SECTION 23 09 00
BUILDING AUTOMATION SYSTEM DESIGN & CONSTRUCTION STANDARDS

1. GENERAL:

1.1 SUMMARY:

A. This specification outlines the specific requirements for the building automation system (BAS).

B. (BAS) engineering design criteria are determined by the specific application requirements, by related requirements of the Brown University Design and Construction Guidelines, by this document, and in meetings with the Brown Project Manager and FM Operations & Engineering staff.

C. Utility metering (electrical and thermal) is part of the Campus Central Metering System, which is not a part of the BAS.

D. Related Sections:

1. Section 01 13 01 – Design Guidelines for Sustainability
2. Section 01 70 10 - MEPFPS Identification & Labeling
3. Sections 13 00 01 – General Laboratory Design Standards, 13 00 02 Vivaria Facility Requirements, and Section 13 00 23 Laboratory HVAC Design Requirements
4. Section 23 00 10 – HVAC Design Criteria
5. Section 23 05 23 – HVAC&R Valves
6. Section 23 09 01 – Building Automation System Naming Conventions
7. Section 23 09 02 – Building Automation System Alarm Extensions
8. Section 26 05 33 – Raceway and Boxes
9. Section 26 09 01 - Campus Central Metering System Design Criteria
10. Section 26 29 10 – Variable Speed Drives

1.2 PROJECT DESIGN AND SUBMITTAL REQUIREMENTS:

A. DESIGN PHASE: The project design professional (Engineer of Record) shall provide an Operational Narrative on the proposed Sequences of Operation for the new BAS system by the 60% or Design Development submittal.

B. Detailed, written sequences of operation for the BAS system, based on the Design Development Operational Narratives, shall be provided in the final Design Documents.

C. Sequences shall be provided on the project drawings. Specification-based sequences are NOT acceptable.

D. These detailed sequences shall provide at a minimum:

1. Sequences in all modes of normal operation: on, off, occupied, unoccupied, warm-up, cool-down, summer, winter, economizer, etc.
2. Organization into logical groupings including run/stop, pressure, economizer, coils, discharge air, humidification, dehumidification, hydronic temperature, etc.
3. Fire/smoke control system interfaces and sequences.
4. Schedule of operation.
5. Details of system operation for abnormal conditions, such as during and after a power outage or fire alarm event. Include details such that a loss of status associated with power outages are not indicated as failures with a subsequent alarm.
6. Specific direction on failure scenarios for loss of signal and all safety device trips.
7. Setpoints, trip points, and ranges. Initially these shall be the designer's intent and eventually be the actual settings at the time of as-built submittal.
8. Communications protocol and available points list for BAS interface for large unitary equipment such as chiller control panels.
9. Where renovations to existing BAS sequences are required, the required revisions shall be clearly identified for all modes of operation.

E. Construction Phase: The BAS controls contractor shall provide fully developed Control Drawings based upon the operational sequences developed by the project Engineer of Record. Drawings shall be developed in Microsoft Visio. These control drawings shall include at a minimum:

1. A network riser diagram indicating supervisory controllers and relative addressing as well as field controllers, interconnections to packaged equipment control systems and respective network wiring.
2. Schematic diagrams of all systems controlled or connected to the automation system in the format of the final graphical interface.
3. Schematic diagrams of all electrical interface connections indicating device, voltage, and any relevant terminal numbers.
4. A bill of material indicating for each component part furnished by contract or interfaced to and furnished by others:
5. A narrative Sequence of Operation indicating: the operational timeline of the respective system, including all initial set points and the adjustability of same, as well as details of system operation for abnormal conditions, such as during

and after a power outage.

6. Detailed equipment and software data sheets.
7. Valve and damper schedules with all control parameters listed.
8. As applicable for the project, a schedule of rooms served by VAV boxes including:
    a. Room name and/or number; relative to thermostat location.
    b. The parent air handler unit.
    c. Supervisory controller and field bus ID.
    d. Relative mechanical drawing number.
    e. Hardware address.
    f. Associated equipment including sensors, reheat coils and radiation.
    g. Box size, inlet area, K factor, and all relative flow set points.

F. Turnover Phase:

1. Provide all software and hardware required to operationally program, control, maintain, balance, diagnose and replace any and all components installed. Include licensing information and serial numbers as well as installation compact disks.
2. Furnish all final control programs.
3. For projects that are renovations of existing systems and affect a portion of the building controls, the controls contractor shall furnish as-built shop drawings of project work that are consistent with existing drawings, including compatible page numbers, a revised table of contents and revised schedules.
4. Operations and Maintenance (O&M) Manuals shall include a digital copy download with complete as-built control drawings in Microsoft Visio format.
5. All software and hardware required to install, operate and maintain all components of the installed system shall be turned over to the Owner including, but not limited to, all software licenses, all operating programs, recovery programs, system backups and field controller programs.
6. As-built control drawings shall include as-built control setpoints.
7. As-built control drawings shall include the actual location of any remote sensors for the system (i.e. air and water side differential pressure sensors). i.e. markup on floor plan drawing or specific room numbers/locations.
8. As-Built control drawings shall include a list of BACnet device identifiers for all supervisory and field devices installed as part of the project.
9. The Engineer of Record shall review these as-builts.
10. The final as-built control drawings and operational sequences shall be submitted prior to training.

1.3 Automation Contractor Requirements:

A. The BAS manufacturer shall authorize the BAS contractor to design, install, and service the specified equipment.

B. Any deviation from these specifications shall require the contractor to obtain an approved waiver from the Applications Engineering department.

C. The BAS contractor shall have installed networked building automation systems for at least five years.

D. The BAS contractor shall have an office within a seventy-five-mile radius of the installation site.

E. The BAS contractor shall demonstrate their ability to respond to an emergency repair service inclusive of 24 hours/day, seven days a week, for the specified warranty period. Third-party service or service during specific hours or days is not acceptable.

F. The BAS contractor shall be staffed with personnel capable of performing troubleshooting and correction to all levels of installation and programming-related issues.

G. The BAS contractor shall have personnel dedicated to application engineering and software generation.

1.4 BAS Submittal Requirements:

A. Control Drawings:

1. The contractor shall provide fully developed control drawings based on the installed equipment and operational control sequences developed by the engineer of record. This includes sequences for all third-party self-contained equipment.
2. All control drawings shall be developed in Microsoft Visio.
3. All submittal packages shall be provided in Adobe PDF format. Original Microsoft Visio drawings shall be turned over to the University as part of the O&M deliverables.
4. The control drawings shall include, at a minimum, the following:
    a. A communications riser and a detailed system architecture overview outlining all controller locations, including third-party devices.
    b. A terminal unit room schedule that contains the equipment name, room thermostat location served by equipment, controller address, minimum/maximum airflow setpoints, box size, area, and k-factor.
    c. Detailed electrical wiring schematics for all hardware and sensors, which includes the voltage and relevant controller terminations.

d. Valve and/or damper schedules with all parameters listed, including sizes, CV ratings, close-off pressures, etc.
e. Additional items denoted in paragraph 1.2 E and F above.

B. Control Narratives:

1. The contractor shall provide an operational narrative on the proposed sequence of operations no later than the sixty-percent design phase. The narrative shall provide, at a minimum, the following:

a. Proposed sequence of operations for all modes: occupied, unoccupied, heating, cooling, summer, winter, economizer, etc., organized into logical sections.
b. Fire/smoke control system interfaces (if applicable).
c. Detailed operations for all emergency/abnormal operation scenarios, such as safety device activations, power loss, and sensor failures.
d. Valve and/or damper positions during emergency/abnormal conditions.
e. Initial setpoint values, safety device trip points, and sensor ranges.

1.5 General BAS Requirements:

A. BACnet Requirements:

1. All supervisory network-level controls shall be BACnet/IP and BACnet/SC compatible.
2. All supervisory network-level controls shall be capable of directly connecting to the Johnson Controls ADX server. Custom programming and/or integration of supervisory network-level controllers is prohibited, regardless of waiver approval.
3. Any controllers or devices connected to the University LAN shall be capable of Gigabit speeds natively.
4. All field controllers shall be capable of communicating with BACnet MS/TP.
5. Third-party (non-JCI) BACnet MS/TP controllers shall be installed on their own communication network segment to the supervisory controller.
6. Variable frequency drives shall not be connected to the BAS system via BACnet.
7. Only Johnson Controls-approved and supported BACnet routers shall be installed with the BAS architecture.
8. A secondary local LAN on the supervisory controller is only allowed for third-party BACnet/IP integrations. The network adapter shall be approved and supported by Johnson Controls.
9. The University's Application Engineering department shall provide the following information to the controls contractor:

a. Network-level supervisor controller name.
b. Network addressing for all network-connected devices.
c. Network-level supervisory controller BACnet ID's (OID).

10. Refer to Building Automation BACnet Standards - 23 09 03 for more detailed information.

B. BAS User Interface:

1. The Johnson Controls Metasys User Interface (MUI) shall provide the primary user interface for all projects, new construction, renovations, and expansions.
2. At a minimum, the MUI shall contain the following:
    a. All spaces and equipment are defined for the navigation and operation of the system.
    b. Controller relationships between systems (AHU serving terminal equipment as an example).
    c. Equipment shall be mapped so that the MUI's equipment summary can display similar equipment for each space as an overview, such as when viewing a floor.
    d. Equipment templates and graphics shall be saved using the same building or property name prefix defined in 'Brown University's Active Building List.' (example: ANDREWSMEM_AHU1).
    e. The Application Engineering department shall approve all file naming conventions in advance.
    f. Before the initial MUI deployment, the contractor shall schedule and host a meeting with the Application Engineering team to approve the configuration.

C. BAS Color Graphical Interfaces:

1. The color graphics shall be provided in the MUI.
2. For each system, equipment, or floor plan, the color graphic shall contain all necessary points required for the complete operation of the system or space.
3. Each building shall have a dedicated dashboard with links to all major equipment and floors.
4. The graphic shall be capable of displaying override values, high/low, and warning of alarm values using discrete colors.

D. BAS Historical Trend Data:

1. At a minimum, all hardware point types (AI, AO, BI, BO), setpoints (actual or calculated), and states/modes with each system or piece of equipment shall be trended.
2. Analog values shall be trended at an interval of ten minutes, while binary and multi-state values shall be trended on a change of value (COV).

3. Refer to the standard Building Automation Historical Data - Trending (23 09 04) for more information.

E. SHARED DATA POINTS:

1. BAS system design for individual buildings shall be as a true standalone facility.
2. Critical systems shall be configured to default to a sensor in the same Ethernet subnet on loss of network for reliability. Default to a failsafe value for shared data points upon loss of communication or lack of an appropriate substitute sensor.

2. Automation Products:

A. Equipment shall not be supplied with manufacturer-furnished controls, except for chillers. All controls shall be provided by the approved Brown University BAS vendor.

B. BAS controllers provided for air handlers and heating/cooling systems shall have an integral display with all relative points listed as read only.

C. Automation Controllers:

1. Supervisory controllers with more than one hardwired communications trunk are prohibited unless the Application Engineering department has approved a submitted waiver.
2. All new construction and renovated buildings shall have a minimum of one supervisory web-interfaced BAS controller, reporting to the respective BAS supervisory server. Smaller renovations may utilize existing BAS capacity within 75% of any manufacturer specified controller limit.
3. All supervisory controllers shall utilize BACnet IP over Ethernet communications.
4. All controls shall be networked Direct Digital Controls (DDC).
5. The university prefers Johnson Controls Metasys controllers and software.
6. Johnson Controls Facility Explorer products are prohibited.
7. The primary automation controller communication means shall be BACnet MS/TP.
8. Field controllers installed on air handling units (AHUs) or hot/chilled water systems shall have an integral display.
9. All major HVAC equipment shall have a native Johnson Controls fourth generation minimum (CGM, FAC, CVM) controller installed as the primary controller. Deviations from this standard will require a waiver submission and approval by the FM Application Engineering department.
10. All automation controllers shall be capable of resuming normal operations

following a power loss.

D. Automation Software / Software Revisions:

1. For server-side software, Johnson Controls Metasys is required.
2. The Johnson Controls Controller Configuration Tool (CCT) is required for field controller programming. Note: Johnson Controls Programmable Controller Tool (PCT) is prohibited regardless of waiver approval.
3. For all projects, new construction, or renovations, the contractor shall ensure that all supervisory and field controls are upgraded to the latest version of the manufacturer's firmware compatible with the current BAS system in operation at the University.

3. BAS Control Sequences:

3.1 General:

A. Control loops on major HVAC equipment shall be manually tuned.

B. All systems shall restart automatically when equipment safety devices are reset to the safe state.

C. Equipment configured in the lead/lag fashion shall be automatically rotated weekly. Equipment rotations will occur between 10 AM and 1 PM on Tuesday, Wednesday, or Thursday. All variables are to be adjustable at the BAS.

3.2 Control Interlocks:

A. All equipment with Hand- Off- Automatic switches shall operate in the Hand state regardless of the state of the BAS system.

B. All interlocks intended to: prevent injury, avoid damage to equipment, or required for Life safety (i.e. Fire alarm shutdown) shall be hardwired and shall operate in both Hand and Automatic positions.

C. For air handling equipment, if sudden closure of dampers could cause pressure to develop in excess of ductwork system design pressure, provide low and high static switches where appropriate.

3.3 Chillers:

A. Chillers shall be programmed to stage up/down based on their load (%FLA). Chilled water pressures and/or temperatures shall only be utilized as a secondary staging measure.

3.4 Air Handling Units:

A. Airside economizer shall be enabled whenever the outdoor air enthalpy is less than

25 Btu/lb and disabled whenever the outdoor air dry-bulb is greater than 70 degrees Fahrenheit. A network input point shall also be available to disable the economizer.

B. For AHU units performing zone control, the heating and/or cooling devices shall be controlled by utilizing a discharge air reset from zone control strategy. For staged heating or cooling devices, control from zone temperature is acceptable.

C. Humidification:

1. Furnish a discharge air humidity sensor, which will function as the high limit alarm and reset the discharge air humidity control.
2. Humidification control sequencing shall utilize a space, exhaust, or return air humidity sensor to reset the discharge air humidity setpoint. The humidification output shall be modulated to maintain the calculated discharge air setpoint.
3. In scenarios with multiple duct humidity sensors (i.e., humidifier sensor and BAS sensor), the sensor(s) must be calibrated to each other using a certified meter.
4. The humidification system shall utilize a hardwired airflow proving switch.
5. No stand-alone humidification devices are allowed.

3.5 Terminal Airside Units – General:

A. Any terminal airside unit that uses a modulating heating device (hydronic, SRC) shall utilize discharge air reset from zone temperature control. Standard zone control is acceptable if the unit uses a staged heating device.

3.6 Terminal Airside Units – VAVs:

A. All supply/exhaust VAVs shall be programmed such that there is a damper trouble alarm programmed into the controller. The damper trouble shall be shunted whenever the VAV is in either the shutdown or unoccupied modes.

B. All supply VAVs (with reheat) shall be programmed with the Application Engineering standard valve leak alarm (available upon request).

C. All supply VAVs shall be programmed to provide a pressure request for the parent AHU to utilize duct static trim and respond (G36).

D. All supply VAVs shall be programmed to provide a heating and cooling request for the parent AHU to utilize discharge air trim and respond (G36).

3.7 Chilled Beam Control:

A. A pipe-mounted condensation sensor shall be installed for a chilled beam installation in spaces with operable windows. Control logic shall disable the cooling output device and annunciate at the BAS when in alarm.

3.8 Occupancy Sensors:

A. If overall occupied/unoccupied control is not appropriate for the project, provide a setback of temperature and ventilation through space occupancy sensors.

B. Utilize lighting occupancy sensors for respective areas, where available to avoid having duplicate sensors installed in the same space.

C. Hardwired occupancy sensors are preferred over third-party networked sensors.

3.9 Environmental Sensors:

A. Global data sharing of the outdoor air temperature and humidity is required for any control sequences that require these values. Local equipment environmental sensors shall not be used for these purposes.

B. The Global Data object shall use the sensor(s) from Sidney Frank Life Sciences Building (LSB) as the Manager and the sensor(s) from Watson Center for Information Tech (CIT) as the Alternate Manager.

C. Do not utilize outdoor CO2 (carbon dioxide) sensors; utilize a fixed reference value of 400PPM.

D. Do not locate room thermostats on exterior walls, in a direct sightline of sunlight, or in a location directly influenced by airflow (from diffuser as example).

3.10 Hydronic Pumps:

A. All pumps shall be programmed in a standard lead/lag fashion.

B. Each pump shall be programmed with a ‘maintenance’ point to remove it from the normal rotation cycle if needed.

C. Pump rotation shall be weekly and be based on runtime hours.

D. Upon a lead pump failure, it shall be locked out of the rotation, and a lag pump shall start.

E. Should all pumps fail, they should all be commanded on. A software reset in the BAS is required to resume normal operations. An interlock shall be created in the supervisory controller so the reset point cannot be left in the ‘reset’ state.

4. BAS Design Requirements:

4.1 Miscellaneous BAS Design Requirements:

A. Life-safety systems, including smoke control, shall be hard-wired directly to the equipment controllers of the building fire alarm system only and shall operate independently of the BAS system.

B. Field controllers and components used for Animal Care Research areas, and other research labs with limited access, shall be located outside of the area served (utility corridor) so they can be accessed without entering the critical space(s).

C. Controls for unit heaters shall be connected to the BAS to allow them to be disabled during the cooling season.

D. BAS control of fractional (⅓ or less) horsepower exhaust fan motors is not required.

E. Fan coil-type units shall be furnished with the BAS vendor controls/valves installed, not those of the equipment manufacturer.

F. Chillers shall have manufacturer-supplied and installed proof-of-flow switches on the chilled and condenser water inlet piping.

G. Automation hardware shall not be downgraded to be backward compatible with the N2 communications protocol. For instances where N2 devices are installed, the contractor shall install the necessary hardware/software for all new hardware to support BACnet MS/TP communications.

H. Wireless controllers and thermostats are prohibited unless the Application Engineering department approves a waiver submitted by the contractor.

I. The capacity of any field controller shall be at most seventy-five percent of the manufacturer's rated specification. This included its memory, CPU, device, and object count.

J. Field controllers shall be engineered for an additional twenty-five percent capacity for future use.

K. Thermostat sensors installed in shared or public spaces shall be non-adjustable. Smart sensors located in these spaces shall be password protected and only display the current zone temperature at its display.

L. Thermostat sensors in private offices, conference rooms, and classrooms shall be configured to allow occupant adjustment between 70-74 degrees Fahrenheit.

M. All variable air volume systems must have a discharge air temperature sensor.

N. Any equipment with a hydronic coil shall have a discharge air temperature sensor.

O. All input and output signals shall utilize discrete wiring.

P. All specialty sensors (CO, CO2, O2, refrigeration, etc.) shall be a preferred 0-10vdc or 4-20ma signal input to the BAS controller.

Q. Sensors for heating, cooling, or low-limit control shall be averaging-type sensors.

R. Heat recovery, preheat, cooling, and reheat coils shall have an individual averaging temperature sensor installed when possible.

4.2 Application-Specific BAS Design Requirements:

A. Energy Conservation Measures:

1. Refer to section 01 13 01 Design Guidelines for Sustainability for related design requirements.

B. Smoke Shutdown & Life Safety:

1. The building automation system shall not be used for any smoke control or life safety control. The building automation system is for monitoring only.

C. Standby/Emergency Power:

1. In all buildings where standby generator power is available, all BAS controllers and devices shall be connected to the standby power system.
2. Uninterruptible Power Supply (UPS) is not required for BAS control panels except in specific cases as directed by FM Operations staff.

D. Variable Frequency Drives (VFDs):

1. Each variable frequency drive shall have the following BAS connections:
   a. A hardwired signal for drive modulation.
   b. A hardwired start/stop signal.
   c. A hardwired status device.
   d. A hardwired VFD failure signal.
   e. Note: these devices shall not be connected to the MS/TP network.

E. All Heat Exchangers (Excluding High Temperature):

1. Heat exchangers require four temperature sensors for BAS temperature monitoring (inlet and outlet of both supply side and load side fluids.
2. All heat exchangers shall have differential pressure sensors installed on inlet and outlet pipes for monitoring and alarming of pressures on the BAS.
3. Any flow switch device shall be installed in a serviceable location that does not require draining the entire building loop/riser for service.

F. High-temperature hot water heat exchangers:

1. Heat exchangers require four temperature sensors for BAS temperature monitoring (inlet and outlet of both supply side and load side fluids).
2. All heat exchangers shall have differential pressure sensors installed on inlet and outlet pipes for monitoring and alarming of pressures on the BAS.
3. Each high-temperature hot water heat exchanger shall have a manual reset high-temperature limit immersion sensor installed into the shell or downstream discharge header.
4. The high-limit safety device shall have dual contacts that trip simultaneously on

an alarm condition. One set of contacts shall be connected to the BAS controller, and the other shall disconnect the isolation and/or control valve(s) power supply.

5. Control programming shall include proof of flow (pump flow/flow switch) interlocking such that the control valve(s) shall be closed without proof of flow.
6. Any flow switch device shall be installed in a serviceable location that does not require draining the entire building loop/riser for service.

G. Air Handling Unit Air Filters:

1. Each air filter bank equal to or exceeding 4,000 cubic feet per minute (CFM) shall have an analog differential pressure transducer installed across each filter bank. Provide separate differential pressure transducers across prefilters, main filters and final filter banks.
2. The contractor shall calibrate the sensor upon the initial filter change and ensure the BAS alarm is defined correctly.

H. Air-to-Air Heat Exchangers:

1. Air-to-air heat exchangers or energy recovery ventilators of 4,000 cfm and over require four temperature sensors for BAS temperature monitoring (inlet and outlet of both process and regeneration air) and an analog pressure transducer on each air pathway (one required for each rotary heat exchanger; two required for each flat plate or heat pipe).
2. Each air filter bank equal to or exceeding 4,000 cubic feet per minute (CFM) shall have an analog differential pressure transducer installed across each filter bank. Provide separate differential pressure transducers across prefilters, main filters and final filter banks.

I. Additional BAS Monitoring Points:

1. The following building monitoring points shall be connected to the BAS (where applicable):
   a. Generator run status.
   b. Automatic transfer switch status (Normal – Emergency) (discrete for each switch).
   c. Sewage ejector pump high-level and failure alarms.
   d. Dewatering sump high-level and failure alarms.
   e. Fire pump ‘run’ status.
   f. Fire alarm system ‘trouble’ and ‘alarm’ status.
   g. Fire and Smoke damper position status.
   h. Laboratory space differential pressure sensors and alarms.
   i. Laboratory occupancy status.
   j. Laboratory oxygen deprivation and hazardous gas detection systems and alarms.

k. Refrigerant leak detection systems and alarms.

2. For steam boilers exceeding 1MMBH:
   a. Run/Off status.
   b. Low water level alarms.
   c. High water level alarms.
   d. High Steam Pressure Alarm
   e. Common Boiler Alarm (if provided)
   f. Analog steam pressure (may be common for multi-boiler installations).
   g. Analog boiler flue temperature sensor.
3. For hot water boilers exceeding 1MMBH:
   a. Run/off status.
   b. Low water level alarms.
   c. Common boiler alarm (if provided) .
   d. Analog leaving water temperature.
   e. Analog entering water temperature.
   f. Analog remote setpoint control.
   g. Analog boiler flue temperature sensor.

J. Safety Devices:

1. All safety devices shall be wired in series with control voltage so that upon a trip, devices will fail safe.
2. All safety devices, specific to the equipment on the BAS, shall be manual reset type.
3. Where required, safety devices shall be provided with dual contacts: one contact for BAS monitoring and one contact for the safety circuit. These devices shall be simultaneous trip.
4. Safety devices, excluding coil protection devices (i.e., freeze-stat), shall be mounted in the respective equipment field panel in an easy to reach location (i.e. no ladder required).
5. Coil protection devices (i.e., freeze-stat) shall be installed after the preheat coil and before any cooling coil, glycol, or otherwise.
6. Air handling units that could be damaged from the sudden closure of dampers shall have manual reset duct static safeties installed as needed.
7. Duct static safeties shall be two-pole simultaneous trip. Sequential trip devices shall be prohibited.
8. No safety devices shall be installed/mounted where the reset would require entering an operational unit.

4.3. Fume Hood Controls & Air Valves:

A. Laboratory HVAC airflow controls, fume hood and ventilated device controls and alarms shall be integrated into the BAS (BACnet MS/TP preferred). BAS information shall include graphic displays, trend data and alarms for each lab space,

B. Laboratory HVAC airflow controls, fume hood and ventilated device controls, alarms and status points shall be grouped into individual room graphic displays depicting all relevant room devices, operating and alarm parameters that are installed in the room. HVAC data shall include setpoint and actual values for airflow, temperature, air pressure, differential pressure and humidity as required for the monitored space conditions and use. Device status points shall include control valve and VAV settings, alarm status, room occupied and space status inputs. Refer to figures 4.3.1 and 4.3.2 below for examples.

C. Refer to Section 13 00 23 – Laboratory HVAC Design Criteria for additional fume hood lab HVAC Controls interface requirements.

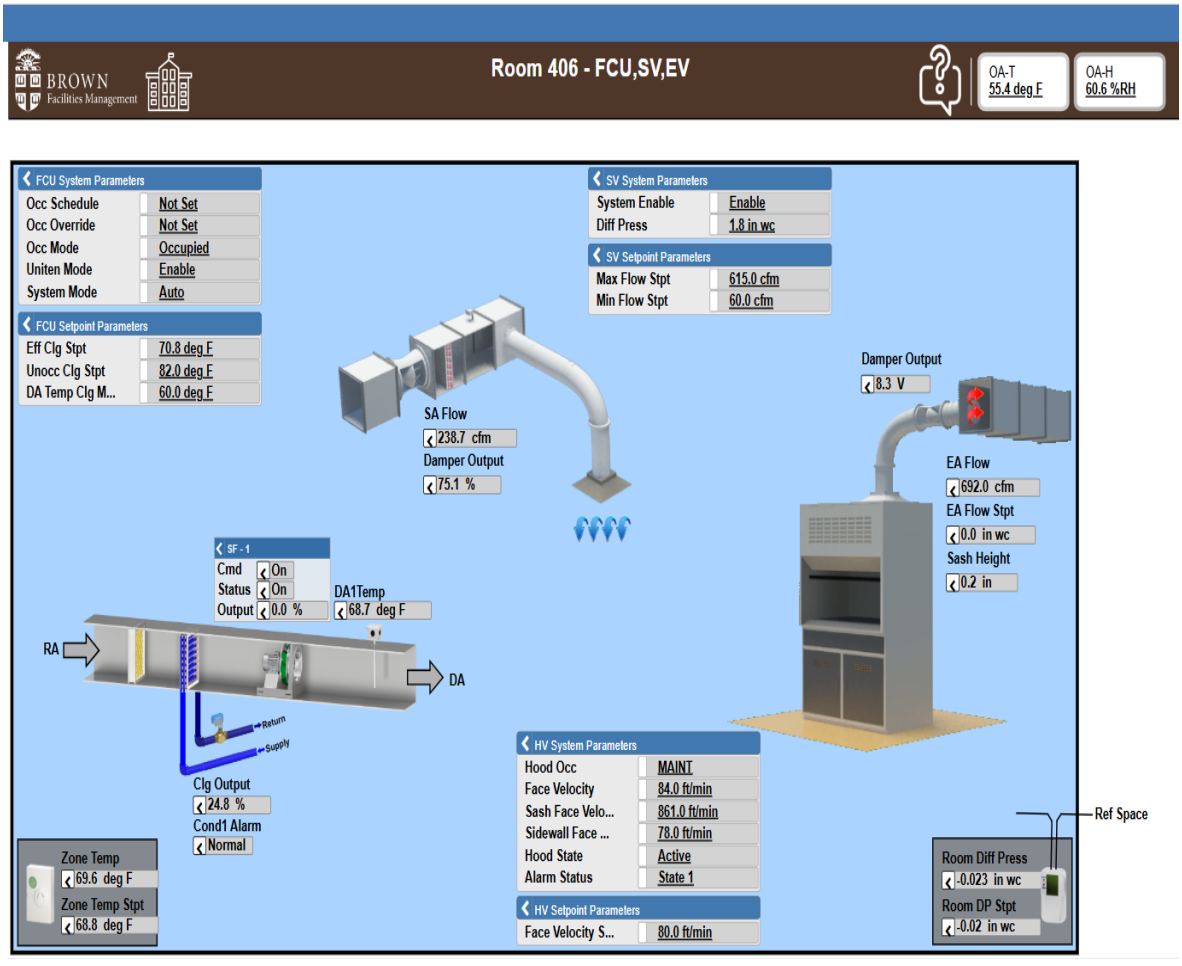

Figure 4.3.1 – Typical Small Lab BAS Graphic

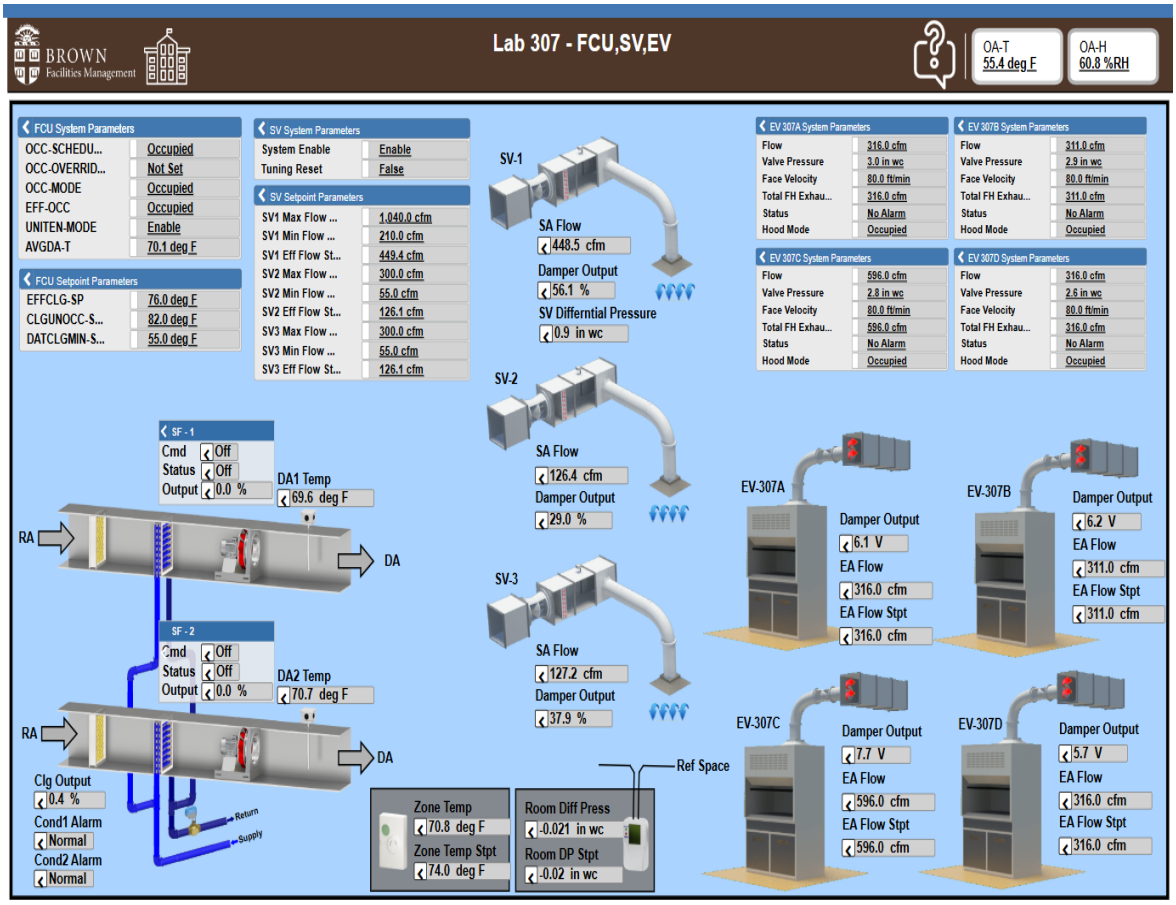

Figure 4.3.2 – Typical Large Lab BAS Graphic

5. Pneumatic Controls:

A. Avoid the use of pneumatic controls on new projects whenever other types of controls are available to perform satisfactorily and safely. Pneumatic controls as described herein are only for new controls to be installed with locations that already utilize pneumatic controls.

B. Do not install pneumatic controls outside or in other unheated locations. Use electric actuators wherever control equipment may be exposed to sub-freezing weather.

C. Air compressors shall be duplex type, using synthetic oil or oil free type, each adequately sized to handle 100% of the anticipated peak load, with compressor alternating controls to assure equal run time, and an accumulator tank sized for the application. Provide tank with an automatic condensate drain piped to the floor drain. Compressors shall be sized for maximum 30-40% run time. Tanks shall be sized to provide a minimum of 30 minutes of operation in event of a power failure.

D. Connect pneumatic compressors and controls to a Standby electrical power source when it is available in a building. Equip pneumatic control systems with an automatic refrigeration air dryer, a compressed air prefilter, and an oil coalescing filter installed

in the system's supply line to ensure dry and clean control air.

E. Provide combination-type air pressure-reducing stations with integral isolation and relief valves on each main branch from the air supply header.

F. Provide ball-type isolation valves to allow for the ready isolation of each major system component for servicing, as well as at each branch connection to a control device.

G. Pneumatic tubing:

1. All pneumatic piping shall be concealed except in mechanical rooms or areas where other piping is exposed.
2. Pneumatic tubing shall be minimum ¼" hard or soft-drawn copper except as specifically described to the contrary below. All tubing shall run parallel to the building lines. Only tool-made bends are acceptable.
3. Fittings for copper tubing shall be hard drawn brass or copper solder joint type except at connections to apparatus, where brass compression or barbed typed fittings shall be used.
4. All pneumatic tubing shall be routed to within a maximum of 18" of each control actuator.
5. At actuators, use poly tubing and associated fittings for final air connections.
6. Polyethylene tubing is an acceptable alternative to copper tubing when installed as follows:
    a. Tubing shall be rated for a minimum of 90 PSIG.
    b. Tubing shall be run within EMT electrical conduit where run exposed in mechanical and equipment rooms, to within 18" of the actuator and control devices.
    c. Tubing shall also be run in conduit where run concealed behind finished walls (to reduce the risk of damage due to nails and screws).
7. All tubing shall be tested for leaks during installation and all tubing shall be blown out to purge installation impurities and moisture before connections to the control instrument. The entire piping system shall be tested by placing it under 60psig pressure for 24 hours. The pressure drop during this period shall not exceed 2 psig.

6. Products:

6.1 Control Valves:

A. Control Valves shall have design pressure and close-off ratings that exceed the maximum operating pressure for the equipment and system they are installed on.

B. Control Valves shall be mechanically fit with isolation valves and a union or flange on each connection point.

C. Steam and high-temperature hot water valves shall be normally closed.

D. All self-contained thermostatically controlled valves for hot water radiators shall be Macon or Danfoss fail-closed/minimum flow.

E. For terminal equipment valves up to 2", the following are acceptable:

1. Characterized ball valve with a stainless-steel ball, stem, and trim.
2. Globe valves with a bronze body, stainless steel stem, and plug.

F. Refer to Section 23 05 23 – HVAC&R Valves, for additional requirements.

6.2 Control Dampers:

A. All control dampers shall include air seals.

B. The outdoor, isolation, and exhaust leakage shall not exceed the guidelines outlined in the AMCA 500D standard.

C. Installed linkages shall be non-binding and non-interfering across their entire travel.

D. Linkage shall not be attached to any damper blades.

E. Provide parallel blade dampers for any two-position applications.

F. Provide opposed blade dampers for modulating applications.

G. The following manufacturers are acceptable:

1. Johnson Controls
2. Ruskin
3. Greenheck
4. TAMCO

6.3 Valve and Damper Actuators:

A. The preferred vendors for small electric actuators are Belimo or Johnson Controls.

B. Belimo actuators are required for critical control/care applications in harsh environments, such as animal care, MRI facilities, and within mechanical rooms.

C. The preferred vendor for larger electric valves is Bray. Bray valves shall be classified as a high-performance type. Valve operators shall be powered by 120vac and operated with low voltage control signals. Bray actuators shall include a hand-wheel override feature.

D. All actuators shall have a minimum of a three-year manufacturer's warranty.

E. Install valve actuators such that the position indicator is visible from the ground

without needing a ladder, while following the manufacturer's installation guidelines.

F. Actuators on all steam and high-temperature hot water control valves shall be electric with a manual override feature.

G. Actuators shall have a mechanical spring-return fail-safe mechanism integral to the device. The fail-safe position shall be based on the system design requirements.

H. In non-critical applications, actuators for supplemental heating and reheat coil valves may fail in place.

I. Actuators shall be spring-closed for supplemental heating and reheat coil valves in critical applications or locations (i.e., animal care, data centers, research laboratories, MRI).

6.4 Safety Devices:

A. Preferred installation of safety devices to the parent controller is to use a multi-functional logic circuit board (as example: Functional Devices RIBMNLB-x)

B. Where required, safety devices shall be provided with dual contacts: one contact for BAS monitoring and one contact for the safety circuit.

C. Relays for hydronic heating devices (i.e. boiler, HW pump) shall be wired to the normally closed contact.

6.5 Temperature Sensors:

A. The following is preferred when selecting temperature control sensors:

1. Averaging, bulb, and hydronic well sensors shall be Johnson Controls 1k ohm platinum.
2. Air handling equipment shall have an averaging sensor installed after each coil. Averaging sensors are mandatory for the equipment controller sensor (i.e. discharge air) and shall be sized appropriately for the duct in which it is installed in.
3. Hydronic well sensors shall be installed with thermally conductive paste.
4. Room temperature sensors shall be installed with a manufacturer-provided or recommended insulation kit.
5. Air-side sensors shall be located in a straight run of duct and installed in the center of the primary airstream.

6.6 Humidity Sensors:

A. The preferred control signal shall be 0-10vdc.

B. Wall and duct sensors shall be capacitive type.

C. For general-purpose use, sensor accuracy shall be +/- three percent.

D. Sensor accuracy shall be +/- two percent for critical application use.

E. Duct humidity sensors shall be located in a straight run of duct and installed in the center of the primary airstream.

F. The following manufacturers are acceptable:

1. Johnson Controls
2. Vaisala
3. Veris Industries
4. General Eastern

6.7 Air Quality Sensors:

A. The preferred control signal shall be 0-10vdc.

B. Duct air quality sensors shall be located in a straight run of duct and installed in the center of the primary airstream.

C. The following manufacturers are acceptable:

1. Johnson Controls
2. Vaisala
3. Veris Industries

6.8 Pressure Transducers:

A. The preferred control signal shall be 0-10vdc.

B. If possible, transducer shall be installed in equipment control cabinet.

C. All transducers shall be of the appropriate range for the system they are being installed on.

D. For wet transducer installation, ball valved shall be installed in the sensor line for easy replacement and maintenance of the sensor.

E. The following manufacturers are acceptable:

1. Dry Transducers:
   - Setra Sensing Solutions
   - Veris Industries
2. Wet Transducers:
   - Setra Sensing Solutions

6.9 Control Relays:

A. Control relays manufactured as self-contained assemblies shall be provided by

Functional Devices (RIB) or Veris Industries.

B. General purpose panel mounted relays and bases shall be manufactured by IDEC and mounted on suitable DIN rail.

C. Provide relays with internal LED "on" status light.

6.10 Current Switches:

A. All current switches shall be off the Go/No-go type and not analog.

B. All current switches shall be provided with a split-core.

C. All current switches shall be sized appropriately for the device load (i.e., amperage).

D. All current switches shall be approved for use with the load installed on (i.e., VFD).

E. The following manufacturers are acceptable:

1. Setra Sensing Solutions
2. Veris Industries
3. Functional Devices

7. Installation

7.1 Field Panels:

A. Field panels shall be fabricated and built under requirements of applicable UL standards and comply with NEC section 408.18 "Switchboards and Panelboard clearances."

B. Panels shall be of NEMA 1 construction when installed within normally dry indoor environments. Panels installed in exterior locations, or normally wet indoor locations (i.e. Cage wash areas) shall be rated NEMA 4x.

C. Field panels containing any supervisory or primary equipment controllers (AHU, HW, CHW, etc.) shall be installed with resettable surge protection devices.

D. Field panels containing a supervisory network level controller or any panel mounted in a public area/space shall be provided with lockable doors.

E. Supervisory controller field panels shall not contain a network switch, and the network drop shall be installed outside and directly next to the field panel. A certified CAT6 patch cord shall connect the device to the network tap. Every device that requires network connectivity will need a dedicated network connection.

F. Field panels shall contain a 120vac duplex power receptacle and a primary power disconnect.

G. Field panels shall be provided with a secondary voltage transformer with a resettable circuit breaker for overcurrent protection.

H. An engraved phenolic label shall be affixed to the panel exterior, containing the system name and area served (i.e., AHU-1 / Floor 1 VAV). The label shall be a minimum of 6" wide by 3" in height and have a white background with black text. Label examples shall be provided to Brown University before installation for approval.

I. All devices (relays, safeties, terminal blocks, etc.) installed in a field panel shall be machine-labeled, including the point tag and wiring reference (i.e. DA-T / UI IN1).

J. A wiring duct shall be installed in the field panel to conceal the wires. The wiring duct shall be sized at most 40% of its capacity. The wiring duct shall not contain wires with mixed voltages (i.e., 24vac and 120vac).

K. Field controller terminations shall be made with factory controller screw terminals. Auxiliary connections such as low voltage power distribution shall be made on DIN rail-mounted terminal blocks.

L. Field panel interconnection and remote device wiring shall be identified with machine-printed labels referencing the point tag name (i.e. DA-T).

M. Field panels that contain primary equipment (AHU, HW, CHW) shall be accessible without having to breach the ceiling plane.

N. Field panels shall be installed at a maximum height of 6'0" (top of the panel) and a minimum height of 3'0" from the floor (bottom of the panel).

O. Panel junction boxes have a minimum of 18" floor clearance.

1. Any control panel containing a power source shall have a machine-printed label on the interior door per design standard 01-70-10 MEPFPS Identification and Labeling, for voltage and power source.

7.2 Wiring:

A. Junction boxes and their respective covers or wire troughs containing BAS wiring shall be marked "BAS" with machine-printed labels and painted yellow.

B. All BAS wiring and wiring methods shall comply with the NEC code and applicable Brown University Division 26 standards.

C. All BAS wiring shall be stranded unless otherwise required by the manufacturer.

D. All exposed wiring in utility or mechanical rooms shall be run in metallic electrical tubing utilizing steel fittings (die-cast conduit fittings are unacceptable).

E. Any conduit used for an exterior or wet application shall be rigid steel.

F. Mixed wiring (low/high voltage) is not allowed in the same conduit.

G. All exposed class 2 and class 3 wiring shall be plenum-rated.

7.3 Labeling:

A. All labeling shall be generated by a device (Brady, Dymo Industrial, etc.) designed for that purpose. Hand-written labels are not acceptable.

B. BAS labeling and component designations shall match Brown University's labeling requirements. See section 01-70-10 MEPFPS Identification and Labeling.

C. When installing communication trunk cabling between devices, use a machine-created label to designate where it originates from and where it is going (i.e., from VAV-1 to VAV-2)

D. Controller terminations shall be machined labeled within 6" of the final termination and shall include point tag and I/O designation (i.e., DA-T / UI IN1).

E. Equipment-mounted sensors shall be labeled and contain the system name and point tag (i.e., AHU-1 - DA-T) at both the sensor and controller termination point.

F. Controller expansion modules shall be labeled with the parent equipment's name and address.

7.4 Field Controllers, Sensors, & Hardware:

A. All supervisory controllers shall be installed on suitable DIN rail in the panel enclosure.

B. All equipment controllers and expansion controllers shall be installed on suitable DIN rail when installed in an enclosure.

C. Multiple connections, such as power distribution, shall be connected to appropriate terminal blocks rated for the voltage used. Multiple connections under a wire nut device are not permitted.

8. Demolition:

A. All network-level supervisory devices shall not be destroyed or disposed of and shall be turned over to the University's Application Engineering department.

B. The controls contractor is responsible for removing all associated data points, user views, and color graphics for demolished equipment in the BAS system.

C. The controls contractor is responsible for updating and/or removing any orphaned control logic and unbound references from the supervisory controller due to the demolition.

D. Licensed pipefitters shall be utilized for the demolition or removal of pneumatic systems. All terminated lines shall be secured with fittings rated and designed for pneumatic installations.

E. The controls contractor is responsible for removing and disposing of all demolished

controls-related equipment.

F. No abandoned equipment shall remain.

9. Commissioning:

A. All BAS installations and expansions, whether new, renovations, or additions, shall be fully commissioned. Deliverables shall include point-to-point checkout documents that indicate the test date, tester, results, and corrective actions. Reports from the Johnson Controls MAP Gateway or CWa software tool are preferred.

B. The controls contractor shall be responsible for all field device calibration before commissioning is performed. Any calibration offsets/adjustments shall be documented on the point-to-point reports.

C. The controls contractor's point-to-point and commissioning responsibilities include, but are not limited to, the following:

1. Support for the selected commissioning agent or owner, including but not limited to onsite/remote testing of the BAS components and sequences, system manipulations, and data gathering for evaluation.
2. Providing the selected commissioning agent or owner with system trends, color graphics, and control logic.
3. Turnover of all point-to-point checkout documents.

10. Customer Training:

A. The controls contractor shall provide training, based upon project size, that includes both field and classroom training. For large projects, at least eight combined field and classroom training hours shall be provided. The total training hours shall be finalized during the project design phase. Regardless of project size, a minimum of two hours of training, whether onsite or classroom, shall be required.

B. A certified or factory-authorized representative of the controls system and/or equipment shall provide all training.

C. The controls contractor shall provide the University with a digitally recorded copy of the training session(s).

D. Before the training session, the controls contractor shall provide a final as-built copy of the controls system. Training shall be rejected if this requirement is not met.

E. The controls contractor may be responsible for providing more than one training session per day to accommodate multiple shifts.

End of Section