a "Px Include file" on all graphics required for the project.
8. Operator specific password access protection shall be provided for each application to allow the administrator to limit access to point control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. There shall be 4 access levels as defined below.
   a) Super User
      (1) No restriction. Can set or override adjustable setpoints on graphics.
   b) Operator
      (1) WebUI access only. View all graphics and override points only, no set point access, can acknowledge alarms. Can override adjustable setpoints on graphics. Can change own user name, password and email address.
   c) Read Only
      (1) Read only WebUI access. Can change own user name, password and email address.
   d) Scheduler
      (1) Read only WebUI access with ability to modify equipment schedules as required. Can change own user name, password and email address.
9. All overrides are globally limited to a maximum of 8 hours.

B. HEADER

1. Header is one PX Include file for the entire project that shall appear on every graphic page. For efficiency of graphics maintenance, all links, labels, etc., shall be edited from only one instance of header. The header and each of the link buttons should appear exactly the same on all campus buildings.
2. The Home hyperlink, is the Hope page for UCSC Campus BAS.

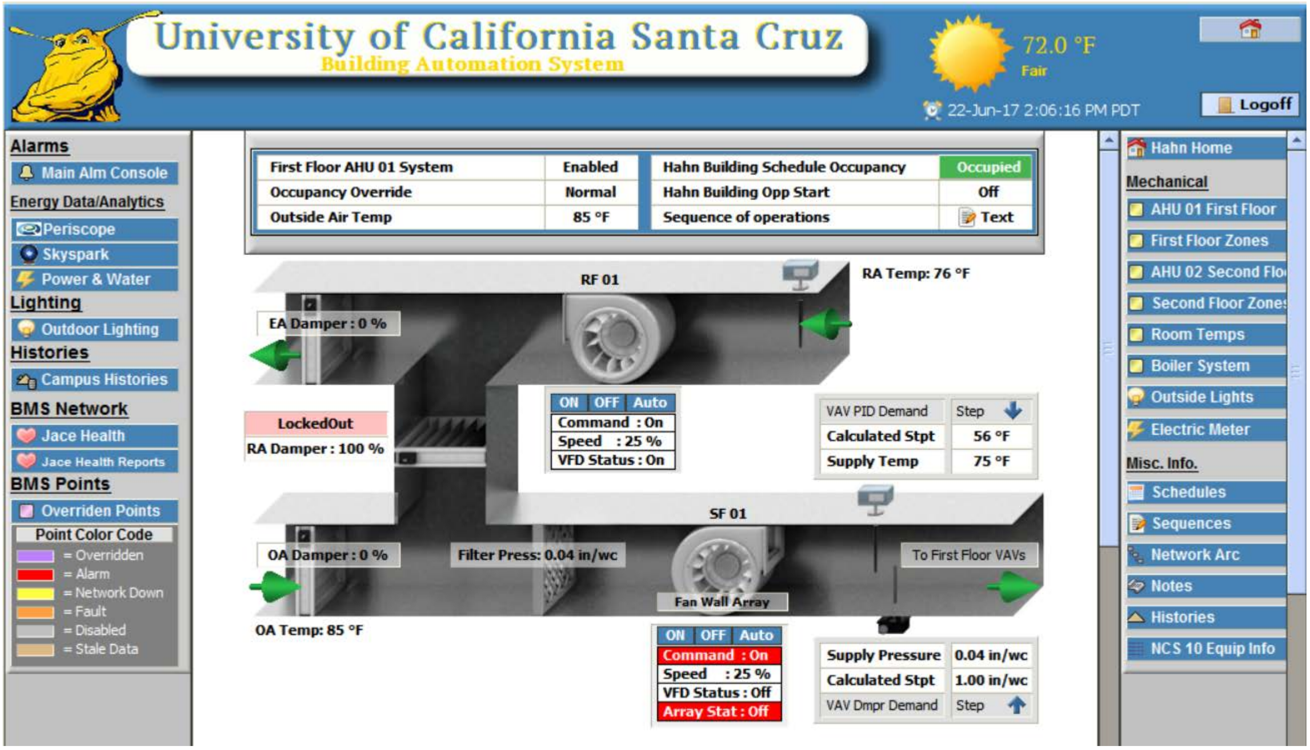
C. HOME PAGE

1. The primary purpose of the building home page is to provide an Operator one place to quickly see the status of major equipment in the building and other critical, real-time information. The contents of the home page will vary by building depending on critical systems and mechanical equipment in that building. Typical systems include air handlers; building chilled water; building hot water, etc.

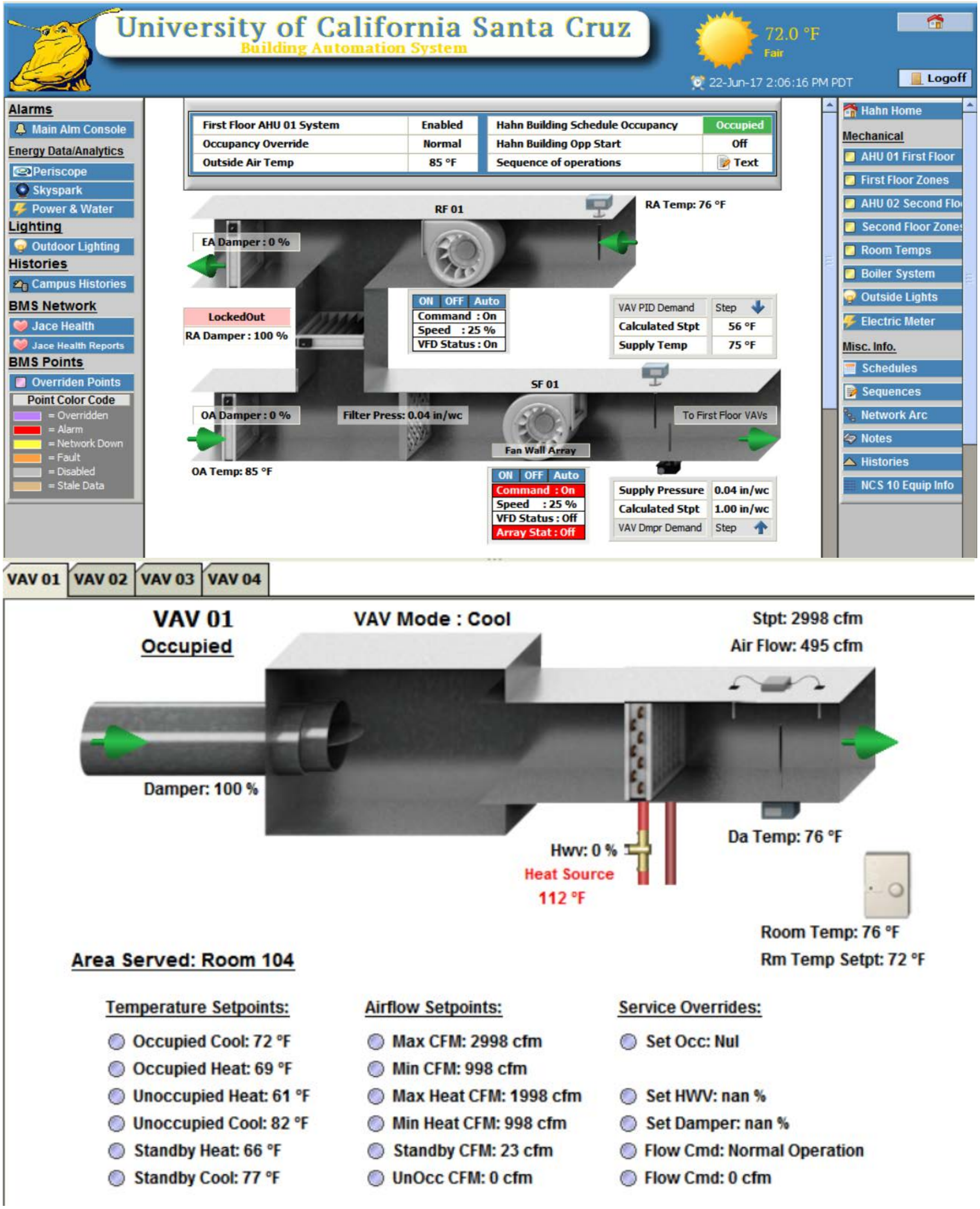
2. Home Page Example

D. AIR HANDLING UNIT

1. It is not feasible to convey examples of every possible permutation of air handler configuration. Specific details shall be developed on a per-project or per-building basis.
2. Typical Air Handler Graphic Page



3. AHU with VAV's



4. Use a ScrollPane with a SplitPane Center content to expose both graphics as one.

E. ENERGY EFFICIENT SEQUENCES

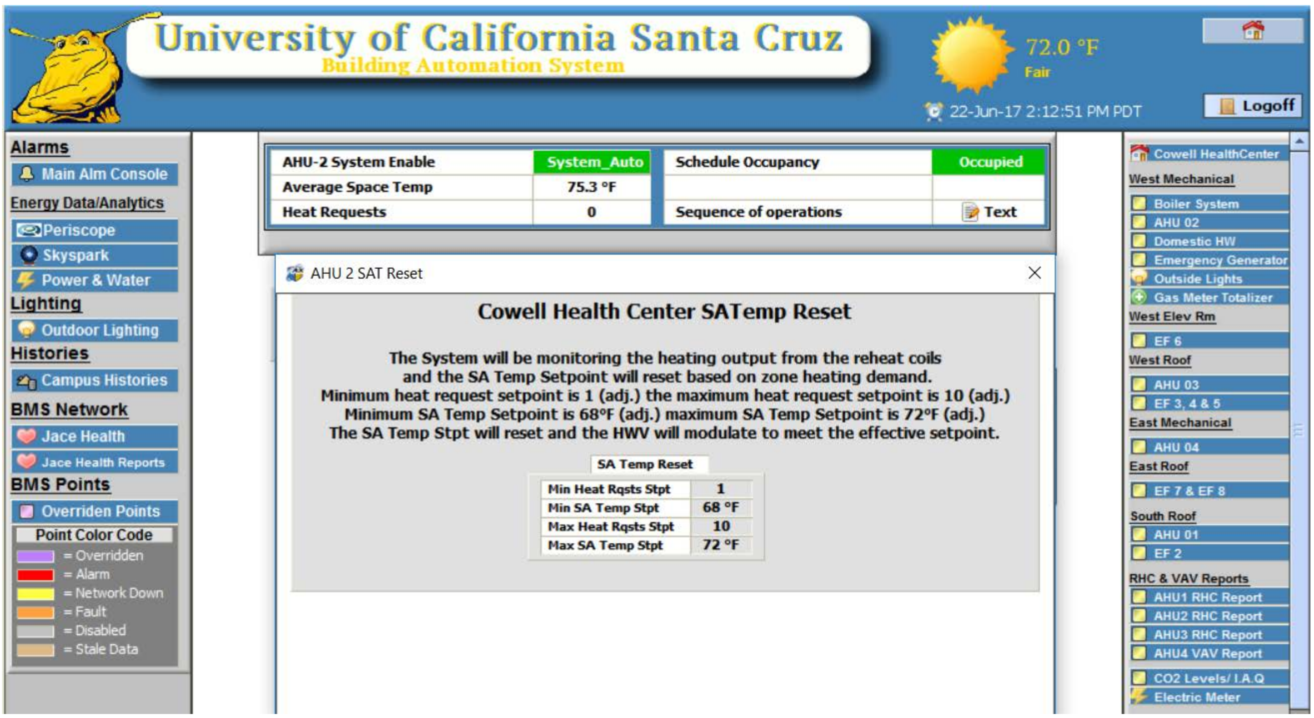
1. Heat Request:

   a) The purpose of the requests page is to see the relationship of zone data and how that zone data is resetting air handler setpoints. Include graphic table for all Zone Requests for Air Handler Reset, by floor & by air handler.

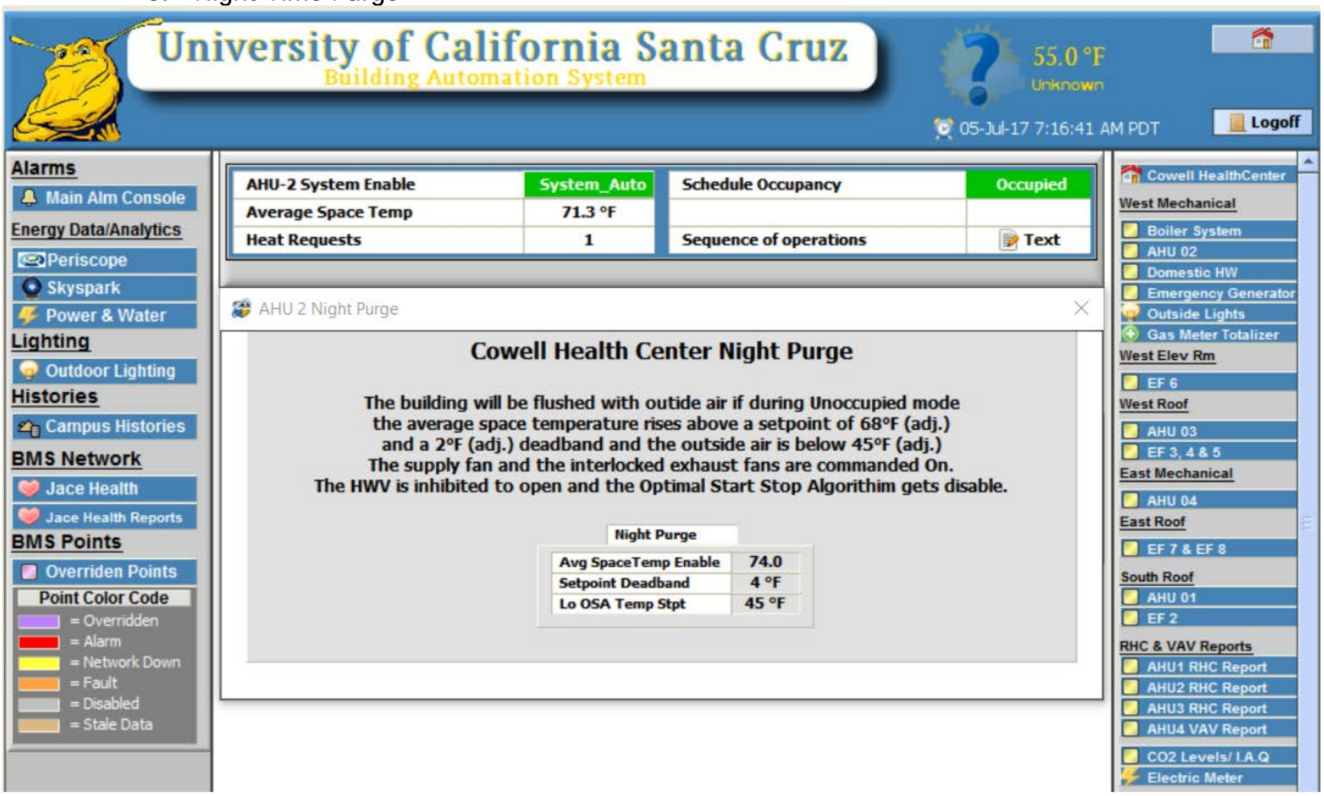
2. Depending on equipment configuration, other related Trim & Respond (Reset) parameters.

3. The contents of the request page will vary by building depending on critical systems and mechanical equipment in that building.

4. Supply Air Temp Reset

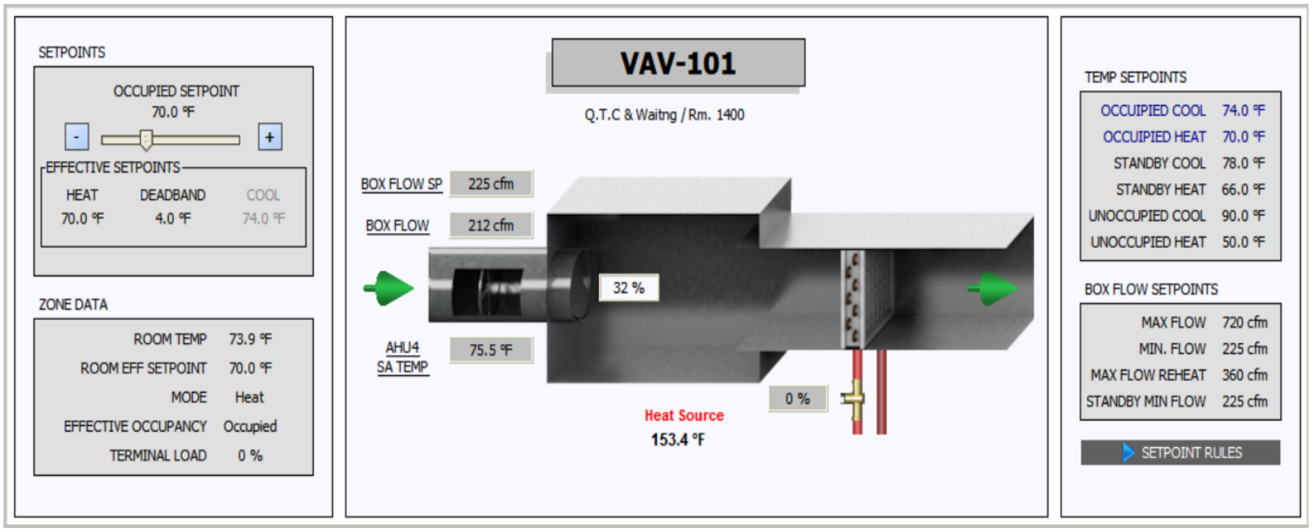


5. Night Time Purge



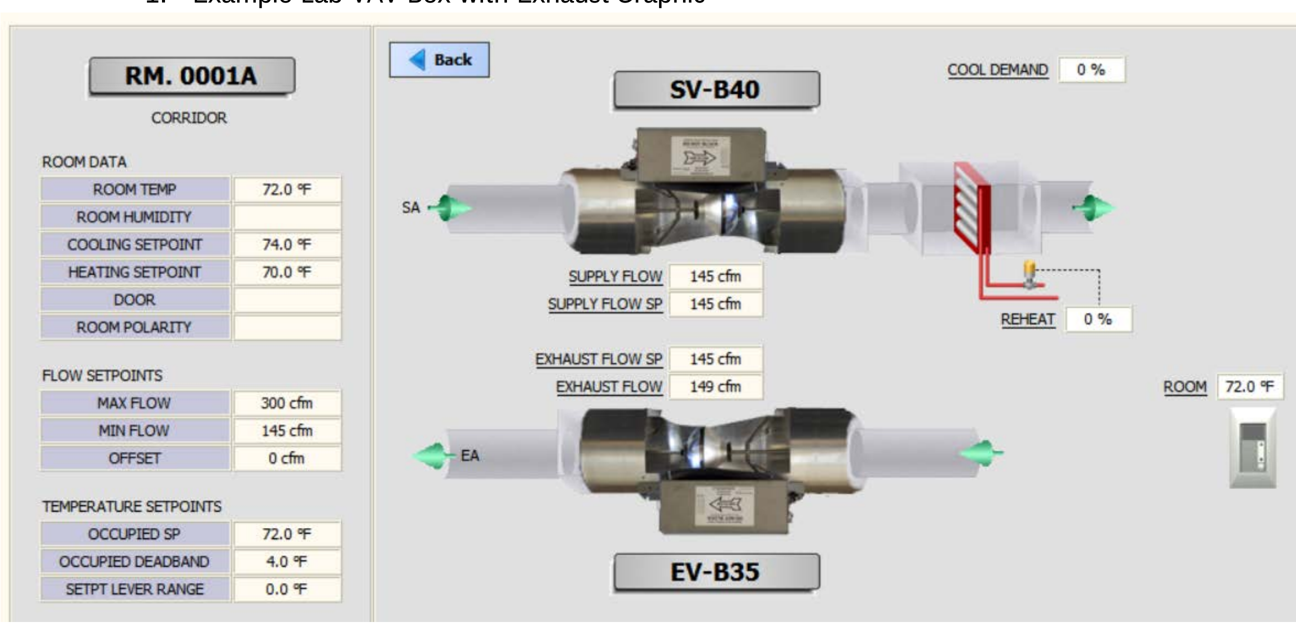
F. VARIABLE AIR VOLUME BOX – WITH REHEAT

1. Example VAV Box with Reheat Graphic



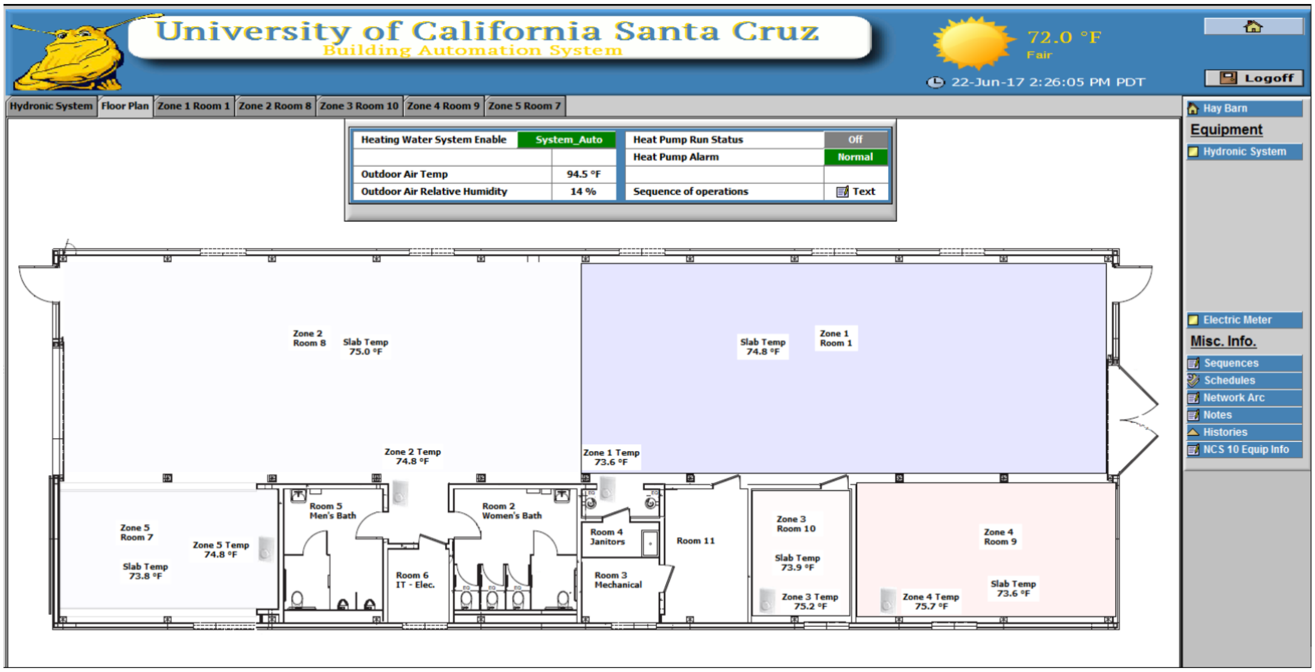
G. LAB VARIABLE AIR VOLUME BOX – WITH EXHAUST

1. Example Lab VAV Box with Exhaust Graphic



H. FLOOR PLAN

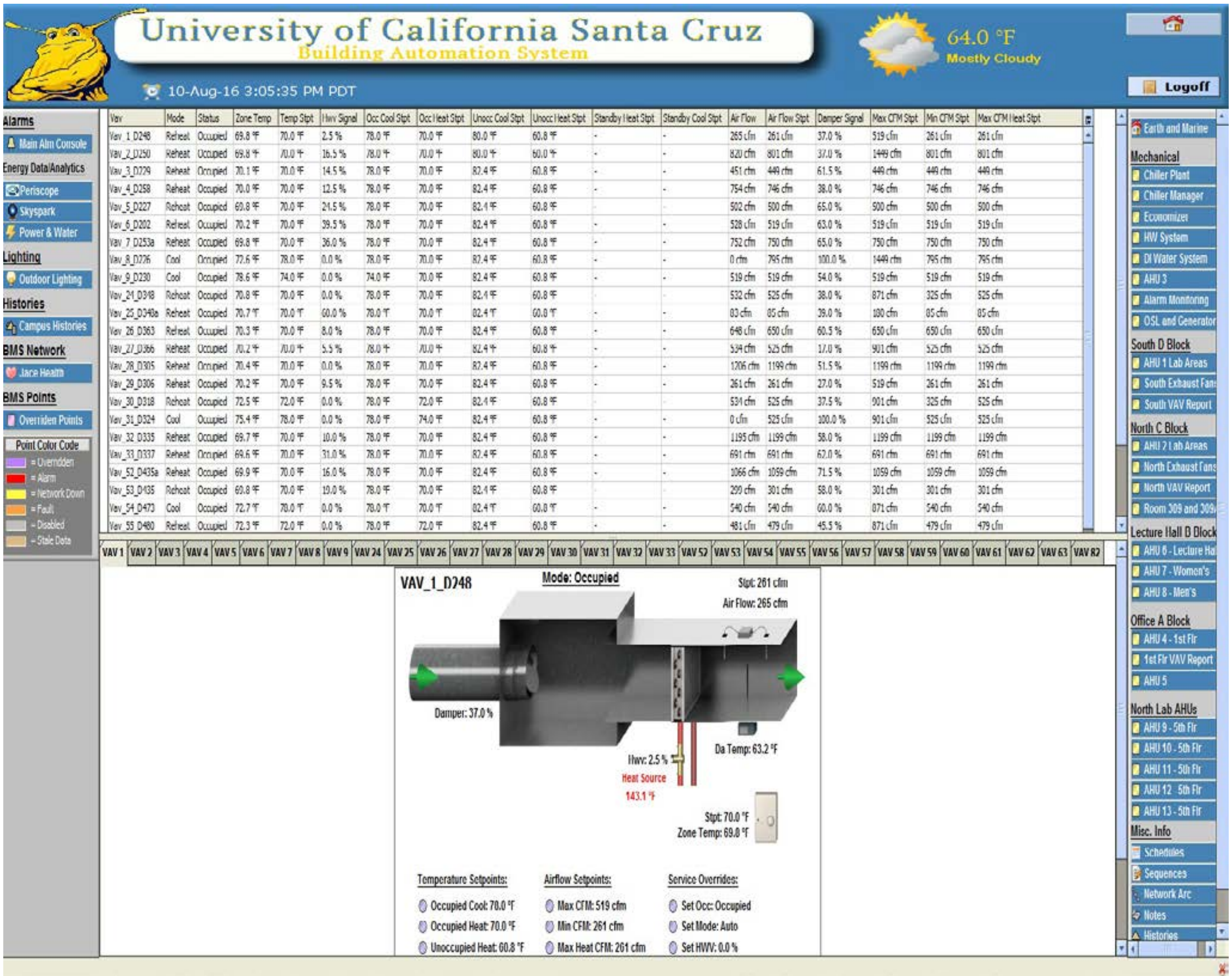
1. Example Floorplan Graphic



a) Typical animated spectrum binding of entire area served by VAV box to indicate zone temperature. Zone color shall go from light blue to bright blue with greater deviation below effective setpoint and from light red to bright red with greater deviation above effective setpoint. Zones between heating and cooling setpoint shall be white. Each spectrum binding shape shall maintain approximately 10 pixel space to distinguish from adjacent spectrum binding shape to prevent confusion when both shapes are the same color. Entire spectrum binding shape shall be a navigation link to the specific VAV box. Upon mouse over, mouse cursor icon shall change from pointer to hyperlink.

I. VAV OVERVIEW TABLE

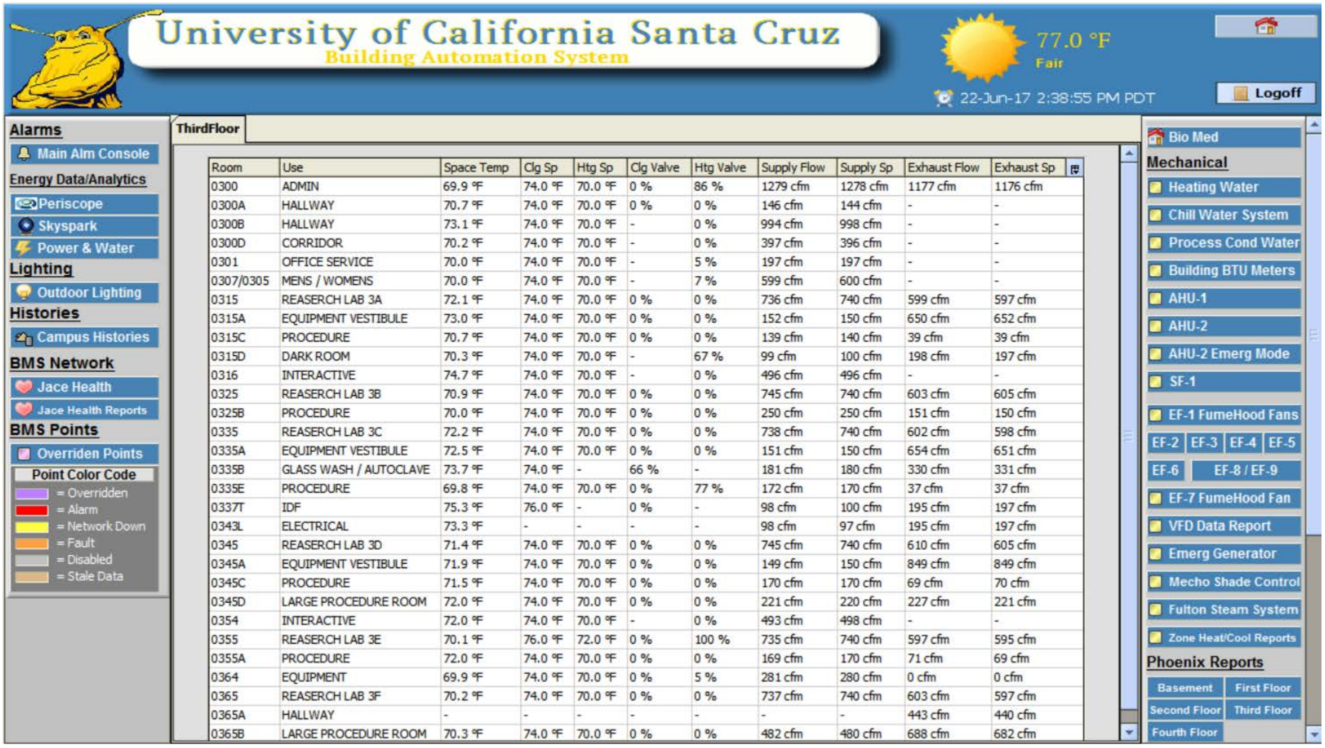
1. Example VAV Overview Page (one page per air handling unit, per floor)



Vav	Mode	Status	Zone Temp	Temp Stpt	Hwv Signal	Occ Cool Stpt	Occ Heat Stpt	Unocc Cool Stpt	Unocc Heat Stpt	Standby Heat Stpt	Standby Cool Stpt	Air Flow	Air Flow Stpt	Damper Signal	Max CFM Stpt	Min CFM Stpt	Max CFM Heat Stpt
Vav_1_D248	Reheat	Occupied	69.8 °F	70.0 °F	2.5 %	78.0 °F	70.0 °F	80.0 °F	60.8 °F	-	-	265 cfm	261 cfm	37.0 %	519 cfm	261 cfm	261 cfm
Vav_2_D250	Reheat	Occupied	69.8 °F	70.0 °F	16.5 %	78.0 °F	70.0 °F	80.0 °F	60.0 °F	-	-	820 cfm	801 cfm	37.0 %	1449 cfm	801 cfm	801 cfm
Vav_3_D229	Reheat	Occupied	70.1 °F	70.0 °F	14.5 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	451 cfm	449 cfm	61.5 %	449 cfm	449 cfm	449 cfm
Vav_4_D258	Reheat	Occupied	70.0 °F	70.0 °F	12.5 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	754 cfm	746 cfm	38.0 %	746 cfm	746 cfm	746 cfm
Vav_5_D227	Reheat	Occupied	69.8 °F	70.0 °F	21.5 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	502 cfm	500 cfm	65.0 %	500 cfm	500 cfm	500 cfm
Vav_6_D202	Reheat	Occupied	70.2 °F	70.0 °F	39.5 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	528 cfm	519 cfm	63.0 %	519 cfm	519 cfm	519 cfm
Vav_7_D253a	Reheat	Occupied	69.8 °F	70.0 °F	36.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	752 cfm	750 cfm	65.0 %	750 cfm	750 cfm	750 cfm
Vav_8_D226	Cool	Occupied	72.6 °F	78.0 °F	0.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	0 cfm	795 cfm	100.0 %	1449 cfm	795 cfm	795 cfm
Vav_9_D230	Cool	Occupied	78.6 °F	74.0 °F	0.0 %	74.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	519 cfm	519 cfm	54.0 %	519 cfm	519 cfm	519 cfm
Vav_24_D348	Reheat	Occupied	70.8 °F	70.0 °F	0.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	532 cfm	525 cfm	38.0 %	871 cfm	325 cfm	525 cfm
Vav_25_D348a	Reheat	Occupied	70.7 °F	70.0 °F	60.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	83 cfm	85 cfm	39.0 %	180 cfm	85 cfm	85 cfm
Vav_26_D363	Reheat	Occupied	70.3 °F	70.0 °F	8.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	648 cfm	650 cfm	60.5 %	650 cfm	650 cfm	650 cfm
Vav_27_D366	Reheat	Occupied	70.2 °F	70.0 °F	5.5 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	534 cfm	525 cfm	17.0 %	901 cfm	525 cfm	525 cfm
Vav_28_D305	Reheat	Occupied	70.4 °F	70.0 °F	0.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	1206 cfm	1199 cfm	51.5 %	1199 cfm	1199 cfm	1199 cfm
Vav_29_D306	Reheat	Occupied	70.2 °F	70.0 °F	9.5 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	261 cfm	261 cfm	27.0 %	519 cfm	261 cfm	261 cfm
Vav_30_D318	Reheat	Occupied	72.5 °F	72.0 °F	0.0 %	78.0 °F	72.0 °F	82.4 °F	60.8 °F	-	-	534 cfm	525 cfm	37.5 %	901 cfm	325 cfm	525 cfm
Vav_31_D324	Cool	Occupied	75.4 °F	78.0 °F	0.0 %	78.0 °F	74.0 °F	82.4 °F	60.8 °F	-	-	0 cfm	525 cfm	100.0 %	901 cfm	525 cfm	525 cfm
Vav_32_D335	Reheat	Occupied	69.7 °F	70.0 °F	10.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	1195 cfm	1199 cfm	58.0 %	1199 cfm	1199 cfm	1199 cfm
Vav_33_D337	Reheat	Occupied	69.6 °F	70.0 °F	31.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	691 cfm	691 cfm	62.0 %	691 cfm	691 cfm	691 cfm
Vav_52_D435a	Reheat	Occupied	69.9 °F	70.0 °F	16.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	1066 cfm	1059 cfm	71.5 %	1059 cfm	1059 cfm	1059 cfm
Vav_53_D435	Reheat	Occupied	69.8 °F	70.0 °F	19.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	299 cfm	301 cfm	58.0 %	301 cfm	301 cfm	301 cfm
Vav_54_D473	Cool	Occupied	72.7 °F	78.0 °F	0.0 %	78.0 °F	70.0 °F	82.4 °F	60.8 °F	-	-	540 cfm	540 cfm	60.0 %	871 cfm	540 cfm	540 cfm
Vav_55_D480	Reheat	Occupied	72.3 °F	72.0 °F	0.0 %	78.0 °F	72.0 °F	82.4 °F	60.8 °F	-	-	481 cfm	479 cfm	45.5 %	871 cfm	479 cfm	479 cfm

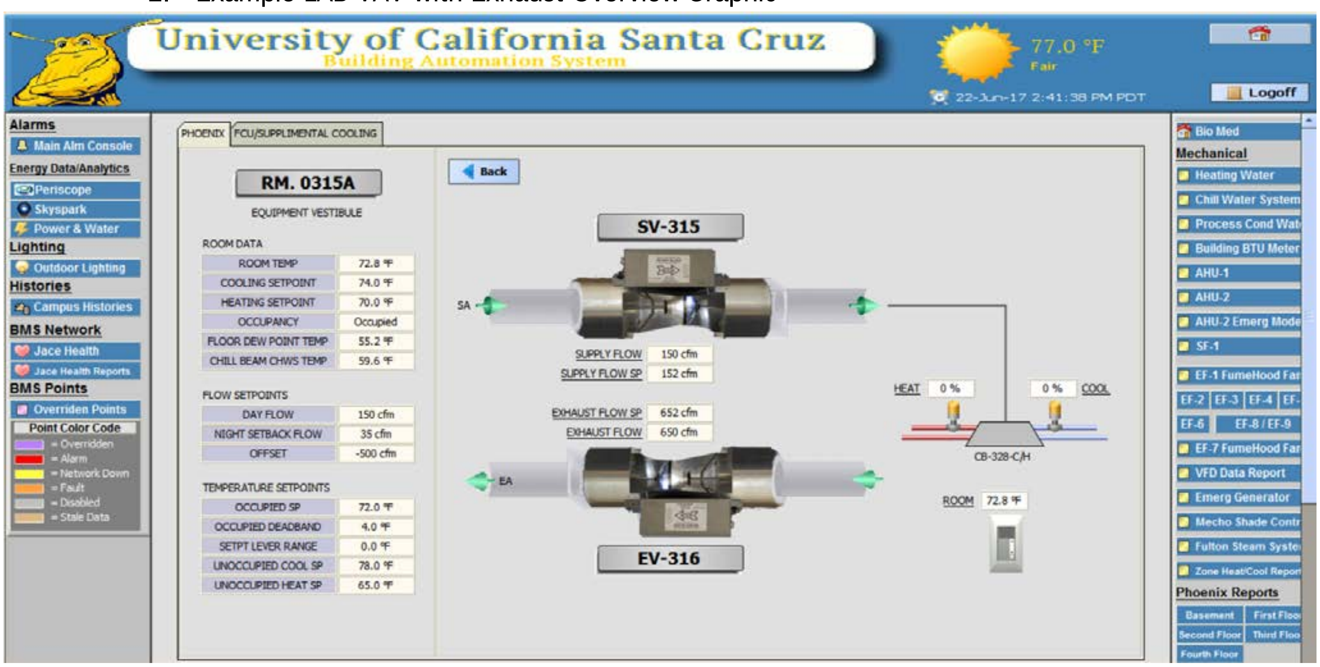
J. LAB OVERVIEW

1. Example LAB Overview Graphic

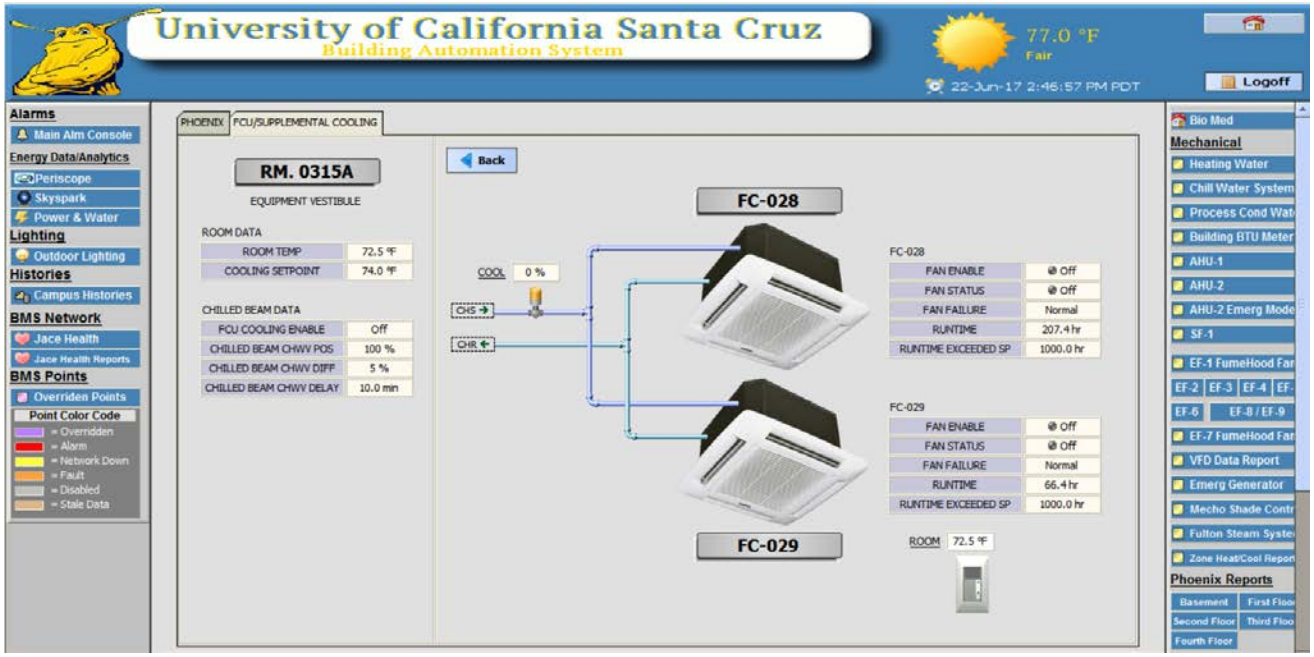


Room	Use	Space Temp	Clg Sp	Htg Sp	Clg Valve	Htg Valve	Supply Flow	Supply Sp	Exhaust Flow	Exhaust Sp
0300	ADMIN	69.9 °F	74.0 °F	70.0 °F	0 %	86 %	1279 cfm	1278 cfm	1177 cfm	1176 cfm
0300A	HALLWAY	70.7 °F	74.0 °F	70.0 °F	0 %	0 %	146 cfm	144 cfm	-	-
0300B	HALLWAY	73.1 °F	74.0 °F	70.0 °F	-	0 %	994 cfm	998 cfm	-	-
0300D	CORRIDOR	70.2 °F	74.0 °F	70.0 °F	-	0 %	397 cfm	396 cfm	-	-
0301	OFFICE SERVICE	70.0 °F	74.0 °F	70.0 °F	-	5 %	197 cfm	197 cfm	-	-
0307/0305	MENS / WOMENS	70.0 °F	74.0 °F	70.0 °F	-	7 %	599 cfm	600 cfm	-	-
0315	REASERCH LAB 3A	72.1 °F	74.0 °F	70.0 °F	0 %	0 %	736 cfm	740 cfm	599 cfm	597 cfm
0315A	EQUIPMENT VESTIBULE	73.0 °F	74.0 °F	70.0 °F	0 %	0 %	152 cfm	150 cfm	650 cfm	652 cfm
0315C	PROCEDURE	70.7 °F	74.0 °F	70.0 °F	0 %	0 %	139 cfm	140 cfm	39 cfm	39 cfm
0315D	DARK ROOM	70.3 °F	74.0 °F	70.0 °F	-	67 %	99 cfm	100 cfm	198 cfm	197 cfm
0316	INTERACTIVE	74.7 °F	74.0 °F	70.0 °F	-	0 %	496 cfm	496 cfm	-	-
0325	REASERCH LAB 3B	70.9 °F	74.0 °F	70.0 °F	0 %	0 %	745 cfm	740 cfm	603 cfm	605 cfm
0325B	PROCEDURE	70.0 °F	74.0 °F	70.0 °F	0 %	0 %	250 cfm	250 cfm	151 cfm	150 cfm
0335	REASERCH LAB 3C	72.2 °F	74.0 °F	70.0 °F	0 %	0 %	738 cfm	740 cfm	602 cfm	598 cfm
0335A	EQUIPMENT VESTIBULE	72.5 °F	74.0 °F	70.0 °F	0 %	0 %	151 cfm	150 cfm	654 cfm	651 cfm
0335B	GLASS WASH / AUTOCLAVE	73.7 °F	74.0 °F	-	66 %	-	181 cfm	180 cfm	330 cfm	331 cfm
0335E	PROCEDURE	69.8 °F	74.0 °F	70.0 °F	0 %	77 %	172 cfm	170 cfm	37 cfm	37 cfm
0337T	IDF	75.3 °F	76.0 °F	-	0 %	-	98 cfm	100 cfm	195 cfm	197 cfm
0343L	ELECTRICAL	73.3 °F	-	-	-	-	98 cfm	97 cfm	195 cfm	197 cfm
0345	REASERCH LAB 3D	71.4 °F	74.0 °F	70.0 °F	0 %	0 %	745 cfm	740 cfm	610 cfm	605 cfm
0345A	EQUIPMENT VESTIBULE	71.9 °F	74.0 °F	70.0 °F	0 %	0 %	149 cfm	150 cfm	849 cfm	849 cfm
0345C	PROCEDURE	71.5 °F	74.0 °F	70.0 °F	0 %	0 %	170 cfm	170 cfm	69 cfm	70 cfm
0345D	LARGE PROCEDURE ROOM	72.0 °F	74.0 °F	70.0 °F	0 %	0 %	221 cfm	220 cfm	227 cfm	221 cfm
0354	INTERACTIVE	72.0 °F	74.0 °F	70.0 °F	-	0 %	493 cfm	498 cfm	-	-
0355	REASERCH LAB 3E	70.1 °F	76.0 °F	72.0 °F	0 %	100 %	735 cfm	740 cfm	597 cfm	595 cfm
0355A	PROCEDURE	72.0 °F	74.0 °F	70.0 °F	0 %	0 %	169 cfm	170 cfm	71 cfm	69 cfm
0364	EQUIPMENT	69.9 °F	74.0 °F	70.0 °F	0 %	5 %	281 cfm	280 cfm	0 cfm	0 cfm
0365	REASERCH LAB 3F	70.2 °F	74.0 °F	70.0 °F	0 %	0 %	737 cfm	740 cfm	603 cfm	597 cfm
0365A	HALLWAY	-	-	-	-	-	-	-	443 cfm	440 cfm
0365B	LARGE PROCEDURE ROOM	70.3 °F	74.0 °F	70.0 °F	0 %	0 %	482 cfm	480 cfm	688 cfm	682 cfm

2. Example LAB VAV with Exhaust Overview Graphic

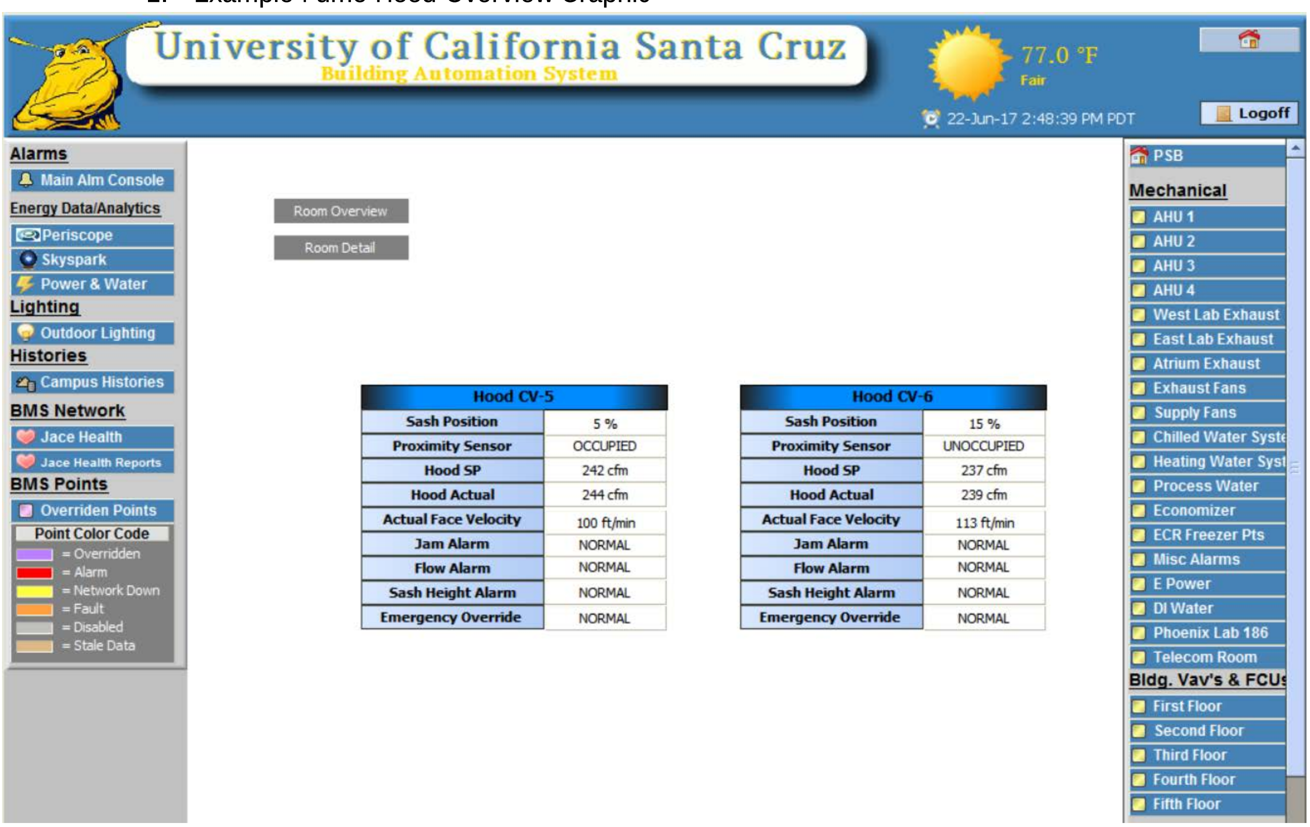


3. Example LAB VAV with FCU Supplemental Cooling Graphic

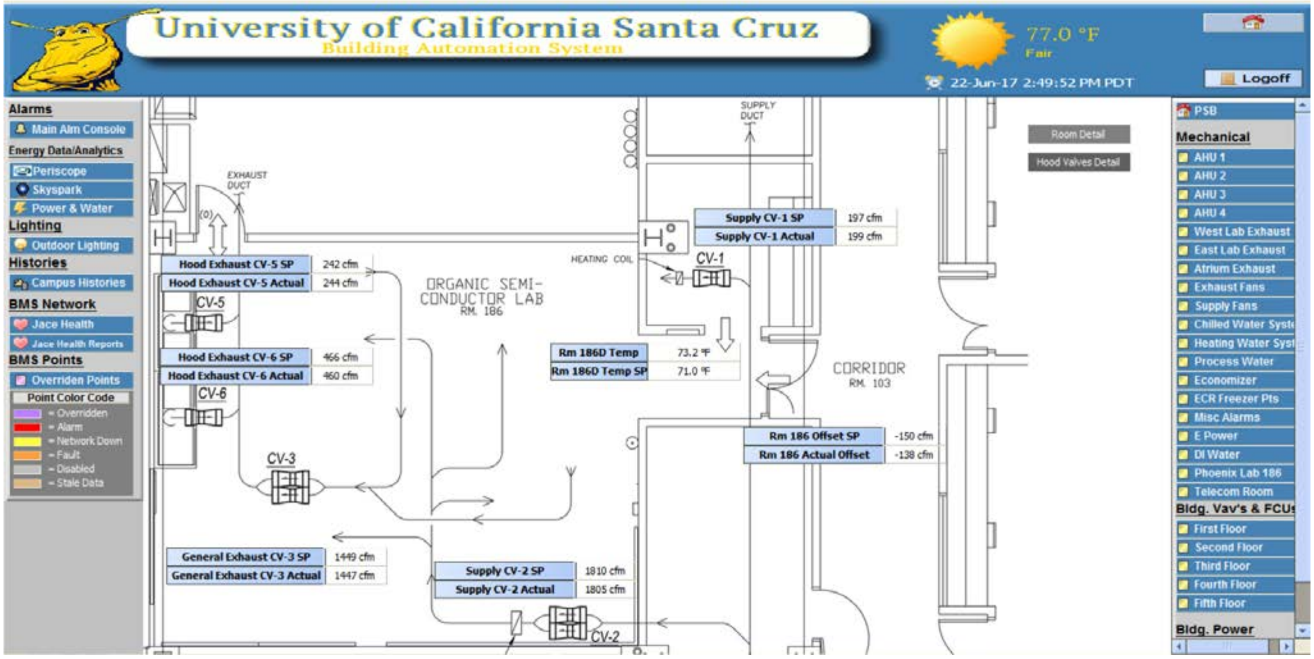


K. FUME HOOD OVERVIEW

1. Example Fume Hood Overview Graphic

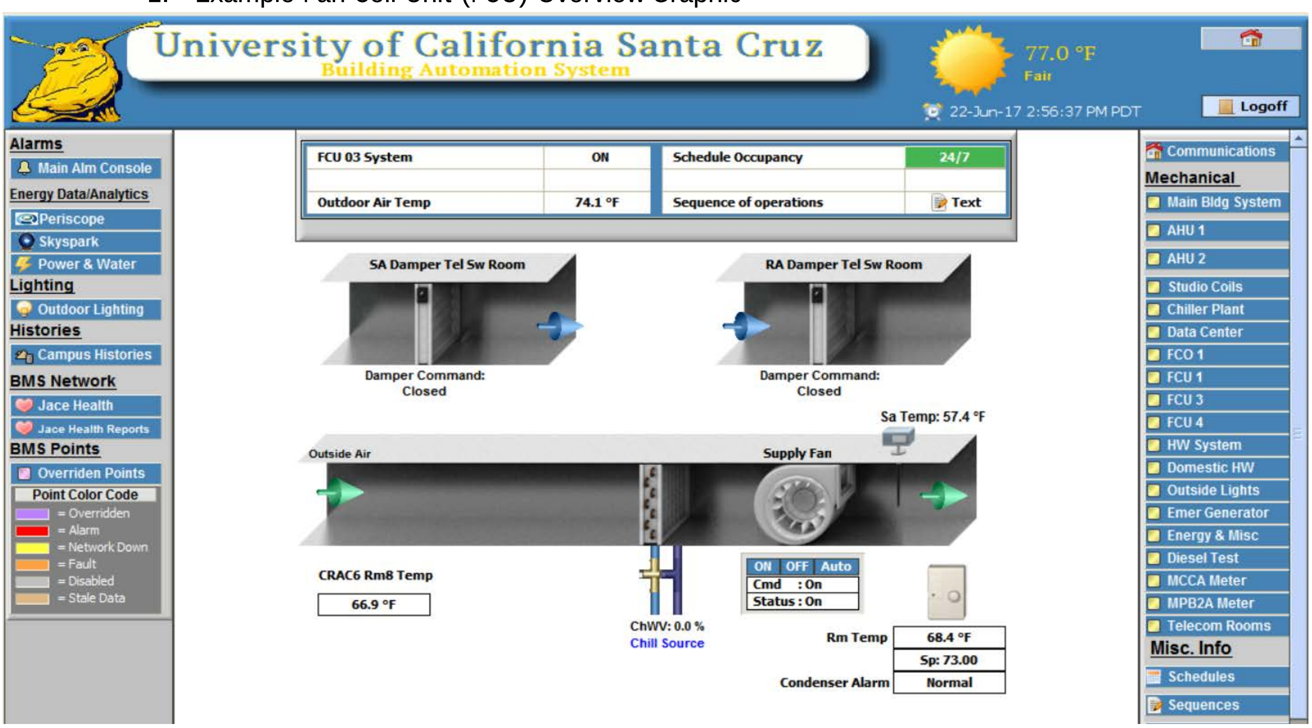


2. Example Fume Hood Room Detail Graphic



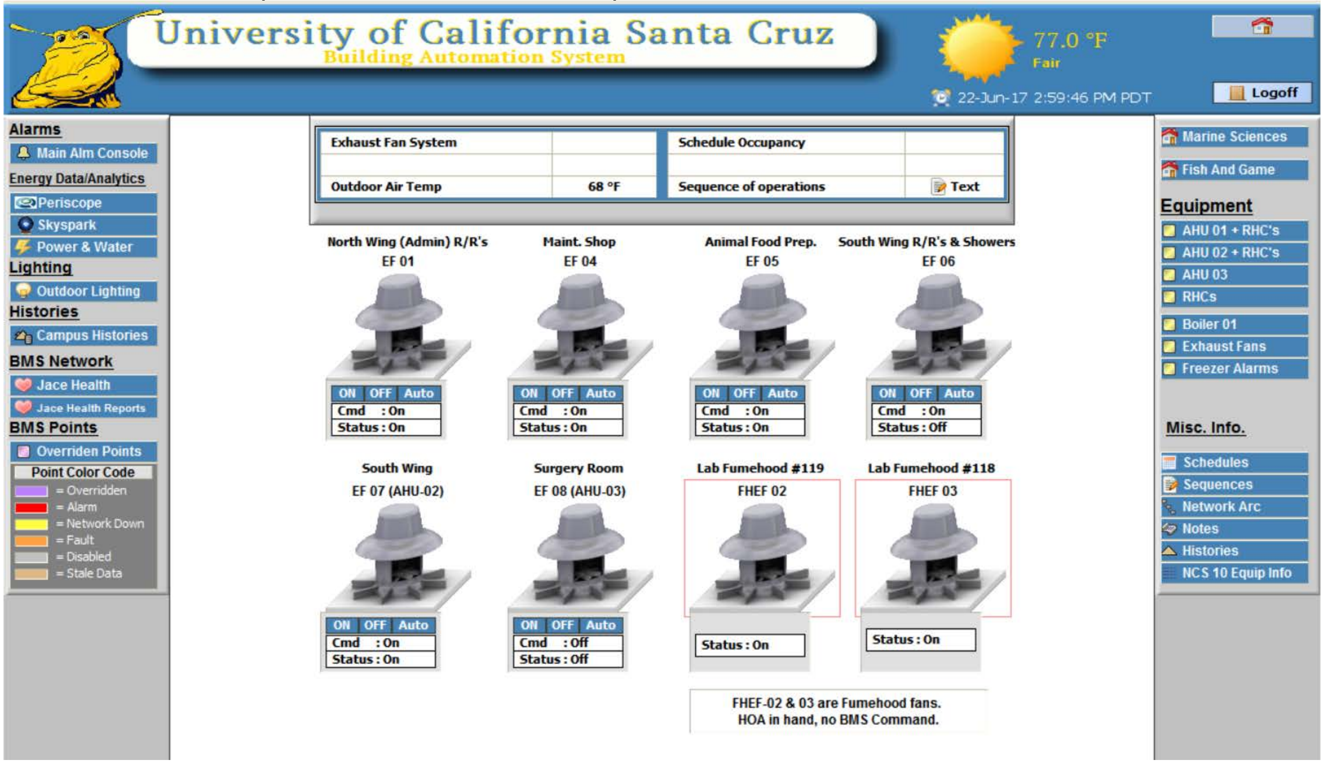
L. FAN COIL UNIT OVERVIEW

1. Example Fan Coil Unit (FCU) Overview Graphic



M. EXHAUST FAN OVERVIEW GRAPHIC

1. Example Exhaust Fan Overview Graphic

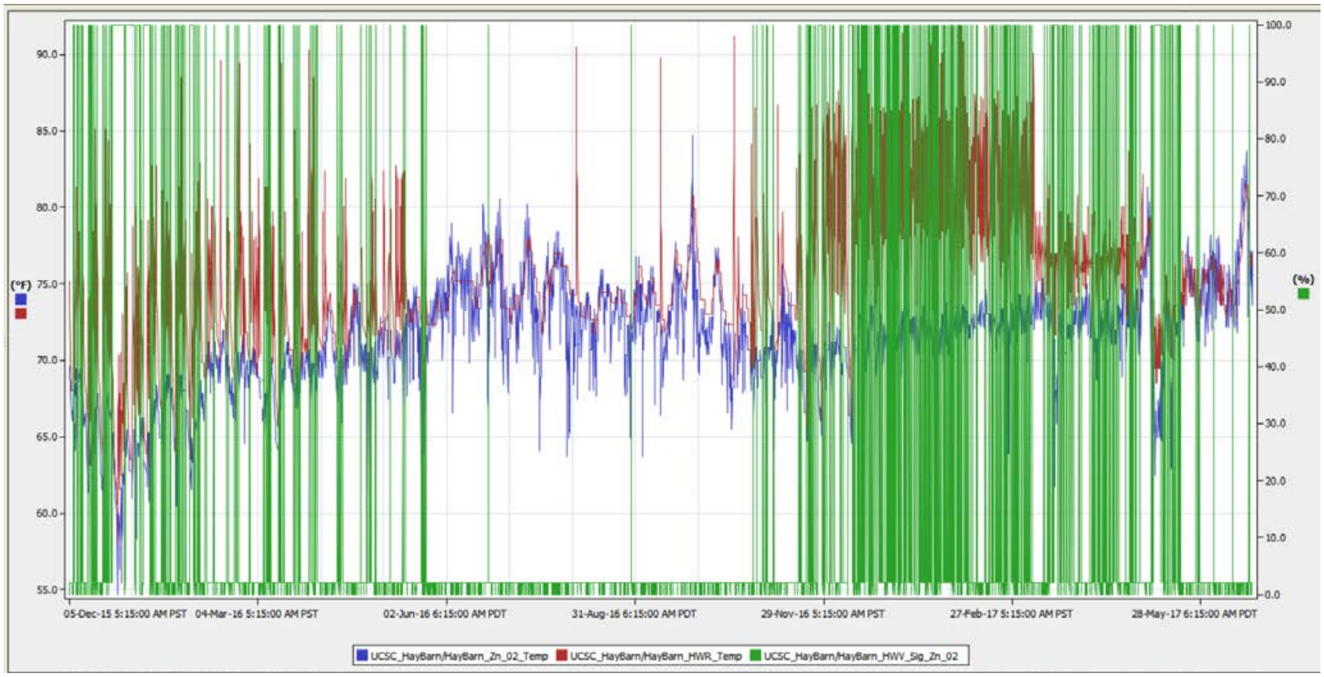


N. TREND SELECTION SCREEN (CHART BUILDER)

1. When the "Histories" Right Side Bar Button is clicked, a pop-up window will open showing the available trends (Histories).

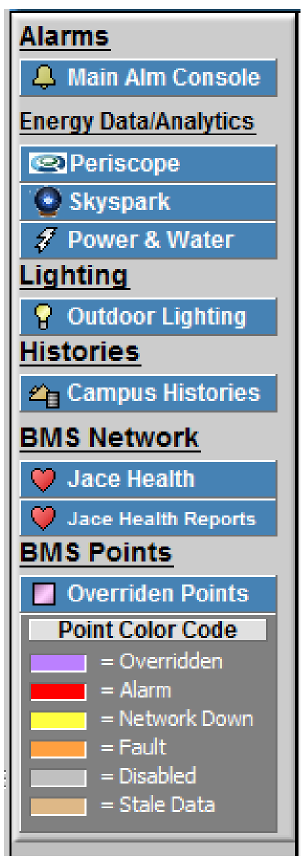
O. TREND POP-UP WINDOW

1. When the “Build” button is selected from Chart Builder (see above), a pop-up window will open showing the trended value(s).



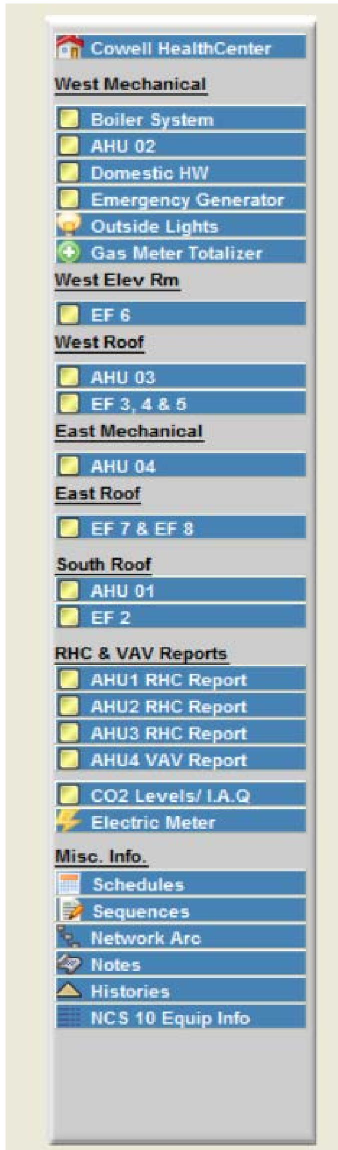
P. CAMPUS NAV BAR (left side)

1. Campus NavBar



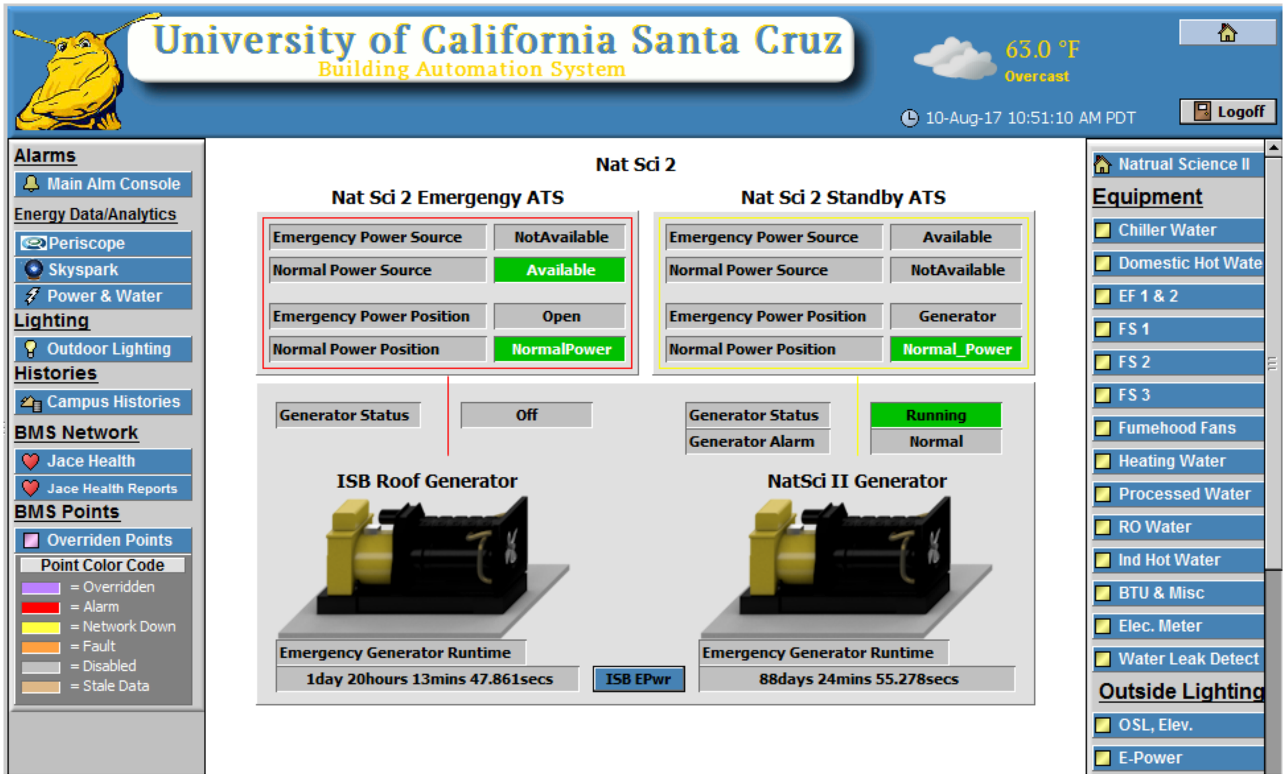
Q. NAVIGATION BAR (right side)

1. Navigation or Selection bars facilitate logical site navigation with organized link buttons. Typical applications include selection from multiple Floorplans, Overviews, HVAC Equipment, Reports, etc.
2. Example of Typical Navigation Bar



R. EMERGENCY POWER

1. Example of a Typical Emergency Power Graphic



XII. REPORTS

A. Standard Reports:

1. Standard DDC system reports shall be provided and operator shall be able to customize reports later.
2. All I/O:
    a) With current status and values.
3. All I/O in a manual override state:
    a) With current status and values.
4. Alarm:
    a) All current alarms.
5. Disabled I/O:
    a) All I/O points that are disabled.
6. Logs:
    a) Alarm history.
    b) Audit history, displaying all operator initiated events.
    c) System messages.
    d) System events.
    e) Trends.

B. Custom Reports:

1. Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

C. Custom Trends:

1. Operator shall be able to define a custom trend log for any I/O point in DDC system.
2. Each trend shall include interval, start time, and stop time.
3. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server hard drives.
4. Data shall be retrievable for use in spreadsheets and standard database programs.

XIII. DDC CONTROLLERS

A. DDC CONTROLLERS

1. DDC system shall consist of a combination of JACE network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
2. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
3. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
4. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

5. Environment Requirements:
    a) Controller hardware shall be suitable for the anticipated ambient conditions.

B. Power and Noise Immunity:
    1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
    2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within 36 inches of enclosure.

C. DDC Controller Spare Processing Capacity:
    1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
    2. Network Controllers:
        a) 15 percent spare. Average operating CPU% shall not be greater than 85 percent and “heap used” value shall not exceed 85 percent of “heap total”.
    3. Programmable Application Controllers:
        a) 15 percent spare.
    4. Application-Specific Controllers:
        a) 15 percent spare.

D. Memory shall support network controller's operating system and database and shall include the following:
    1. Monitoring and control.
    2. Energy Automation, operation, and optimization applications.
    3. Alarm Automation.
    4. Historical trend data of all connected I/O points.
    5. Maintenance applications.
    6. Operator interfaces.
    7. Monitoring of manual overrides.
    8. DDC Controller Spare I/O Point Capacity:
        a) Include spare I/O point capacity for each controller as follows:

E. Network Controllers:
    1. Room in panel shall be allocated to allow for additional I/O devices and associated wiring needed to achieve 25 percent added point capacity in the future. Anticipated point mixture shall be planned at approximately 6-1/2 percent of each point type, AI, AO, BI and BO.

F. Programmable Application Controllers:
    1. When applied to equipment other than a zone terminal unit, spare capacity requirements shall follow that of network controller.
    2. When applied to a zone terminal unit, no spare capacity is required.

G. Application-Specific Controllers:
    1. Spare capacity requirements shall be identical to programmable application controllers.
    2. Maintenance and Support:
        a) Include the following features to facilitate maintenance and support:
        b) Mount microprocessor components on circuit cards for ease of removal and replacement.

c) Means to quickly and easily disconnect controller from network.

d) Means to quickly and easily connect to field test equipment.

e) Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

3. Input and Output Point Interface:

a) Hardwired input and output points shall connect to network controller I/O devices, programmable application and application-specific controllers.

b) Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.

c) Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

XIV. NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Tridium Niagara framework JACE controllers with open NiCS (open Niagara Implementation Conformance Statement).
2. Include adequate number of controllers to achieve performance indicated.
3. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
4. Controller shall have enough memory to support its operating system, database, and programming requirements.
5. Data shall be shared between networked controllers and other network devices.
6. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
7. Controllers that perform scheduling shall have a real-time clock.
8. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
9. Controllers shall be fully programmable.
10. Controllers shall be capable of routing necessary configuration software tools to attached level three controllers.
11. Communication:
    a) Network controllers shall communicate with other devices on DDC system level one and/or level two networks.
    b) Network controller also shall perform routing if connected to a level three network of programmable application, application-specific controllers or integrated equipment. Level three network shall be open protocol; BACnet MS/TP. The use of other open protocols including, Lonworks or Modbus is acceptable when integrating third party devices.
    c) A separate level three network is required for each unique device manufacturer type. For example; a single level three network connecting several different size BACnet VAV controllers and FCU controllers from a common manufacturer would be acceptable, but it would not be acceptable to add a BACnet chiller to this same network. A separate level three network would be required to connect the BACnet chiller or chillers. The only exception to this requirement would be for level three networks connecting less than (10) devices with Client approval.
12. Serviceability:
    a) Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
    b) Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
    c) Controller shall maintain BIOS and programming information in event of a power loss for at least 96 hours.

XV. PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform internal scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable with configuration software tool connected via the attached network controller or with embedded tools within the network controller.
8. Communication:
   a) Programmable application controllers shall communicate with other devices on level three network.
   b) Communication at this third level shall be open protocol; BACnet or LonWorks
9. Serviceability:
   a) Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
   b) Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
   c) Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

XVI. APPLICATION-SPECIFIC CONTROLLERS

A. Description:
   1. Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
   2. Capable of standalone operation and shall continue to include control functions without being connected to network.
   3. Data shall be shared between networked controllers and other network devices.
   4. Controllers shall be configured or programmed using the configuration software tool connected via the attached network controller or with embedded tools within the network controller.
   5. Communication:
      a) Application-specific controllers shall communicate with other application- specific controller and devices on level three network, and to programmable application and network controllers. Communication at this third level shall be open protocol; BACnet or LonWorks.
6. Serviceability:
   a) Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
   b) Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
   c) Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

XVII. POINT NAMING – TYPICAL

A. It is required that a logical and consistent point naming strategy be used. The point naming strategy described here may be used or alternative strategy may be submitted for engineer's approval prior to implementation. The naming abbreviations listed here show common abbreviations, it is expected that additional abbreviations be added when applicable.

B. Actual point names of Boolean, Numeric, Enumerated and String points shall be simple short names that are repeated as much as possible throughout system to take advantage of batch commands. For example, there should be many points throughout the system with the name "Zn_Temp" The key is that these repeat points are all in different, uniquely named folders. The full point name shall be derived from folder structure naming and extracted as needed automatically by the BAS. For example, when a point alarms and is issued to the alarm log, the full point name, extracted from the folder structure shall be included in the alarm message so it is known exactly which Zn_Temp of all the Zn_Temps throughout the system is in alarm.

C. Title-case is used in this naming strategy to efficiently group abbreviations without the need to use several separator characters. When it is prudent to use a separator character, the use of the underscore character is preferred. Total character count in point naming is limited.

D. Order of text within the point name from left to right is important. Often alphabetical sorting techniques are inherent within BAS systems. This point naming strategy takes advantage of this by starting with broad location in the left-most characters and narrowing to fine detail in the right-most characters, all the while attempting to group like items.

1. <Prefix> = <Building Name>_<System Name>_< Equipment Name>
    a) LML_HS_Br_01 (Long Marine Labs_Hydronic System_Boiler 01

2. This prefix to be included in all full point names. Prefix shall be derived from folder structure and shall automatically change with folder renaming.

3. <Point Name> = <Component Name>_<Feature Name>
    a) At least first feature name must be included. Additional feature names to be included as appropriate.
        (1) Hws_Temp (Heating Water Supply Temperature)

4. <Full Point Name> = <Prefix>_<Point Name>
    a) Example Full Point Names:

Point Type	Tridium Name
AI-1	Classroom_SF_01_SA_Temp
AI-2	Classroom_SF_01_RA_1_Temp
AI-3	AI_3_Unused
AI-4	Classroom_LectHall_2_Temp
AI-5	Classroom_OA_Temp
AI-6	Classroom_SF_02_SA_Temp
AI-7	Classroom_SF_02_RA_Temp
AI-8	Classroom_SF_03_SA_Temp

AI-1	Classroom_SF_03_RA_Temp
AI-2	Classroom_LectHall_1A_Temp
AI-3	Classroom_LectHall_1B_Temp
AI-4	Classroom_Office_107_Temp
AI-5	Classroom_BR_01_Temp
AO-1	Classroom_SF_01_EconDmpr_Sig
AO-2	Classroom_SF_01_HWV_Sig
AO-3	Classroom_SF_02_EconDmpr_Sig
AO-4	Classroom_SF_02_HWV_Sig

DI-1	Classroom_SF_01_Stat
DI-2	Classroom_SF_02_Stat
DI-3	Classroom_SF_03_Stat
DI-4	HWP_01_Stat
DI-5	HWP_02_Stat
DI-6	Classroom_EF_01_Stat
DI-7	Classroom_EF_02_Stat
DI-8	Classroom_EF_03_Stat
DI-9	Classroom_NrmPwr_Stat
DI-10	Classroom_EmPwr_Stat

DI-1	ACC_01_Alm
DI-2	Classroom_OSL_Stat

DO-1	Classroom_SF_01_Cmd
DO-2	Classroom_SF_02_Cmd
DO-3	Classroom_SF_03_Cmd
DO-4	Classroom_EF_02_Cmd

DO-1	Classroom_OSL_Cmd

5. <Building>_<System>_<Equipment>_<Component>_<Feature>

This part of the actual point name (optional) can be used to describe a component of a piece of equipment. Combine with multiple component names as appropriate to further clarify the component. Examples might include: Ahu01_SaFan_Cmd, ClgPlnt_ClgTwr1_FanA_Sts

Dmpr	Control damper	Filt	Filter
Safety	Safety device value	Oa	Outside air section
EmgStop	Emergency stop button	Ma	Mixed air section
SF	Supply Fan	Da	Discharge air section
RF	Return Fan	EF	Exhaust Fan
Zn	Controlled zone, room or	Sa	Supply air section
Pri	Primary water loop	Ra	Return air section
Sec	Secondary water loop	Rlf	Relief air section
Chw	Chilled water	PreHt	Pre-heating coil and valve
Chws	Chilled water supply	Rht	Re-heating coil and valve
Chwr	Chilled water return	Htg	Heating coil and valve
Hw	Heating water	Clg	Cooling coil and valve
Hws	Heating water supply	DxCmp	Direct exp clg compressor
Hwr	Heating water return	Vlv	Control valve
Sump	Sump tank	RevVlv	Reversing Valve
Rad	Radiation	Vfd	Variable frequency drive
Humid	Humidifier	PriAir	Primary air section
Light	Lighting	Pmp	Circulating pump
FrzStat	Freezestat	Iso	Isolation, as in Isolation
Set	Part of a set, such as a pump set	Sys	Indicate part of a specific system

6. <Building>_<System>_<Equipment>_<Component>_<Feature>

This last part of the actual point name is used to describe the feature of the equipment/component. The action, reading, calculated value, associated setpoint, etc. Combine with multiple feature or component names as appropriate to further clarify the feature. Examples might include: Vav05_Zn_ClgUnocTempSpt, Vav05_Zn_SptAdjustable, Ahu01_SaFan_Cmd, Ahu01_Ra_MaxCo2

Cmd	Command; on/off	Occ	Occupied value
Sig	Modulating signal; controller to	Unoc	Unoccupied value
Sts	Status: on/off device to	StndBy	Stand-by value
FdBk	Feedback signal from device to	Co2	Carbon dioxide
Alm	Alarm status from device	Co	Carbon monoxide
Flow	Air or water flow	No2	Nitrogen dioxide
Temp	Temperature	Mode	Operating control mode
Rh	Relative humidity	Vel	Velocity
Enth	Enthalpy	Area	Area
Dew	Dewpoint temperature	Lvl	Level measurement
Press	Gauge pressure	Kfactor	Balancing constant
Dp	Differential pressure	Config	Configuration value
Sched	Schedule value	Pct	Percentage
Calc	Calculated value in software	Cap	Capacity
Stpt	Setpoint value in software	Eff	Effective or resulting
Offset	Offset value	Select	Selected value
Hi	Highest value	OptStart	Optimum start value
Lo	Lowest value	Mwu	Morning warm-up
Min	Minimum value	Mcd	Morning cool-down
Max	Maximum value	Btuh	Power
Spec	Red/Blue floor plan color	Btu	Energy
Adj	Adjustable adjustment slider,	Int	Interior
Btn	Button, user initiated	Ext	Exterior
kW	Power - electrical	Lux	Lighting level -
kWh	Energy - electrical	PctRla	Percent run load amps

XVIII. HISTORY TRENDING - TYPICAL

A. It is required that a logical and consistent history trend strategy be used. The history trend strategy described here may be used or alternative strategy may be submitted for engineer's approval prior to implementation. The typical history trends listed here show common situations, it is expected that additional history trends be added when applicable.

B. History trend extensions shall be added and configured for all typical situations described here. This includes every hardware point and every calculated software point that changes automatically by way of program logic.

C. Full point name shall be included in every trend name, refer to "Point Naming" this specification section.

D. All history trends shall store at minimum (3) years' worth of data before rolling to overwrite data. It is understood that change of value (COV) type trend sizes will have to be estimated, configure at least 10,000 records for these.

E. History trend data shall be stored on the EnergyAx Supervisor server.

F. Change of Value (COV) trends are where a sample is logged whenever the value changes by a specified amount.

   1. Boolean and Enumerated point COV trends shall log a sample every change of state. Examples of Boolean or Enumerated points are; fan command, fan status and current mode.
   2. For Numeric points, COV trends are not recommended, use Interval trends instead.

G. Interval trends are where a sample is logged according to a preset regular time interval.

   1. Numeric point Interval trends log interval times shall be set as:
      a) 15 minute intervals for slower variables such as; outside temp, room temp, return temp, discharge air temp, heating valve signal, building static pressure, etc.
   2. For Boolean and Enumerated points, Interval trends are not recommended, use COV trends instead.

XIX. CONTROL FUNCTIONALITY

A. Building and energy management application software and logic:
   1. Shall reside and operate in system controllers. Applications shall be configurable through the operator workstation, web browser interface, or engineering workstation.
B. Memory and System Time:
   1. All controllers shall have a Non-Volatile Memory providing indefinite storage of application and configuration data. The system must have an ability to maintain time, and automatically correct for daylight savings time and leap year adjustments. In the event of power failure or user generated power cycle, all system components must automatically updated with current time and date from a network Time Sync device.
C. Stand-alone capability:
   1. All controllers shall be capable of providing all control functions of the HVAC system without the use of a computer. The controllers shall include the inherent capability to access the system control selections as well as to monitor system performance by means of a communicating network with a PC and EMS software program.
D. Sequencing:
   1. Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
E. Control Loops:
   1. Support any of the following control loops, as applicable to control required:
      a) Two-position (on/off, open/close, slow/fast) control.
      b) Proportional control.
      c) Proportional plus integral (PI) control.
   2. Include PID algorithms with direct or reverse action and anti-windup.
   3. Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
   4. Controlled variable, set point, and PID gains shall be operator-selectable.
F. Staggered Start:
   1. Application software shall sequence chillers, boilers, and pumps as specified in Sequence of Operations for HVAC Controls.
G. Anti-Short Cycling:
   1. Binary Output points shall be protected from short cycling.
   2. Feature shall allow minimum on-time and off-time to be selected.
H. On and Off Control with Differential:
   1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
   2. Algorithm shall be direct or reverse-acting and incorporate an adjustable differential.
I. Zoning system compatible with constant volume air source (Variable Volume/Variable Temperature) (VVT). The zoning system shall be compatible with constant volume air source and consist of programmable, multiple communicating Zone Controllers and a Bypass Controller. The system shall also include a complete array of input and output devices. The system shall provide full control of HVAC heating and cooling equipment in a multiple zone application. The zoning system shall be capable of operating as a stand-alone system or networked with multiple systems to communicating air source controllers.
   1. Zone control. Each zone shall be capable of monitoring space conditions and providing the correct amount of conditioned air to satisfy the space load. Each zone shall be capable of the following:

a) Space temperatures control. To maintain individual heating and cooling set points.

b) Relative Humidity/Air Quality (DCV). Each zone shall be capable of maintaining space relative humidity set point or air quality set point (zone level demand control ventilation).

c) Demand coordination. Each zone shall be capable of zone demand data coordination with other zones in the system.

2. Static pressure control. The zoning system shall be capable of maintaining a user adjustable supply air duct static pressure set point.

a) The Bypass controller shall additionally provide the capability to increase system airflow during conditions when the temperature of the supply air from the equipment is approaching the limits of operation. In these cases, the Bypass controller shall raise the static pressure setpoint to a user configurable maximum limit in order to increase the system airflow during these conditions.

b) The Bypass control shall contain the ability to monitor the bypass damper movement (or VFD speed) and automatically adjust the setpoint control band and/or hysteresis in order to provide stability and prevent premature actuator failure.

3. Air source control. Shall control all associated HVAC rooftop equipment functions, and be capable of stand-alone or networked operation. The resident algorithms shall use error reduction logic as designated in ASHRAE standard 90.1 to provide temperature control and lower energy usage. The Air source shall be capable of zone demand data coordination with the associated zones.

4. System Terminal Modes. Each air terminal mode shall be based on the current air source mode, terminal type, space temperature, and the current temperature set points.

a) Off:

(1) All terminal dampers will maintain a 65% open position. Fans shall be disabled.

(2) If the zone requirement is heating, all single duct terminals shall maintain their damper position at 65%. Any zone controller servicing a parallel box shall fully close their dampers while the fan is operating. If local heat is available, the parallel fans shall start and local heat shall be enabled to maintain its unoccupied heating set point. The damper shall be modulated open to 65% after heating is no longer required.

b) Cooling and Night Time Free Cooling (NTFC):

(1) If the zone requirement is none, then the zone controllers shall modulate their dampers to maintain their minimum cooling damper position or damper ventilation position if the supply air temp is between 65 and 75 F. During the NTFC mode the zone controller shall control between its occupied heating and cooling set points. During the cooling mode, the zone controller shall modulate its damper to its appropriate (occupied or unoccupied) cooling set point.

(2) If the zone requirement is cooling, then the zone controllers shall modulate their air dampers between their minimum and maximum cooling damper position to maintain their cooling set point. Parallel fans shall be disabled unless the damper has closed below the user adjustable fan-on minimum position (optional). In that case, the fan shall be energized to mix return air with the cold primary air in order to prevent “cold air dumping” from the diffusers.

(3) If the zone requirement is heating, then the zone controllers shall modulate their dampers to maintain their minimum cooling damper position. Any zone controllers servicing single duct units with reheat capability shall maintain the greater of either the minimum cooling damper position or the specified reheat damper position. Zone controllers servicing parallel units shall enable their fans while the damper shall maintain its minimum cooling damper position.

c) Vent:

(1) If the air source equipment is operating in a fan only mode to provide ventilation without mechanical heating or cooling, then the zone controllers shall maintain the user configured ventilation damper position.

d) Heat:

(1) If the zone requirement is none, then the zone controller shall maintain its minimum heating damper position. Parallel fans shall be disabled and their air damper shall be modulated to maintain their minimum heating damper position.

(2) If the zone requirement is cooling, then the zone controller shall modulate its damper to maintain its minimum heating damper position. Parallel fans shall be disabled.

(3) If the zone requirement is heating, then the zone controllers shall modulate their air dampers between their minimum and maximum heating damper position to maintain their heating set point.

e) Pressurization:

(1) If the zone requirement is none or cooling, then the zone controller shall maintain its maximum cooling damper position. Parallel fans shall be disabled.

(2) If the zone requirement is heating, and the zone controller has been enabled to provide local heating, then the zone controller shall modulate its damper to its maximum cooling damper position and enable its auxiliary heat. If local heat is not available, the damper shall still be modulated to maintain its maximum cooling damper position.

f) Evacuation:

(1) During the Evacuation mode all terminal fans shall be disabled and all dampers shall close.

5. Air source interface. The zoning system shall be capable of zone demand data coordination with a communicating rooftop. Setpoint and zone temperature information from the zones shall be shared with the rooftop controller so that the rooftop controller's error reduction calculations can determine the proper number of heating or cooling stages to operate in order to satisfy the system load.

a) The zoning system shall have the capability of linking up to 32 zones to a single air source and determining system heating and cooling requirements.

b) The zoning system shall be capable of providing a communication check of all associated controls and display device type as well as error conditions.

c) The zoning system shall coordinate and exchange the flowing data as minimum:

(1) Average zone temperature

(2) Average occupied zone temperature

(3) Average occupied and unoccupied heat/cool set points

(4) Occupancy status

d) Space temperature and space temperature set points for use by the air source controller shall include a weighted factor, proportional to the size of the zone.

e) Only those zones with valid temperature readings shall be included.

f) The zoning system shall provide periodic updates to the air source.

g) The zoning system shall obtain and support the following air source modes as a minimum:
   (1) Off
   (2) Cooling
   (3) Heating
   (4) Night Time Free Cooling
   (5) Ventilation
   (6) Pressurization
   (7) Evacuation
h) The air source controller shall, through the Air Distribution System, bias its occupancy time schedules to provide optimization routines and occupant override.
i) For those zoning systems that do not include inherent air source interface capacity, each zone shall independently determine the operational mode of the equipment through its associated duct temperature sensor mounted in the supply ductwork. If there is air source controller, then the system will assumed to be always On.

6. HVAC Equipment Protection. The air sources controller shall be capable of monitoring the leaving air temperature to control stages in both the heating and cooling modes. It shall have the capability to shut down stages based on a rise or fall in leaving air temperature above or below adjustable or calculated values. Calculated supply air temperature requirements shall be based on error reduction calculations from reference zone data to determine the optimum supply air temperature to satisfy space requirements. The system shall provide protection from short cycling of heating and cooling by utilizing time guards and minimum run time configurations.
7. Energy Conservation.
   a) Load balancing from error reduction calculations that optimize staging.
   b) The locking out of mechanical heating or cooling modes based on configurable outside air temperature limits.
   c) Staggered start. The system shall intelligently start all equipment in a stagger start manner after a transition from unoccupied to occupied modes as well as power failure to reduce high peak power consumption on start-up.
   d) Peak Demand Limiting. Controllers in the system shall have the capability of being overridden by separate heating and cooling Peak Demand Limiting signals. Option/General purpose controller existing on the communications bus shall be able to send a demand limiting broadcast to reduce overall energy consumption and control on and off peak time kW usage
   e) Temperature compensated start. The zone controller shall be capable of supporting temperature compensated start with the air source. Prior to occupancy the zone controllers and Air Source shall work together to provide zone-by-zone temperature compensated conditioning. The air source will track the time required for recovery report the optimal start bias time to the zones prior to each occupied period so that the zone can start conditioning the space prior to occupancy.
8. Demand Control Ventilation (DCV). The zone shall be capable of reading an analog signal from a CO2 sensor or other sensor measuring volatile contaminants, or relative humidity and provide DCV at the zone by calculating a DCV damper position and participate in system DCV operation with the air source

a) System DCV (System Level).The zoning system shall have the ability to collect the DCV value from any or all of the zone controllers in the system. These values may be the average or the highest sensor value which will be transmitted to an air source controller's analog DCV sensor input. The air sources configured DCV routine may perform the appropriate actions to reduce CO2 concentration at the reporting zones. The system shall be capable of maintaining a ventilation setpoint through a DCV algorithm in conjunction with zone.

b) Local DCV (Zone Level). Each zone shall be capable of reading an analog signal from a CO2 sensor or other sensors measuring volatile contaminants and maintaining a ventilation setpoint through a DCV algorithm in conjunction with system. The zone shall calculate a DCV damper position for the zone based on an error reduction calculation. When the DCV damper position value is greater than temperature control damper position the DCV damper position shall be used to position the damper. System heating and cooling and zone supplemental heat shall be allowed to operate.

9. Abnormal Conditions. The proposed system shall include the ability to detect abnormal conditions, and to react to them automatically. A return to normal conditions shall also generate a return to normal notification and the system shall revert back to its original control scheme before the abnormal condition existed. The following abnormal terminal conditions shall automatically generate an alarm and the system shall take the following actions:

a) If a space temperature sensor is determined by the zone controller to be invalid, the zone controller shall generate an alarm. During this condition, the zone damper will be positioned to either the minimum heating, minimum cooling or the configured ventilation damper position, based on the air source equipment operating mode.

b) If a relative humidity sensor is determined by the zone controller to be invalid, the zone controller shall generate an alarm.

c) If an indoor air quality sensor is determined by the zone controller to be invalid, the zone controller shall generate an alarm, and disable its IAQ algorithm.

d) System level demand coordination. If an air source controller is participating in demand coordination with other zones and loses communication with the associated zones, it shall generate an alarm. Likewise, any zone detecting a communication failure, will generate an alarm.

e) Zone level demand coordination. If the system loses communication with one of the zones associated with that system the zoning system shall remove that zone temperature from its weighted averages. The zone controller shall continue to operate in a stand-alone mode.

f) If the zoning system if configured to interface with the air source for zone demand data coordination and that communication is broken, each zone controller shall determine the equipment operating mode based on the temperature of the primary air. The air source will be assumed to be always on.

J. Run-Time Totalization:

1. Include software with the capability to totalize run-times for BI points.

XX. ENCLOSURES

A. General Enclosure Requirements:
   1. Include enclosure door with secure latching mechanism.
   2. All enclosures containing a DDC controller applied to equipment other than a zone terminal unit shall have hinged door.
   3. All enclosures associated with DDC control system shall be alike color/style with a visible label identifying its tag/controlled equipment.
   4. Supply each enclosure with a complete set of as-built schematics, wiring diagrams, and product literature located in a pocket on inside of door.
   5. Enclosure shall be NRTL listed according to UL 508 A.
   6. Constructed of steel with factory applied galvanized coating or paint.
   7. Internal panel mounting hardware, grounding hardware and sealing washers.
   8. Grounding stud on enclosure body.
   9. Internal Arrangement:
      a) Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
      b) Arrange layout to group similar products together.
      c) Include a barrier between line-voltage and low-voltage electrical and electronic products.
      d) Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
      e) Terminate field cable and wire using heavy-duty terminal blocks.
      f) Install a maximum of two wires on each side of a terminal.
      g) Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
      h) Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch.
      i) Mount products within enclosure on removable internal panel/backplane.
      j) All internal panel components to be labeled.
      k) Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
      l) Label controller end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
      m) Size enclosure internal panel to include at least 25 percent spare area on backplane of panel.
   10. Environmental Requirements:
      a) Evaluate temperature and humidity requirements of each product to be installed within each enclosure and locate panel accordingly.
      b) Outdoors, Type 4X. Additional panel heater is required when components are not rated for design outdoor temperature and humidity levels.
      c) Indoors, Dry Areas: Type 1.

d) Indoors, Wet Areas or Areas Exposed to Condensation or Wash-down: Type 4X

XXI. ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.
2. Transformer shall be UL Listed.
3. Transformer shall be at least 40 VA.
4. Transformer shall have secondary resettable breaker.

B. DC Power Supply:

1. Output voltage nominally 24-VDC or other voltage within 5 percent.
2. Output power minimum of 14W.
3. Input voltage nominally 120-VAC, 60 Hz. Lower voltage input is not acceptable.
4. Load regulation within 0.5 percent from zero- to 100-mA load.
5. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
6. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warm-up.

XXII. CONTROL WIRE AND CABLE

A. Low Voltage Power Wiring
   1. Wiring runs less than 150 feet
      a) Wire size shall be minimum 18 AWG.
   2. Wiring runs greater than 150 feet
      a) Wire size shall be minimum 16 AWG. Power/voltage drop calculation must be completed for all longer runs to determine if even larger wire is required.
   3. Conductors shall be twisted soft annealed copper strand.
   4. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
   5. Outer jacket insulation shall have a 300-V, 105-degrees C rating and shall be Type PLTC cable.
   6. Power cabling to have a unique jacket color or striping color.
B. Low Voltage Input/Output wiring - Must be shielded.
   1. Wire size shall be minimum 18 AWG.
   2. Conductors shall be twisted soft annealed copper strand.
   3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
   4. Outer jacket insulation shall have a 300-V, 105-degrees C rating and shall be Type PLTC cable.
   5. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
   6. Input cabling to have a unique jacket color or striping color.
   7. Output cabling to have a unique jacket color or striping color.
C. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
   1. Cable shall be plenum rated.
   2. Cable shall comply with NFPA 70.
   3. Cable shall have a unique color that is different from other cables used on Project.
      a) Jacket color: LonWorks - Orange, Bacnet - Blue, Modbus – Purple
   4. Copper Cable for Ethernet Network:
      a) 100BASE-TX.
      b) TIA/EIA 586, Category 6.
      c) Minimum No. 24 AWG solid.
      d) Unshielded Twisted Pair (UTP).
      e) Thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, Class CMP as plenum rated.
   5. Wire Color Code:

a)

Volts	Color
110	Black
Neutral	White
Ground	Green
24 ac	Orange
24 ac common	Brown
24 dc	Red
24 dc common	White
Analog Input	Purple
Analog Output	Yellow
Digital Input	Pink
Digital Output	Blue
Signal Common	Grey

XXIII. PART 3 EXECUTION

A. DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

1. Communication Interface to Equipment with Integral Controls and Other Building Systems:
   a) DDC system shall have communication interface with equipment and building systems having integral controls and having a communication interface for remote monitoring or control.
   b) Perform all steps necessary for integration. These steps may include:
      (1) Research and gathering effort to identify how to integrate each particular piece of equipment and identify the significance of each integrated point.
      (2) Trial and error troubleshooting time as required. May require time to contact equipment manufacturer's technical support.
      (3) Testing of interface. Disconnect communication bus and confirm that points do indeed display as "down". Confirm values are accurate by comparing with onboard equipment display screen. Test writable points and confirm written values are accepted by comparing with onboard equipment display screen and equipment operation.
      (4) Create a meaningful graphic screen displaying integrated points in a logical fashion with accompanying system schematic diagram.
      (5) Add trending and alarming as appropriate and/or as shown on point lists.
2. Integration with Existing SupervisorAx System, Supervisor Server:
   a) When expanding an existing DDC system and it is necessary to interface with an existing SupervisorAx system, Supervisor server, it is required to adhere to UCSC standards already in-place and to achieve integration.
   b) Expand existing Supervisor Server by adding all new controls matching the process utilized to integrate previous installations. Expanded system shall very much resemble existing DDC system, both in appearance and functionality. This includes; graphic layout, navigation, point override and setpoint capabilities, alarming, reporting and trending.
   c) Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system. Obtain approval from UCSC's control system representative before proceeding with installation.

B. CONTROL DEVICES FOR INSTALLATION BY OTHER INSTALLERS

1. Deliver selected control devices, to identified equipment and systems manufacturers for factory installation and to identify installers for field installation.
2. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
   a) Automatic control dampers
   b) Airflow sensors and switches
   c) Pressure sensors

3. Deliver the following control devices specified in indicated HVAC instrumentation and control device Section 23 09 00, to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
   a) Automatic control valves
   b) Pipe-mounted flow meters
   c) Pipe-mounted sensors, switches and transmitters.
   d) Tank-mounted sensors, switches and transmitters.

C. CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

1. When applicable as indicated on plans, deliver the following to manufacturer for factory installation. Include installation instructions to unit manufacturer.
   a) Programmable or application specific controller.
   b) Motorized damper actuators when not integral to controller or as applicable.
   c) Flow and pressure sensors, transmitters and transducers when not integral to controller or as applicable.
   d) Unit-mounted temperature sensors when applicable.
   e) Unit-mounted relays when applicable.

D. GENERAL INSTALLATION REQUIREMENTS

1. Install room sensors such that they are centered at 60 inches above finished floor A.F.F. unless mounting height is specifically called out on drawings.
2. Install products to satisfy more stringent of all requirements indicated.
3. Install products level, plumb, parallel, and perpendicular with building construction.
4. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.
5. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
6. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjustable adjacent condition.
7. Firestop penetrations made in fire-rated assemblies. Contact the University Representative for requirements for “Penetration Firestopping."
8. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 92 00 "Joint Sealants."
9. Fastening Hardware:
   a) Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
   b) Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   c) Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

10. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

E. SUPERVISOR SERVER CONFIGURATION

1. Perform all steps necessary to provide a fully functional supervisor server as specified earlier in this document. Steps to include, but not limited to: operating system configuration, supervisor software installation and licensing, site specific supervisor server software configuration, graphics, schedules, trends, alarms, scheduling, operator setup, etc.

F. LAN, ROUTER AND GATEWAY INSTALLATION

1. All LAN/WAN network equipment; including LAN drops near JACE controllers to be furnished and installed near JACE controllers by Client.
2. Install level two LAN network and network equipment if required for DDC system communication interface requirements indicated.
3. Test LAN and LAN equipment to verify that communication interface functions properly.
4. Locations of all requested LAN drops must be communicated in writing with locations clearly identified on floor plans. Allow at least two-weeks from time of request for LAN drops to be installed.
5. Provide a temporary LAN if required to keep pace with construction schedule. Permanent Client LAN drops may be delayed and it is not acceptable to delay any control work as a result of these delays. Temporary construction LAN may be abandoned and permanent Client LAN connected when available. Any necessary JACE reconfiguration must be included.

G. CONTROLLER INSTALLATION

1. Install controllers in enclosures to comply with indicated requirements.
2. Connect controllers to field power supply.
3. Install controller with latest version of applicable software and configure to execute requirements indicated.
4. Test and adjustable adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
5. Installation of Network Controllers:
    a) Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
    b) Install controllers in a protected location that is easily accessible by operators.
6. Installation of Programmable Application Controllers:
    a) Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
    b) Install controllers in a protected location that is easily accessible by operators.
    c) Top of controller shall be within 84 inches of finished floor.
7. Application-Specific Controllers:

a) Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.

b) For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

H. ENCLOSURES INSTALLATION

1. Attach wall-mounted enclosures to wall using galvanized steel struts in dry areas and stainless- steel struts in wet areas:
2. Align top of adjustable adjacent enclosures.

I. ELECTRIC POWER CONNECTIONS

1. Connect electrical power to DDC system products requiring electrical power connections.
2. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.
3. Comply with requirements for electrical power circuit breakers.
4. Comply with requirements for electrical power conductors and cables.
5. Comply with requirements for electrical power raceways and boxes.

J. IDENTIFICATION

1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification products and installation.
2. Where product is installed above ceiling, also install location identification on ceiling grid directly below. This includes all terminal units such as VAV boxes, fan coil units, etc.
3. Include identification on all DDC devices including; room sensors, duct sensors, pipe sensors, relays, power supplies, controllers, control dampers and controls valves.

K. NETWORK NAMING AND NUMBERING

1. Coordinate with Client to provide unique naming and addressing for networks and devices.

L. CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

1. Comply with NECA 1.
2. Comply with TIA 568-C.1.
3. Wiring Method:
   a) Install cables in raceways and cable trays. Conceal raceway and cables except in unfinished spaces.
      (1) Install plenum cable in environmental air spaces, including plenum ceilings.
      (2) Comply with requirements for cable trays specifications.
      (3) Comply with requirements for raceways and boxes specifications.
4. Wiring Method:
   a) Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
5. Field Wiring within Enclosures:
   a) Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

6. Conduit Installation:
   a) Install conduit expansion joints where conduit runs exceed 200 feet and where conduit crosses building expansion joints.
   b) Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
   c) Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
   d) Limit above-grade conduit runs to 100 feet without pull or junction box.
   e) Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
   f) Do not fasten conduits onto the bottom side of a metal deck roof.
   g) Flexible conduit is permitted only where flexibility and vibration control is required.
   h) Limit flexible conduit to 3 feet long.
   i) Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
   j) Direct bury conduits underground or install in concrete-encased duct bank where indicated.
      (1) Use rigid, nonmetallic, Schedule 80 PVC.
      (2) Provide a burial depth according to NFPA 70, but not less than 24 inches.
   k) Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
   l) Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
   m) Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
   n) Offset conduits where entering surface-mounted equipment.
   o) Seal conduit runs by sealing fittings to prevent the circulation of air for the following:
      (1) Conduit extending from interior to exterior of building.
      (2) Conduit extending into pressurized duct and equipment.
      (3) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
7. Wire and Cable Installation:
   a) Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
   b) Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 194 degrees F with no measurable effect on physical and electrical properties of cable.

(1) Provide shielding to prevent interference and distortion from adjustable adjacent cables and equipment.

c) Installation of Cable Routed Exposed under Raised Floors:

(1) Install plenum-rated cable only.

(2) Install cabling after the flooring system has been installed in raised floor areas.

(3) Coil cable 6 feet long not less than 12 inches in diameter below each feed point.

d) Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

e) Provide strain relief.

f) Terminate wiring in a junction box.

(1) Clamp cable over jacket in junction box.

(2) Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

g) Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.

h) Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.

i) Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

j) Wire and cable shall be continuous from terminal to terminal without splices.

k) Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.

l) Monitor cable pull tensions.

M. DDC SYSTEM I/O CHECKOUT PROCEDURES

1. Check instruments for proper location and accessibility.
2. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.
4. Control Damper Checkout:

a) For pneumatic dampers, verify that pressure gages are provided in each airline to damper actuator and positioner.

b) Verify that control dampers are installed correctly for flow direction.

c) Verify that proper blade alignment, either parallel or opposed, has been provided.

d) Verify that damper frame attachment is properly secured and sealed.

e) Verify that damper actuator and linkage attachment is secure.

f) Verify that actuator wiring is complete, enclosed and connected to correct power source.

g) Verify that damper blade travel is unobstructed.

h) Verify that any configurable switches on device are set properly.

5. Control Valve Checkout:

a) Verify that control valves are installed correctly for flow direction.

b) Verify that valve body attachment is properly secured and sealed.

c) Verify that valve actuator and linkage attachment is secure.

d) Verify that actuator wiring is complete, enclosed and connected to correct power source.

e) Verify that valve ball, disc or plug travel is unobstructed.

f) After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjustable adjust or replace packing to stop leaks. Replace the valve if leaks persist.

g) Verify that any configurable switches on device are set properly.

6. Instrument Checkout:

a) Verify that instrument is correctly installed for location, orientation, direction and operating clearances.

b) Verify that attachment is properly secured and sealed.

c) Verify that conduit connections are properly secured and sealed.

d) Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.

e) Inspect instrument tag against approved submittal.

f) For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.

g) For flow instruments, verify that recommended upstream and downstream distances have been maintained.

h) For temperature instruments:

(1) Verify sensing element type and proper material.

(2) Verify length and insertion.

i) Verify that any configurable switches on device are set properly

N. DDC SYSTEM I/O ADJUSTABLEUSTMENT, CALIBRATION AND TESTING:

1. Calibrate each instrument installed that is not factory calibrated and/or provided with calibration documentation. Calibrate according to instrument instruction manual supplied by manufacturer.

2. Provide traceable diagnostic and test equipment for calibration and adjustable adjustment.

3. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

4. Control Dampers:
   a) Stroke and adjustable adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   b) For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
5. Control Valves:
   a) Stroke and adjustable adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
   b) For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
6. Switches: Calibrate switches to make or break contact at set points indicated.

O. DDC SYSTEM CONTROLLER CHECKOUT

1. Verify power supply.
   a) Verify voltage, polarity, and protection.
   b) Verify that ground fault protection is installed.
   c) If applicable, verify that power conditioning units are installed.
2. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

P. DDC CONTROLLER I/O CONTROL LOOP TESTS

1. Test every control loop to verify operation is stable and accurate.

Q. COMMISSIONING, TESTING, AND ACCEPTANCE

1. The calibration and commissioning procedure shall consist of validating field I/O calibration, loop checks, actuator stroking, and integrated system operation validation. Document all commissioning information on commissioning data sheets, which shall be submitted to UCSC for approval prior to testing. Notify UCSC of the testing schedule so that operating personnel may observe calibration and commissioning.
2. Field I/O Calibration and Commissioning: Prior to system program commissioning, bring on- line each control device by:
   a) Performing a single point measurement validation of all analog devices.
   b) It is not acceptable to use an infrared non-contact thermometer to calibrate temperature sensors.
   c) Verifying instrument ranges.

d) Verifying and documenting binary switch settings.

e) Verifying and documenting actuator operating ranges.

f) Verifying and documenting fail-safe position on loss of control signal.

g) Submit calibration data sheets. Data sheets shall include the device designation, the date of calibration and the name of person who performed calibration.

3. Loop checks: Perform test of every control device with UCSC personnel.

4. System Program Commissioning: After control devices have been calibrated and loop control verified, each program shall be put on-line and commissioned. UCSC shall confirm that the program logic follows the approved software flow chart and sequence of operation. Each control loop shall be adjusted to provide stable control within the specified accuracies.

5. Point to Point Installation Verification Procedure to consist of the following (as a minimum):

a) Documentation - An Excel spreadsheet listing all I/O in the system including point name, address, Controller ID#, analog range or digital normal state, engineering units. Provide one signature block per page for BAS Contractor's representative and UCSC's BAS Department Representative to accept the test results.

b) Digital Inputs: Jumper or open the wires at the device and verify change of state at controller and/or GUI. Record results on spreadsheet.

c) Analog Inputs: Lift wire at device to see change of state and record default value on spreadsheet.

d) Digital/Analog Outputs: Command the field device from the controller and verify corresponding change of state at the field device. Record results on spreadsheet.

6. Functional Testing and Sequence of Operation Verification Procedures to consist of the following (as a minimum):

a) Control Loop Tuning:

(1) Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop as part of the O&M package. Except from a startup, maximum allowable variance from set point for controlled variables under normal load fluctuations shall be as follows for general space conditioning applications. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, tolerances shall be maintained:

(i) Duct air temperature: ± 1^{O}F.

(ii) Space Temperature: ± 2^{O}F.

(iii) Chilled Water: ± 1^{O}F.

(iv) Hot water temperature: ± 3^{O}F.

(v) Duct pressure: ± 0.25" w.c.

(vi) Water pressure: ± 1 psid.

(vii) Duct or space Humidity: ± 5%.

(viii) Air flow control: ± 5% of setpoint velocity.

(2) Where the same mechanical system is installed in multiple locations, one system must be tuned and the same tuning parameters may be used in other controllers.

(3) Tuning constants shall be set so that continuous oscillation of actuators does not occur. A steady state shall be achievable.

(4) When floating (3-point, incremental) control is used for VAV control, continual pulsing of actuator against end stops (end stop fickle) shall not occur when box is full open or closed.

(5) Trend logging or other graphical proof of loop tuning stability shall be submitted.

(6) Actuator movement shall not occur before the effects of previous movement have had sufficient time (minimum one time constant) to have affected the sensor.

(7) A detailed sequence of operation is provided for each system, including instructions for testing the sequence.

(8) A checkout form is provided for each system/sequence. Checkout form is to include areas to check and record each facet of the sequence of operations including, but not limited to the following:

- (i) Start/Stop
- (ii) Interlocks
- (iii) Safeties
- (iv) Valve and damper stroke
- (v) PID Loops
- (vi) Modes of Operation
- (vii) Power failure/Recovery

(9) Checkout form is intended to be a functions (yes/no/comment) test form.

7. 72 Hour test Procedures to consist of the following (as a minimum):
   - a) Place Entire System in Automatic Operation.
   - b) Generate Trends and Trend Logs of all I/O as directed by UCSC's Representative.
   - c) Review Trend Logs with UCSC's Representative to ensure system is controlling properly and that control loops do not exhibit excessive oscillation.
   - d) UCSC's Representative shall have the right to change set points and verify that system responds properly.
   - e) Repair any deficiencies found during 72 Hour test.
   - f) Re-Execute 72 Hour Test until no deficiencies are found.

R. PROTECTION

1. Protect installation against and be liable for damage to work and to material caused by Contractor's work or employees.
2. Maintain protection for work and equipment until inspected, tested, and accepted.
3. Protect material not immediately installed.
4. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.
5. Material sensitive to temperature, dust, humidity, or other elements found unprotected shall be replaced.

6. Material showing signs of exposure shall be replaced.

END OF SECTION