Clemson University

Building Automation System Standards

UNIVERSITY FACILITIES

1 | General Specifications

BAS Intent

The intent of this specification section is to establish a set of guidelines to define the requirements for the Building Management System. This BMS shall, at a minimum, offer the capabilities to:

1. Improve and facilitate the monitoring and control of the various HVAC systems and equipment, and the connected operational technologies of the building(s).
2. Facilitate training on the BMS and enhance the understanding of how the systems work, with an emphasis on the relationships of the equipment that serves the spaces of the building(s)
3. Minimize response time to high priority alarms and critical failures with sophisticated, customizable annunciation and targeted information distribution.
4. Standardize system integration and scalability by adhering to open-protocol frameworks that allow for interoperability across multiple vendors, future system expansion, and seamless integration with emerging technologies.
5. Strengthen cybersecurity and system resilience through robust access control policies, encrypted communications, routine security updates, and audit logging to safeguard university assets against cyber threats.

   Facilitate continuous improvement and data-driven decision-making by maintaining a structured historical archive of system performance, anomalies, and energy consumption trends, allowing for periodic review and long-term strategic planning.

Quality Assurance

Manufacturer Qualifications:

1. The BMS manufacturer shall have a full-service office within 50 miles of the project jobsite.
2. The Building Management System installer shall be a manufacturer-owned branch office, or an independent contractor who is factory trained and authorized by the manufacturer to sell, service, and support the Building Management System specified herein. Independent contractors shall submit letters to Clemson from the BMS manufacturer providing a guarantee that the BMS manufacturer will complete any project or work that the independent contractor defaults on or does not complete. This guarantee must explicitly cover warranty obligations, system functionality, and required corrective actions.
3. The office shall maintain a suitable parts inventory and shall have all testing and diagnostic equipment necessary to support this work.
4. The contractor shall have verifiable experience in the engineering, programming, installation, and servicing of BMS installations that are similar in scope and complexity to the project. The contractor must provide references for at least three (3) completed BMS projects of comparable size within the past five (5) years.
5. From the start of installation through the completion of the agreed-upon warranty period, the contractor shall be solely responsible for addressing any defects, failures, or system deficiencies at no additional cost to the University. The contractor shall coordinate with the manufacturers of all supplied devices to ensure proper function, warranty support, and resolution of any product-related issues. In the event of a dispute regarding responsibility for system failures, the contractor shall provide technical documentation and work directly with Clemson University to resolve issues without unnecessary delays..
6. The contractor and local service office shall provide 24/7 emergency support with a guaranteed response time of no more than four (4) hours for critical system failures affecting university operations. Routine service requests must be acknowledged within one (1) business day, with a resolution plan provided within three (3) business days unless otherwise agreed upon. The

contractor must comply with all university policies, state and federal regulations, and industry best practices for BMS installation and service.

7. The installed system shall meet or exceed the university's operational and energy efficiency requirements. The contractor shall conduct a final system verification, provide all necessary training, and ensure that Clemson University personnel have full access to system documentation, programming tools, and administrative controls

BAS System Details

Building Automation System – Server Details:

1. The BMS Contractor shall furnish, install, configure, and commission all BMS server, controller and device programming, data archiving, control and monitoring software as a part of a complete system.
    a. The BMS Contractor shall be responsible for all database creation, new graphics creation, and point naming conventions that shall match the existing BMS database, graphics, and naming convention structures exactly.
    b. All programming for field controllers and I/O points shall be provided and executed exactly as specified further within this document.
    c. Any corruption of the existing server software shall be the BMS Contractor's responsibility to repair.
    d. Modification of existing or downloading new programming to the new field controllers (ie. passthrough) through the existing BMS is required as a capability of this integration.
    e. The BMS Contractor shall provide all software licenses and necessary hardware (laptop PC, tablet, etc.) for all field controller programming tools to the owner at the completion of each project. Owner shall be trained on the use of these tools as part of the training requirements defined elsewhere.
2. A temporary Automation network communications solution will be required to be installed by the BMS Contractor prior to the completion of the Owner's IT network. The temporary network shall provide remote access to the BMS for programming, commissioning, graphics loading and binding, and for access by the contract team. The temporary network shall link together all Building Controllers/Engines via ethernet CAT6 cable and temporary un-managed switches. One Building Controller/Engine shall serve as the system "Master" and shall have a cellular modem to communicate with a remote BMS server that is used for all functionality outlined. Once the Owner's IT network is installed and commissioned, the temporary network shall be de-commissioned and Owner's IT data drops shall be permanently connected to all BACnet IP components/controllers. The database from the temporary server shall be transferred to the permanent server and commissioned for proper on-premises operation.
3. The BMS software shall include, at a minimum, licensed copies of:
    a. System configuration, data storage, upload, and download tools
    b. System alarm, event and interaction audit log
    c. System data trending and archiving and Microsoft SQL server
    d. A Mobile User Interface server application as described herein
    e. An embedded HTML-5 Mobile User Interface graphics development tool
4. Owner access via 50 individual user, password protected sign ons with customized restrictions/access levels
5. All BAS field controller communications shall use BACnet MS/TP protocol. All supervisory controller to supervisory controller communications shall be BACnet IP.
6. Alarms to be fully customizable and generated via email and SMS

7. The system shall allow the distribution of system functions such as monitoring and control, as well as the primary graphical user interface (MUI), across the network to achieve maximum flexibility and performance.
8. Dashboard Displays
    a. The user interface shall provide the ability to view equipment visualizations, floor plans, and/or other graphics on mobile or desktop client devices in a browser environment, without the need for additional plugins or software. Graphics shall be accessible via a space (for floorplans, campus maps, etc.) or equipment dashboard.
    b. Standard dashboards shall be configured for each defined space including one of the following predefined or custom elements:
        i. Equipment Serving Space
        ii. Potential Problem Areas
        iii. Equipment Summary
        iv. Graphic Display
        v. Schedule
    c. Standard dashboards shall be configured for each system or device (typ. mechanical or electrical equipment) including the following predefined or custom elements:
        i. Trend
        ii. Equipment Activity Summary
        iii. Equipment Relationships Summary
        iv. Equipment Data
        v. Graphic Display
        vi. Schedule
    d. Users with appropriate permissions shall have access to a Dashboards Manager that can change the display order of Summaries and Data elements, add or remove elements and apply custom dashboards layouts to equipment and space by type.
    e. Dashboard Manager shall apply dashboards to spaces or equipment based on the viewing platform (Desktop/Tablet or Phone) in order to tailor the user experience to the needs of the specific user base.
9. Graphics
    a. The user interface shall display an equipment visualization or graphic within the context of its associated space (building, floor, room, etc.) or equipment dashboard.
    b. At a minimum, graphics shall be provided for the following:
        i. 3-D image of the building
        ii. Each individual floorplan, or sections of a large floorplan
        iii. Each individual piece of controlled/monitored/integrated HVAC equipment
        iv. Central utility plant and/or pumping systems including animated equipment images and all piping accurate to installed conditions. Include all pipe-mounted sensors and control valves in their approximate locations
        v. Graphical dashboards showing images of integrated third-party equipment and individual data tables displaying all integrated points
        vi. Graphical dashboards showing calculated data and any other points as called for within the I/O summaries on the contract documents
    c. Operators shall have the capability to override all binary and analog outputs directly from the graphics.
    d. Graphics shall include the ability to define individual information layers for operator selection in order to clarify systems status and simplify operation on mobile devices.
    e. Graphics shall support the use of photo-realistic symbols as well as color change and animation to match the status of the related system control point.
    f. It shall be possible to export a time stamped .pdf file of the graphic being viewed in order to communicate the current conditions in the space or the equipment being viewed and to provide a historic record.

g. An integral graphic manager shall be provided including the following features and capabilities:
    i. Creation and modification of graphics from any HTML5 capable browser without the need for additional plug-ins or software packages.
    ii. Access to a full suite of pre-defined templates for air and water sourced HVAC applications as well as the ability to add custom templates as created for other use. Pre-aliased graphic templates may be defined and saved for repetitive representations of common mechanical and electrical equipment.
    iii. A full suite of pre-defined three-dimensional symbols for mechanical and electrical systems as well as all line, text and shape tools required for integration into a graphic with zoom and pan capabilities on multiple platforms and in multiple browsers.
    iv. The ability to search and replace items in multiple graphics with a single command.
    v. The ability to import and insert photos and images into the graphic.
    vi. The ability of the graphics manager to create and edit graphics including the ability to bind graphic elements to the values and conditions of system points in both an on-line and off-line mode.
    vii. The ability to create and import custom SVG symbols that can be selectable from the graphical palette and rendered at runtime.
h. The BMS Contractor shall provide software licenses for programming, configuration and graphics building tools to allow designated representatives to make changes, modifications or additions to the system.

10. Integration
    a. The software shall offer complete integration to third party devices and software, through the use of industry standard protocols.
    b. All integrated equipment shall have seamless software interactivity. Operators should not experience any decline in control or monitoring capabilities when compared to native BMS components.
11. Information accessibility
    a. The BMS Contractor must supply API licenses as Clemson University directs. .
    b. The software shall make use of published RESTful APIs natively, as well as for broader integrations
    c. Clemson University shall own and be able to access all data from the BMS

Low Voltage Wiring

Building Automation System – Wiring Installation:

1. All conduit, wiring accessories and wiring connections required for the installation of the BAS shall be provided by Johnson Controls.
2. All Class 2 (24 VAC or less) wiring shall be installed in conduit unless otherwise specified.
    A) Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers (J Hooks). Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.
3. Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.
4. All wiring shall be installed in conduit or raceway except as noted elsewhere. Minimum control wiring conduit size ¾”.
    a. Thermostat raceways (only from the Thermostat to above ceiling run) and flexible conduit may be ½”.

5. Where it is not possible to conceal raceways in finished locations, surface raceway (wiremold) may be used as approved by the Architect.

Building Automation System – Control Transformers:

1. All terminal units (VAV boxes, Fan Coil Units, Air Valves, etc.) shall be provided with a Class II 24 VAC transformer and disconnect switch. This includes control panels, supervisory controllers (SNE/SNC's) and fire/smoke dampers.
2. Centralized (Gang) transformers are not permitted.120V power wiring shall be run to each terminal unit, control panels, supervisory controllers and fire/smoke dampers. 120V wiring shall be provided and installed under Division 26 contractor unless specified otherwise in project-specific specifications/drawings
3. Label transformers/control panels to appropriately identify the panel and circuit of origin.

Commissioning / Maintenance / Owner Training

Commissioning:

1. BMS Contractor shall commission all controls jobs and set up "typical" trends. *see Appendix for specifications.

The BMS Contractor shall ensure that all control sequences are verified and adjusted as necessary to achieve optimal system performance before system acceptance. Initial trend logs shall be configured to monitor key performance indicators. Some or all of these trends may be removed or modified upon approval during owner training or as directed by Clemson University.Basic Maintenance:

1. This Contractor shall maintain the System for proper functioning through preventive maintenance, repair, examination, analysis, adjustment, cleaning, and calibration of all covered system components.

Preventive maintenance shall be performed at a minimum frequency of four (4) site visits per year. The Contractor shall provide Clemson University with a detailed preventive maintenance schedule based on system requirements and best practices.Scheduled Maintenance Hours

2. This Contractor shall perform all scheduled or non-emergency maintenance service during regular business hours, defined as 7:00 a.m. to 5:00 p.m., Monday - Friday, this Contractor's holidays excepted. Exceptions to be qualified based on Clemson University direction.

Emergency Service

3. Emergency service, defined as service or maintenance provided during other than regular business hours in the event of a critical system failure rendering the system inoperative.
4. Contractor shall provide emergency service required to restore the system to operation at any time, 24 hours a day, 7 days a week, with a 4 hour response time to the location above.
5. The Contractor shall ensure that emergency service personnel are fully trained and equipped to diagnose and restore the system to proper operation promptly.

Service Reports

6. After each repair or maintenance visit, the Contractor shall provide the Clemson with a work order concerning work performed on the system, setting forth each maintenance task and listing, by name and part number, all system components replaced during that repair or maintenance visit.
7. All service reports shall be submitted within 48 hours of the completed service visit.

Owner Training

8. BMS Contractor to present trend data showing proper operation.
9. This Contractor shall engage a factory-authorized service representative to train Clemson's maintenance personnel to adjust, operate, and maintain units.
10. Training shall incorporate both classroom instruction and field instruction
11. Training shall take place over a period of 40 hours minimum for Capital Projects. For small projects, defer to Clemson University to establish required training hours. . If the project specifications require a training duration greater than the minimum stated above, the specifications shall govern and take precedence.

Controls Documentation

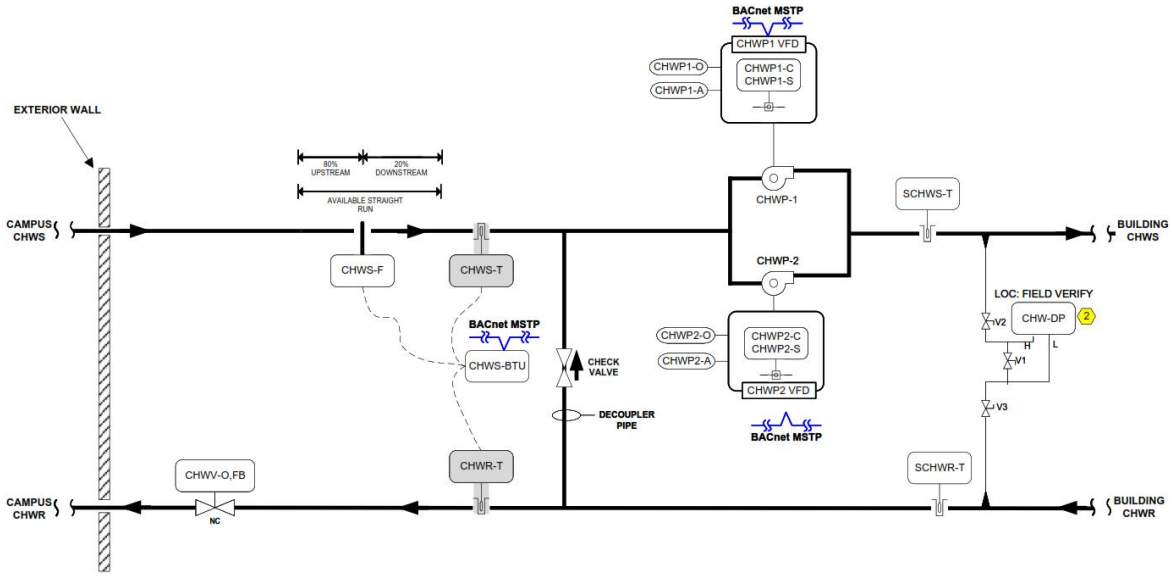
1. Hard copy panel drawings and sequences to be printed and stored within network panel. Digital copies of all control panel documentation shall also be provided to Clemson University in PDF and native file formats (e.g., AutoCAD, Visio, or equivalent).
2. A log of programmer actions to be kept in control panel. Log should contain date, programmer identification and summary of actions.
3. Submittals to be submitted to direct customer (ie mechanical contractor, general contractor, etc) and in turn to Clemson University. Submittals shall include, at a minimum: Control system architecture diagrams, Bill of materials with part numbers, Sequence of operations and control strategies, Points list with naming conventions, Network topology, including IP addresses and BACnet/MSTP addressing where applicable.
4. • As-Built Documentation
5. As-built documentation shall be submitted to the direct customer and subsequently to Clemson University.
6. As-builts shall incorporate:
    - All approved revisions from submittals.
    - Final device addresses, point mapping, and programming logic.
    - Data trends established and verified during owner training.
    - Network diagrams reflecting actual installed conditions.
    - As-builts shall be provided in both hard copy and digital formats (PDF and original working files such as Visio, AutoCAD or Excel for point lists).
7. Ongoing Documentation Updates & Accessibility:
    - The contractor shall provide updated documentation whenever system modifications, software updates, or equipment replacements occur.
    - Clemson University shall have unrestricted access to all documentation, including passwords and programming tools, to ensure long-term system maintainability.
    - A secure online repository (e.g., SharePoint, cloud storage, or university-maintained server) may be established by Clemson University to store and access documentation remotely and Contactor maybe asked to store files at this location
8.

*****All Below Diagrams and Sequences are "Typical" Applications. Subject to change based on project intent and designs by Engineer of Record. Below sequences are for reference only.*****

2 | Chilled Water Bridge

Building Automation System – Typical Chilled Water Bridge:

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
CHW-DP	1	DP110050U3V4V	0 TO 50 PSID, UNIDIRECTIONAL 3-VALVE MANIFOLD, 4-20 MA
CHWS-F	1	F-3500-12	FLOW METER INSERT MAG BID
	1	INSTL0001-FMD	INSTALL KIT, CS, 1.25-42"
SCHWPx-C,-S	2	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
SCHWR-T	1	TE-6300W-102	THERMOWELL. 6" STAINLESS STEEL DIRECT MOUNT
	1	TE-631AM-2	WELL INSERTION TEMPERATURE SENSOR,1K OHM NICKEL 6 IN. PROBE
SCHWS-T	1	TE-6300W-102	THERMOWELL. 6" STAINLESS STEEL DIRECT MOUNT
	1	TE-631AM-2	WELL INSERTION TEMPERATURE SENSOR,1K OHM NICKEL 6 IN. PROBE
BTU	1	SYS10-1X10-01OX	BTU METER, BACNET MSTP
Other Devices:			
CHWV-O,-FB	1	VALVE	REFER VALVE SCHEDULE
CHWPx-VFD	2	VFD	SEE VFD SCHEDULE
Panel Devices:			
CHWS-CP	1	P2BAN-BEHA1N01	PANEL, M4-CGM09090-0H INT DIS and XPM09090-0, 24X20X6.5,120/2

SEQUENCE OF OPERATION

SEQUENCE OF OPERATION:

A. SEE SCHEMATIC FOR LOCATIONS OF ALL TEMPERATURE TRANSMITTERS, PANELS, VALVES AND EQUIPMENT. WHERE SUCH DEVICES ARE NOT INDICATED, HOWEVER REQUIRED BY THE SEQUENCE OF OPERATION WILL BE PROVIDED BY THE CONTRACTOR.

B. A FULL COMMUNICATION INTERFACE AND COMPLETE INTEROPERABILITY WITH THE EXISTING CAMPUS JCI DDC AUTOMATIC TEMPERATURE CONTROL SYSTEM WILL BE PROVIDED TO PERFORM THE FUNCTIONS HEREIN DESCRIBED.

C. CHILLED WATER TEMPERATURE CONTROL:

1. CAMPUS CHILLED WATER RETURN VALVE, V-1 (CHWV-O) WILL BE NORMALLY CLOSED.

2. CAMPUS CHILLED WATER RETURN VALVE, V-1 (CHWV-O) WILL BE MODULATED TO MAINTAIN THE CHILLED WATER RETURN TEMPERATURE SETPOINT AS SEEN BY SCHWR-T.

D. ALARM AND FAILURE MODES:

1. CAMPUS CHILLED WATER RETURN VALVE WILL BE FAIL CLOSED.

Building Automation System – Flow and Energy Meters:

1. All chilled water flow meters must be electromagnetic insertion type with frequency, isolated analog and bi-directional pulse outputs.
2. All chilled water energy meters must be Onicon “System 10” BTU meter with BACnet MS/TP compatibility.
3. All meters specified in project documents to be provided by BMS contractor unless otherwise directed by Clemson University. .

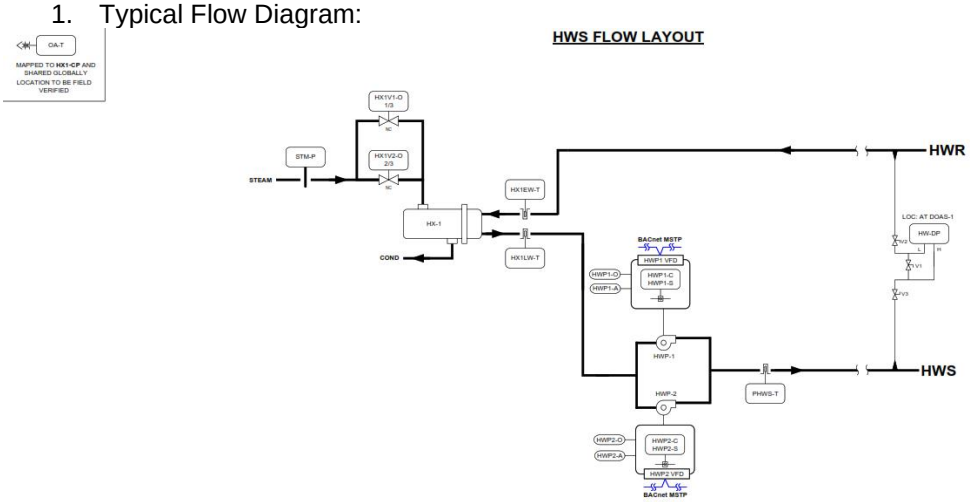
Building Automation System – Chilled, Hot Water and Steam Valves:

4. All chilled water valves to be provided by BMS manufacturer.
5. Pressure Independent valves are not approved for applications greater than 1”. Valves smaller than 1”, the engineer of record to specify valve type.

3 | Steam / Hot Water System

Building Automation System – Typical Steam to Hot Water Heat Exchanger Configuration

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

HWS BOM AND SEQUENCE OF OPERATION

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
STM-P	1	DPT2090-100G	DP TRANS, 0 TO 100 PSIG, 0.5 TO 5.5 VDC
HW-DP	1	DP110050U3V4V	0 TO 50 PSID, UNIDIRECTIONAL 3-VALVE MANIFOLD, 4-20 MA
HX1EW-T	1	TE-6300W-102	THERMOWELL. 6" STAINLESS STEEL DIRECT MOUNT
	1	TE-631AM-2	WELL INSERTION TEMPERATURE SENSOR,1K OHM NICKEL 6 IN. PROBE
HX1LW-T	1	TE-6300W-102	THERMOWELL. 6" STAINLESS STEEL DIRECT MOUNT
	1	TE-631AM-2	WELL INSERTION TEMPERATURE SENSOR,1K OHM NICKEL 6 IN. PROBE
OA-T	1	TE-6313P-1	3, FOR OUTDOOR AIR MTG.
PHWPx-C,-S	2	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
PHWS-T	1	TE-6300W-102	THERMOWELL. 6" STAINLESS STEEL DIRECT MOUNT
	1	TE-631AM-2	WELL INSERTION TEMPERATURE SENSOR,1K OHM NICKEL 6 IN. PROBE
Panel Devices:			
P2DAN-BEHB2N01	1	P2DAN-BEHB2N01	PANEL, M4-CGM09090-0H INT DIS and XPM09090-0, 36X24X6.5,PWR S
Other Devices:			
HX1V1-O 1/3	1	VALVE	
HX1V2-O 2/3	1	VALVE	
HWPx-VFD	2	VFD	

SEQUENCE OF OPERATION

A. HOT WATER PUMP START STOP CONTROL:

1. HOT WATER PUMPS WILL OPERATE IN A PRIMARY AND STANDBY CONFIGURATION. IN THE EVENT OF A FAILURE OF A PRIMARY PUMP AN ALARM WILL BE GIVEN AT THE FMS COMPUTER AND THE STANDBY PUMP WILL BE AUTOMATICALLY STARTED.

PRIMARY AND STANDBY PUMPS WILL BE AUTOMATICALLY ALTERNATED ON A WEEKLY BASIS.

B. HOT WATER PUMP SPEED CONTROL:

1. WHENEVER THE DDC CONTROLLER DETECTS THAT A PUMP IS ON, IT WILL SENSE THE DIFFERENTIAL PRESSURE IN THE HOT WATER SYSTEM AND MODULATE THE VARIABLE SPEED DRIVE OF THAT PUMP AS REQUIRED TO MAINTAIN THE DIFFERENTIAL PRESSURE SET POINT.

2. THE HW SYSTEM DDC CONTROLLER WILL SENSE THE HOT WATER SUPPLY TEMPERATURE AND OUTSIDE AIR TEMPERATURE IN ORDER TO DETERMINE THE HOT WATER SUPPLY TEMPERATURE SET POINT. THE SET POINT WILL BE RESET ACCORDING TO THE FOLLOWING ADJUSTABLE RESET SCHEDULE.

OUTSIDE AIR TEMPERATURE	HOT WATER SUPPLY TEMPERATURE SETPOINT
20°F	160°F
65°F	120°F

3. THE DDC CONTROLLER WILL MODULATE THE HEX STEAM CONTROL VALVES AS REQUIRED TO MAINTAIN THE CALCULATED HOT WATER SUPPLY TEMPERATURE SET POINT.

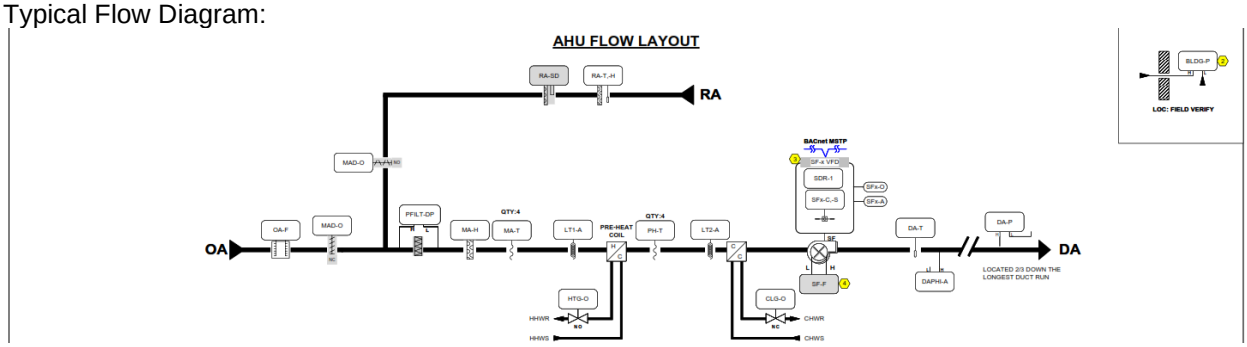
Building Automation System – Meters:

1. All steam flow meters must be accepted by Clemson University.
2. All meters to be provided by BMS manufacturer unless otherwise specified by Clemson University.

4 | Air Handling Units

Building Automation System – Typical VAV Air Handling Unit Configuration

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
BLDG-P	1	RPS	STAINLESS STEEL ROOM PRESSURE SENSOR WITH 1/4 INCH BARB FITTI
	1	A-306-K	OUTDOOR AIR STATIC
	1	SD-01	SURGE DAMPENER
	1	DP140X25B11C	BIDIRECTIONAL + OR -0.25IN. W.C. 0 TO 5 VDC
DA-T	1	TE-6311M-1	1000 OHM NICKEL - METAL ENCLOSURE
DA-P	1	DP140005U21C	UNIDIRECTIONAL 0 TO 5IN. W.C. 24 VDC / 4 TO 20 MA
	1	FTG18A-600R	SENSING TUBE KIT FOR P32
DAPHI-A	1	AFS-460	DIFFERENTIAL PRESSURE SWITCH, 0.06-12" WC, ADJUSTABLE, SPST (
	1	FTG18A-600R	SENSING TUBE KIT FOR P32
PFILT-DP	2	FTG18A-600R	SENSING TUBE KIT FOR P32
	1	DP1402X5U11C	UNIDIRECTIONAL 0 TO 2.5IN. W.C. 0 TO 5 VDC
LT-A	2	A70HA-1C	15/55F, DIFF 5 FIXED,1NO/1NC MAIN OPEN LOW,1/8 X 20' BULB,
	2	TE-6001-8	AVER ELEMENT HLDR QTY =10
MAD-O	4	M9220-GGA-3	20 NM SR DPR ACT 0(2) TO 10 VDC 24 VAC 50/60 HZ 24 VDC
MA-H	1	HT-6903ONP-0	DUCT TRANSMITTER 3%RH
MA-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
PH-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
RA-T,-H	1	HE-69130NP-0	DUCT PROBE, 3%RH, NI TEMP
RELAY BOARD	1	RIBMNLB-6	2.75 TRACK MOUNT AHU FAN SAFETY ALARM AND GENERAL PURPOSE LOG
SDR-1	1	RR10NN	PILOT RELAY, 10A, SPDT
SDR-2	1	RR10NN	PILOT RELAY, 10A, SPDT
SF1-C,-S	1	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
SF2-C,-S	1	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
Panel Devices:			
PANEL	1	P2DAN-BEHB2N01	PANEL, M4-CGM09090-0H INT DIS and XPM09090-0, 36X24X6.5,PWR S
	1	M4-XPM04060-0	10 PT INPUT/OUTPUT EXPANSION MODULE, 3 UI, 1 BI, 4 CO, 2 BO
Other Devices:			
CLG-O	1	VALVE	REFER VALVE SCHEDULE
HTG-O	1	VALVE	REFER VALVE SCHEDULE
OA-F	1	AFMS	REFER AFMS SCHEDULE

SEQUENCE OF OPERATION

A. START/STOP:
1 THE UNIT WILL BE CAPABLE OF BEING STARTED AND STOPPED BASED ON A TIME-OF-DAY SCHEDULE FROM THE FMS.
2 WHEN THE UNIT GOES INTO THE OCCUPIED MODE AND IS TO BE STARTED, THE OUTDOOR AIR DAMPER WILL BE DRIVEN TO ITS MINIMUM CFM POSITION, AS SENSED BY OUTDOOR AIR CFM MEASURING DEVICE. THE OUTDOOR AIR DAMPER WILL REMAIN CLOSED DURING NIGHT LOW LIMIT AND MORNING WARMUP.
3 CO2 LEVELS WILL BE MEASURED IN EACH CLASSROOM SPACE AND IN OTHER SPACES AS INDICATED ON THE DRAWINGS BY INDIVIDUAL ROOM CO 2 SENSORS. OUTDOOR AIR DAMPER WILL BE MODULATED TO CONTROL MAXIMUM ROOM CO2 LEVELS TO 1000 PPM (ADJUSTABLE). OUTDOOR AIR DAMPER WILL BE MODULATED TO MAINTAIN MINIMUM VENTILATION CFM AS SHOWN ON MECHANICAL SCHEDULE.

B. SAFETIES:
1 DUCT SMOKE DETECTOR WILL SHUT THE SUPPLY FAN OFF WHENEVER PRODUCTS OF COMBUSTION ARE SENSED. THE SMOKE DETECTOR WILL BE PROVIDED AND WIRED BACK TO FIRE ALARM SYSTEM BY DIVISION 26 AND INTERLOCKED WITH THE FAN STARTER UNDER DIVISION 23.
2 A TEMPERATURE LOW LIMIT SWITCH WILL SHUTDOWN THE FAN WHENEVER MIXED AIR TEMPERATURES DROP BELOW 38 DEGREES.
3 A STATIC PRESSURE HIGH LIMIT SWITCH WILL SHUT DOWN THE AIR HANDLER WHENEVER STATIC PRESSURE IN THE DISCHARGE OF THE AIR HANDLER EXCEEDS 5" W.G.

C. TEMPERATURE CONTROL:
1 DISCHARGE AIR TEMPERATURE WILL BE CONTROLLED AT 55 DEGREES F. (ADJUSTABLE) BY MODULATING THE CHW VALVE AS NECESSARY TO MAINTAIN SET POINT.
2 DISCHARGE TEMPERATURE RESET SCHEDULE: DISCHARGE AIR RESET SCHEDULE WILL BE ADJUSTABLE.

OUTSIDE AIR TEMP.	DISCHARGE AIR TEMP.
55 DEG F	55 DEG F
45 DEG F	65 DEG F

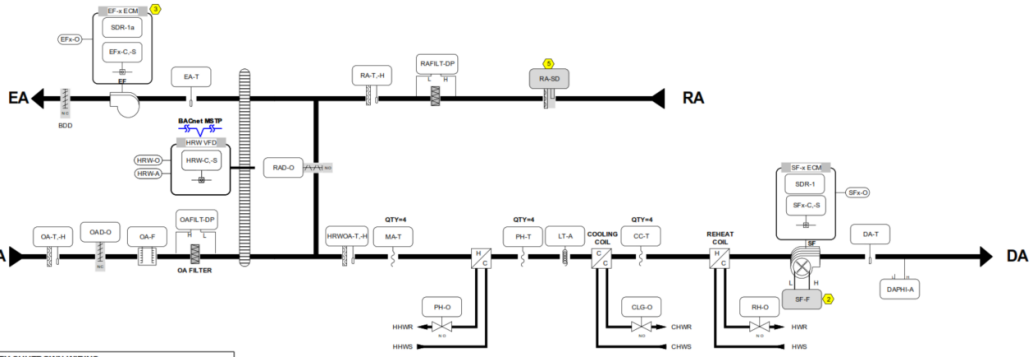
D. PREHEAT COIL DISCHARGE AIR CONTROL:
1 PREHEAT COIL DISCHARGE AIR TEMPERATURE WILL BE CONTROLLED AT 55 DEGREES (ADJUSTABLE) BY MODULATING PREHEAT CONTROL VALVE AS REQUIRED TO MAINTAIN SET POINT.

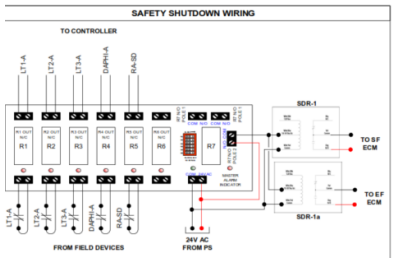
E. PRESSURE CONTROL:
1 THE SUPPLY VARIABLE SPEED DRIVE WILL BE MODULATED TO MAINTAIN SUPPLY DUCT STATIC PRESSURE SET POINT OF 1 IN W.G.
2 WHEN THE SUPPLY FAN STARTS THE VSD WILL BE IN THE "UNLOADED" POSITION. VSD WILL LOAD FAN OVER AN ADJUSTABLE TIME PERIOD.

F. FILTER:
1 PROVIDE ANALOG DIFFERENTIAL PRESSURE SENSOR FOR FILTER MONITORING.

Building Automation System – Typical Energy Recovery Air Handling Unit Configuration

1. Typical Flow Diagram:





2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
DA-T	1	TE-6311M-1	1000 OHM NICKEL - METAL ENCLOSURE
CC-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
DA-P	1	FTG18A-600R	SENSING TUBE KIT FOR P32
	1	DP1400D5U11C	UNIDIRECTIONAL 0 TO 5IN. W.C. 0 TO 5 VDC
DAPHI-A	1	AFS-460	DIFFERENTIAL PRESSURE SWITCH, 0.06-12" WC, ADJUSTABLE, SPST (
	1	FTG18A-600R	SENSING TUBE KIT FOR P32
EA-T	1	TE-6311M-1	1000 OHM NICKEL - METAL ENCLOSURE
MA-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
PH-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
OAFILT-DP	2	FTG18A-600R	SENSING TUBE KIT FOR P32
	1	DP1402X5U11C	UNIDIRECTIONAL 0 TO 2.5IN. W.C. 0 TO 5 VDC
OA-T,-H	1	HE-69130NP-0	DUCT PROBE, 3%RH, NI TEMP
RA-T,-H	1	HE-69130NP-0	DUCT PROBE, 3%RH, NI TEMP
HRWOA-T,-H	1	HE-69130NP-0	DUCT PROBE, 3%RH, NI TEMP
HRW-C,-S	1	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
LT-A	1	A70HA-1C	15/55F, DIFF 5 FIXED,1NO/1NC MAIN OPEN LOW,1/8 X 20' BULB
	1	TE-6001-8	AVER ELEMENT HLDR QTY =10
OAD-O	1	M9220-GGA-3	20 NM SR DPR ACT 0(2) TO 10 VDC 24 VAC 50/60 HZ 24 VDC
RAD-O	1	M9220-GGA-3	20 NM SR DPR ACT 0(2) TO 10 VDC 24 VAC 50/60 HZ 24 VDC
EABYPD-O	1	M9220-GGA-3	20 NM SR DPR ACT 0(2) TO 10 VDC 24 VAC 50/60 HZ 24 VDC
EAFILT-DP	2	FTG18A-600R	SENSING TUBE KIT FOR P32
	1	DP1402X5U11C	UNIDIRECTIONAL 0 TO 2.5IN. W.C. 0 TO 5 VDC
	1	RIBMNLB-6	2.75 TRACK MOUNT AHU FAN SAFETY ALARM AND GENERAL PURPOSE LOG
SDR-1	1	RR10NN	PILOT RELAY, 10A, SPDT
SDR-1a	1	RR10NN	PILOT RELAY, 10A, SPDT
SFx-C,-S	5	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
EFx-C,-S	2	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
Panel Devices:			
DOAS1-CP	1	P2DAN-BEHB2N01	PANEL, M4-CGM09090-0H INT DIS and XPM09090-0, 36X24X6.5,PWR S
	1	M4-XPM18000-0	18 PT BINARY INPUT EXPANSION MODULE
	1	M4-XPM09090-0	18 PT INPUT/OUTPUT EXPANSION MODULE, 7 UI, 2 BI, 4 CO, 2 AO,
Other Devices:			
CLG-O	1	VALVE	REFER VALVE SCHEDULE
OA-F	1	AFMS	REFER AFMS SCHEDULE
PH-O	1	VALVE	REFER VALVE SCHEDULE
RH-O	1	VALVE	REFER VALVE SCHEDULE

SEQUENCE OF OPERATION

SEQUENCE OF OPERATION: DOAS-1

A. GENERAL:
1 OUTSIDE AIR UNITS SHALL SUPPLY NEUTRAL TEMPERATURE AIR TO THE BUILDING.
2 PROVIDE SUPPLY AIR DISCHARGE SENSOR FOR MONITORING ONLY.

B. START/STOP:
1 THE UNIT WILL BE STARTED AND STOPPED BASED ON A TIME OF DAY SCHEDULE FROM THE FMS.
2 ONCE THE START SEQUENCE IS INITIATED, THE OUTSIDE AND EXHAUST AIR DAMPERS SHALL OPEN. ONCE THE OUTSIDE AIR AND EXHAUST AIR DAMPERS ARE PROVEN OPEN, THE SUPPLY AND EXHAUST FAN SHALL BE COMMANDED TO RUN

C. SAFETIES:
1 DUCT SMOKE DETECTOR WILL SHUT THE SUPPLY FAN OFF WHENEVER PRODUCTS OF COMBUSTION ARE SENSED. THE SMOKE DETECTOR WILL BE PROVIDED AND WIREDBACK TO FIRE ALARM SYSTEM BY DIVISION 26 AND INTERLOCKED WITH THE FAN STARTER UNDER DIVISION 23.
2 A TEMPERATURE LOW LIMIT SWITCH WILL SHUTDOWN THE FAN WHENEVER MIXED AIR TEMPERATURES DROP BELOW 38 DEGREES.
3 A STATIC PRESSURE HIGH LIMIT SWITCH WILL SHUT DOWN THE AIR HANDLER WHENEVER STATIC PRESSURE IN THE DISCHARGE OF THE AIR HANDLER EXCEEDS 5" W.G.

D. TEMPERATURE/HUMIDITY CONTROL SUMMER:
1 DURING SUMMER MODE (AMBIENT DEW-POINT IS ABOVE SUMMER SUPPLY AIR DEW-POINT SET POINT), MECHANICAL COOLING AND DEHUMIDIFICATION IS ENABLED AND CHILLED WATER VALVE IS MODULATED TO MAINTAIN SUPPLY AIR DEW-POINT SET POINT. HEAT IS UTILIZED FOR REHEATING SUPPLY AIR TO NEUTRAL CONDITIONS AT REHEAT COIL WHEN OUTDOOR TEMPERATURES DROP BELOW DEW POINT SETPOINT.

E. TEMPERATURE/HUMIDITY CONTROL WINTER:
1 DURING WINTER MODE, SUPPLY AIR IS PREHEATED THROUGH ENERGY RECOVERY, AND HEATED AT PRE-HEAT COIL AS REQUIRED TO MAINTAIN WINTER SUPPLY AIR TEMPERATURE SET POINT.

F. FILTER:
1 PROVIDE ANALOG DIFFERENTIAL PRESSURE SENSOR FOR FILTER MONITORING.

G. RECIRCULATION DAMPER:
RECIRCULATION DAMPER INCLUDED FOR OVERRIDE OPERATION AND NOT A NORMAL SEQUENCE OF OPERATION. RECIRCULATION WILL BE ACCOMPLISHED BY USER OVERRIDE AT CONTROLS INTERFACE. DOAS UNIT WILL PROVIDE 55 DEG F AIR WHEN OUTSIDE AIR TEMPERATURES ARE LOWER THAN 75 DEG UNIT WILL PROVIDE NEUTRAL AIR AT 70 DEG (ADJ). WHEN DOAS IS ENABLED THE DOAS EXHAUST FAN WILL OPERATE CONTINUOUSLY AND NOT SHUT DOWN IN A SMOKE DETECTOR ALARM. EXHAUST FAN WILL BE POWERED INDEPENDENTLY OF SUPPLY FAN AND WILL BE GENERATOR BACKED.

RAD WILL BE AN OVERRIDABLE POINT ONLY, NO CONTROL CONNECTIONS.

DOAS UNIT WILL PROVIDE 55 DEGREE AIR WHEN OUTSIDE AIR TEMPERATURES ARE HIGHER THAN 75 DEGREES. WHEN OUTSIDE AIR TEMPERATURES ARE LOWER THAN 75 DEGREES UNIT WILL PROVIDE NEUTRAL AIR AT 70 DEGREES (ADJ).

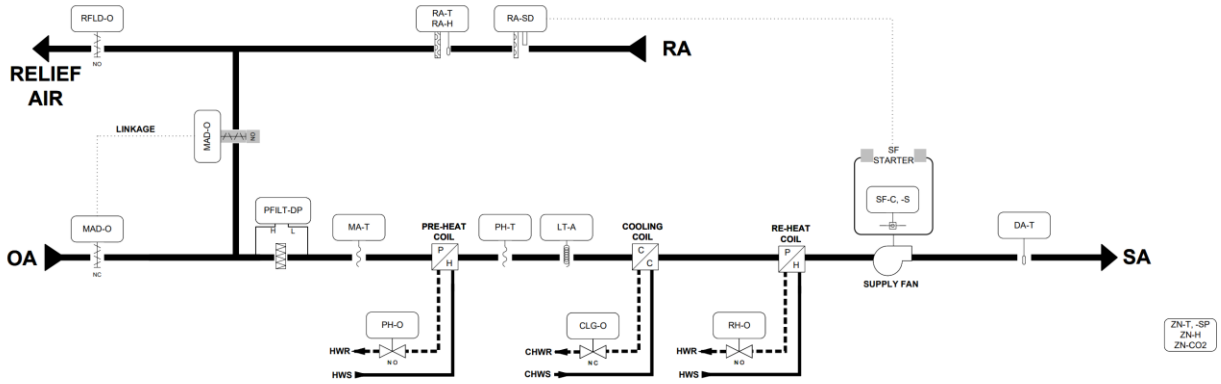
WHEN DOAS IS ENABLED THE DOAS EXHAUST FAN WILL OPERATE CONTINUOUSLY AND NOT SHUT DOWN IN A SMOKE DETECTOR ALARM. EXHAUST FAN WILL BE POWERED INDEPENDENTLY OF SUPPLY FAN AND WILL BE GENERATOR BACKED.

SF WILL CONTROL TO OA-F VIA OAFLOW-SP AND RF WILL OPERATE AT CONSTANT VOLUME VIA NETWORK SETPOINT FOR SPEED % FROM THE CGM.

RAD-O WILL NORMALLY BE AT 0% (CLOSED). IT CAN ONLY BE COMMANDED VIA OVERRIDE AND WILL NOT HAVE ANY LOGIC CONNECTIONS.

Building Automation System – Typical Single Zone Air Handling Unit Configuration

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
DA-T	1	TE-6311M-1	1000 OHM NICKEL - METAL ENCLC
LT-A	4	A70HA-1C	15/55F, DIFF 5 FIXED,1NO/1NC MA
	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
MA-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
MAD-O	8	M9220-GGA-3	20 NM SR DPR ACT 0(2) TO 10 VDC
PFILT-DP	4	DP1402X5U21D	UNIDIRECTIONAL 0 TO 2.5IN. W.C. 24 VDC / 4 TO 20 MA
	8	FTG18A-600R	SENSING TUBE KIT FOR P32
PH-T	4	TE-6001-8	AVER ELEMENT HLDR QTY =10
	4	TE-6316M-1	NICKEL DUCT AVERAGE SENSO
RA-T,-H	4	HE-69130NP-0	DUCT PROBE, 3%RH, NI TEMP
SF-C,-S	4	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
VFD	4	134U8810	DanFoss FC102 VFD 15 HP NEMA 3R ENCLOSURE

SEQUENCE OF OPERATION

LOCKED OUT UNTIL THE RETURN AIR TEMPERATURE RISES ABOVE THE PRE-PROGRAMMED WARM-UP SET POINT OF 65°F. WHEN THE RETURN AIR TEMPERATURE RISES ABOVE THE WANRN-UP TEMPERATURE, THE OUTSIDE AIR DAMPER WILL POSITION TO MINIMUM OUTSIDE AIR SETTING. HEATING AND COOLING WILL OPERATE IN SEQUENCE TO MAINTAIN THE SEPARATE HEATING AND COOLING SET POINTS (WITH ADJUSTABLE SET POINT UPPER AND LOWER LIMITS FOR HEATING AND COOLING). ON A RISE IN SPACE TEMPERATURE ABOVE HEATING SETPOINT (68°F) THE HEATING VALVE WILL MODULATE CLOSED AND SIGNAL TO MAIN MECHANICAL HEATING EQUIPMENT WILL BE TERMINATED. THE PRE-HEAT COIL CONTROL VALVES TO POSITION OPEN ANY TIME THE OUTSIDE AIR TEMPERATURE DROPS TO 38°F. WITH A RISE IN SPACE TEMPERATURE. THE CHILLED WATER COIL VALVE WILL MODULATE TO OPEN. THE COOLING LOOP WILL BE ENABLED BY THE SUPPLY FAN STATUS SWITCH AND WILL INCLUDE AN ADJUSTABLE RAMP FEATURE TO SLOW CONTROL VALVE OPENING TO 20 MINUTES ON START-UP ONLY.

HUMIDITY CONTROL:
A HUMIDITY TRANSMITTER LOCATED IN THE RETUM AIR DUCT WORK WITH SET POINT OF 50% (ADJUSTABLE) WILL CONTROL THE COOLING CONTROL VALVE AND REHEAT CONTROL VALVE WITH A RISE IN HUMIDITY.

SAFETY CONTROLS:
A PNEUMATIC MIXED AIR LOW LIMIT WILL MODULATE THE OUTSIDE AIR DAMPERS TO LIMIT THE MIXED AIR TEMPERATURE TO 55°F (ADJUSTABLE). MIXED AIR LOW LIMIT SAFETY CONTROLS WILL SHUT DOWN THE UNIT IF THE MIXED AIR TEMPERATURE DROPS BELOW 38F (ADJUSTABLE). DUCT SMOKE DETECTOR(S) WILL SHUT THE UNIT DOWN UPON SENSING PARTICLES OF COMBUSTION.

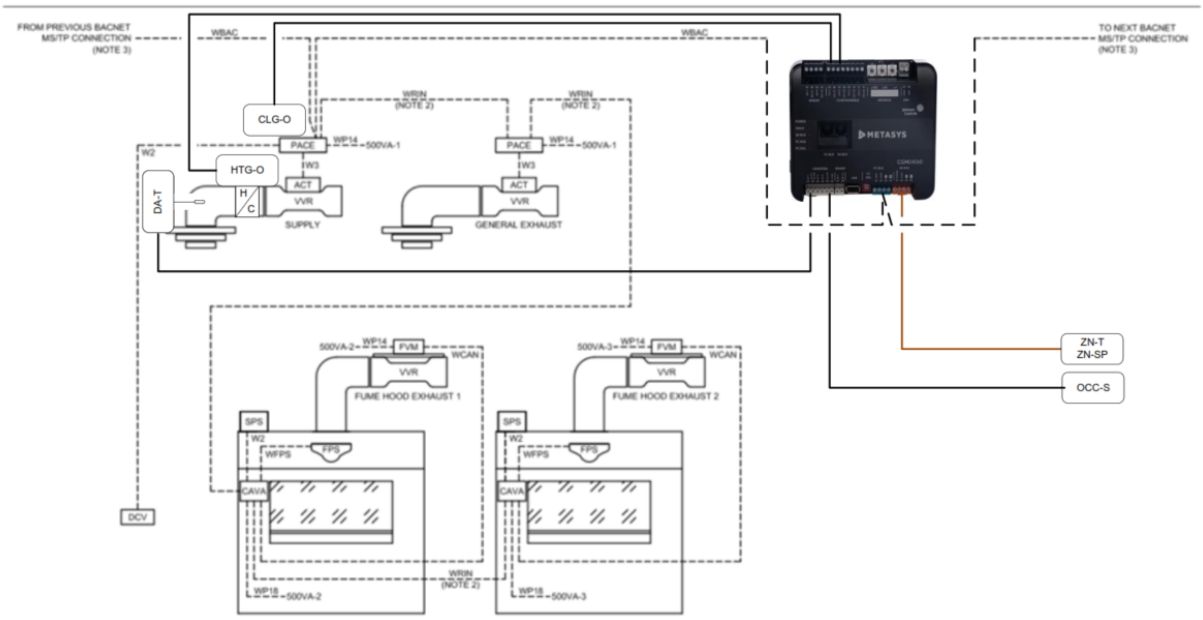
5 | Air Valves

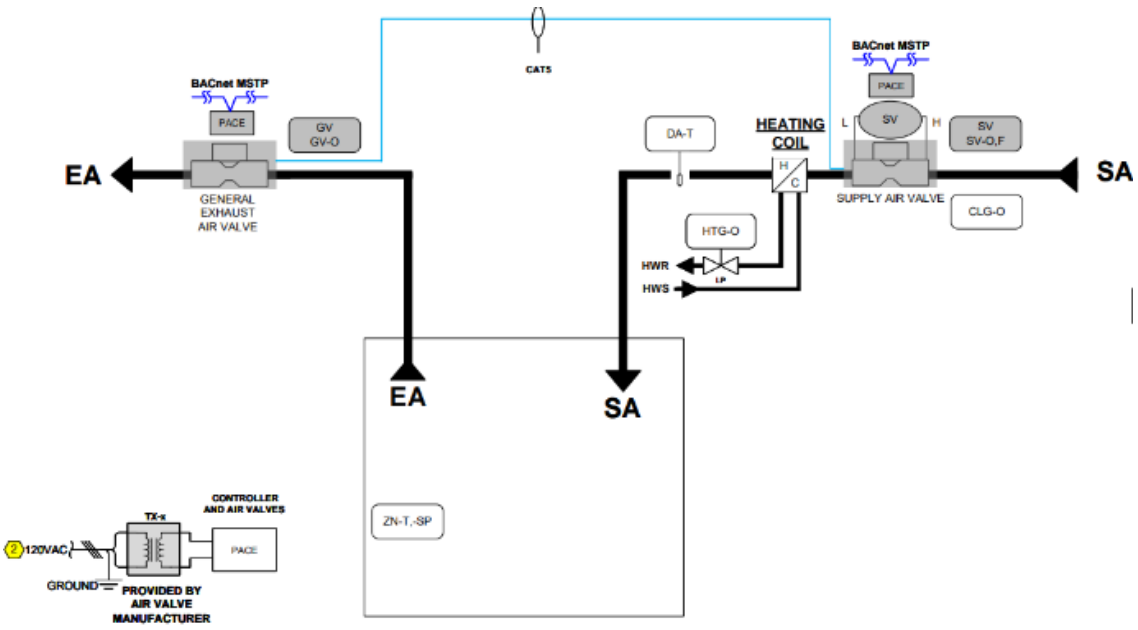
Building Automation System – Venturi Style Valve:

1. All new air valves must match existing air valves on campus. New air valves must be plunger style Venturi valve bodies.
2. All air valve manufacturers must communicate via BACnet MS/TP.
3. BMS Manufacturer will supply hot water valves and zone sensors to control comfort settings within lab spaces.
    a. BMS manufacturer DDC controller will control hot water valves and zone sensors as well as integrate to air valves manufacturer's individual controllers.

Building Automation System – General Lab Configuration:

1. Typical Wiring Diagram:





2.

Typical Sequence of Operations:

SEQUENCE OF OPERATION

PRESSURIZATION CONTROLS - SV & GV

THE PRESSURIZATION CONTROL SYSTEM SERVING ROOMS WITH ONE OR MORE SV AIR VALVES AND ONE OR MORE GV AIR VALVES WILL FUNCTION AS FOLLOWS:

1. **SUPPLY AIR VALVE CONTROL:** THE SUPPLY AIR VALVE WILL MODULATE TO MAINTAIN CONSTANT VOLUMETRIC OFFSET AS INDICATED ON THE DRAWINGS BASED ON THE SUM OF FUME HOOD AND GENERAL EXHAUST VALVE QUANTITIES. IF MEASURED DIFFERENTIAL PRESSURE ACROSS AIR VALVE IS OUTSIDE OF THE RANGE OF PRESSURE INDEPENDENCE, GENERATE AN ALARM. GENERATE A PRESSURE REQUEST TO THE ASSOCIATED AIR HANDLING UNIT ANYTIME MEASURED DIFFERENTIAL PRESSURE IS 0.4" WG OR LOWER.

2. **GENERAL EXHAUST VALVE CONTROL:** THE GENERAL EXHAUST VALVE WILL MODULATE TO MAINTAIN THE OCCUPIED AND UNOCCUPIED MINIMUM AIR CHANGE RATES AS SCHEDULED. OCCUPIED AND UNOCCUPIED STATUS WILL BE SET ON A SCHEDULE THROUGH THE BCS. UPON AN INCREASE IN SPACE TEMPERATURE ABOVE SETPOINT, MODULATE THE GENERAL EXHAUST AIR VALVE TO THE MAXIMUM FLOW TO MAINTAIN TEMPERATURE SETPOINT.

TEMPERATURE SET POINTS & OCCUPANCY SCHEDULE

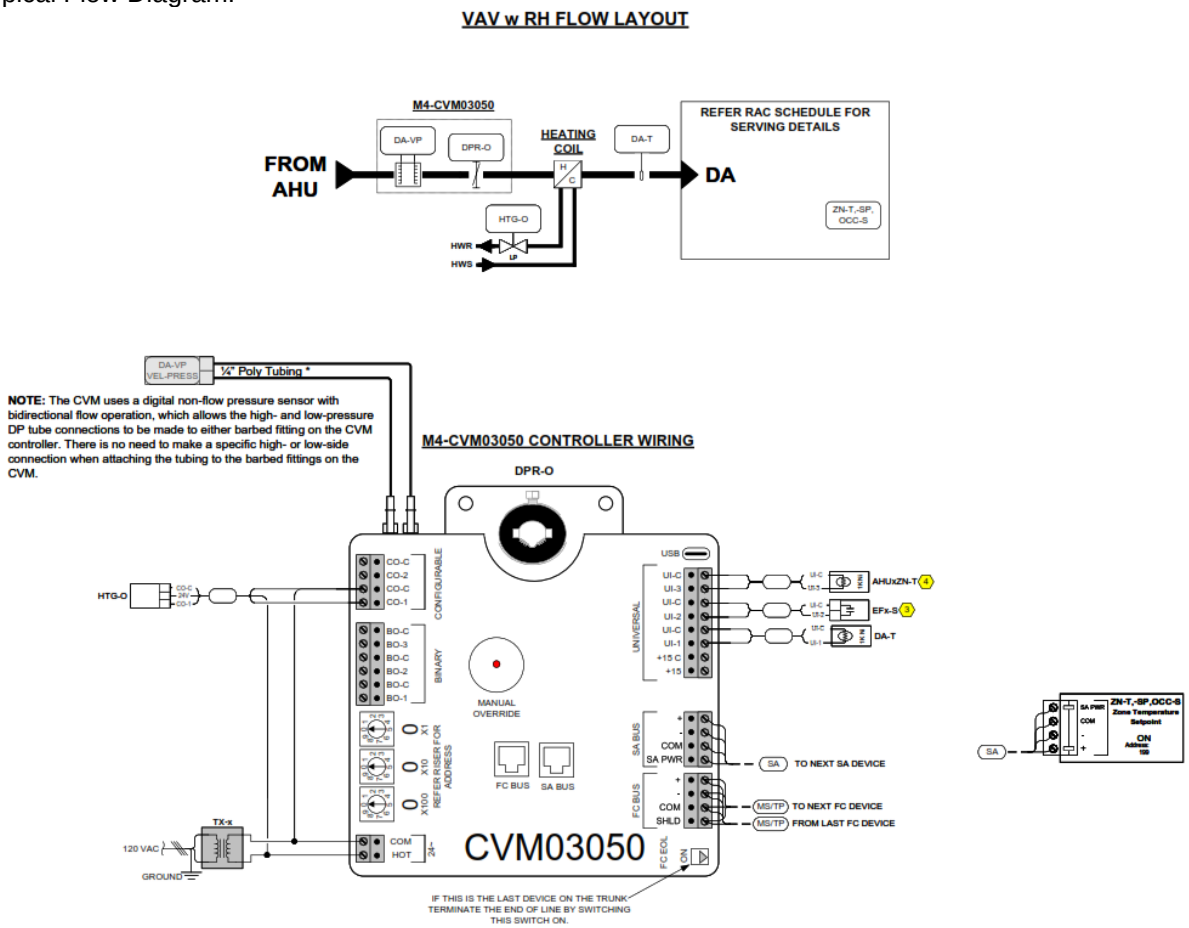
SPACE TEMPERATURE CONTROL: THE REHEAT COIL CONTROL VALVE WILL MODULATE TO MAINTAIN HEATING SPACE TEMPERATURE SETPOINT AS DEFINED.

SPACE TEMPERATURE CONTROL: FOR OFFICE SPACES SERVED BY TERMINAL UNITS, THREE SETPOINTS WILL APPLY. NORMAL (73°F, ADJUSTABLE), SETBACK HEATING (64°F, ADJUSTABLE), AND SETBACK COOLING (78°F, ADJUSTABLE). FOR ALL OTHER SPACES, THE NORMAL TEMPERATURE SETPOINT WILL APPLY AT ALL TIMES (NO SETBACKS WILL APPLY).
NORMAL TEMPERATURE SETPOINT MAY BE ADJUSTED BY THE OCCUPANT VIA THE LOCAL SENSOR SETPOINT ADJUSTMENT. THE RANGE OF ADJUSTMENT WILL BE CONFIGURABLE VIA THE BCS, INITIALLY +/-2°F.
NORMAL HOURS WILL BE FROM 6:00AM TO 11:00PM. SETBACK HOURS WILL BE FROM 11:00PM TO 6:00AM. THIS SCHEDULE WILL BE ADJUSTABLE. DURING THE NORMAL PERIODS, SEPARATE HEATING AND COOLING SETPOINTS WILL BE CALCULATED AS FOLLOWS:
A. NORMAL SPACE COOLING SETPOINT WILL BE THE EFFECTIVE SPACE TEMPERATURE SETPOINT PLUS 2°F (ADJUSTABLE).
B. NORMAL SPACE HEATING SETPOINT WILL BE THE EFFECTIVE SPACE TEMPERATURE SETPOINT MINUS 2°F (ADJUSTABLE).

6 | Terminal Units

Building Automation System – Typical Hot Water VAV Box:

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
DA-T	14	TE-631GV-2	DUCT PROBE TEMP SENSOR 1K NICKEL SENSOR 4IN PROBE
CVM	14	M4-CVM03050-0	8PT CNTL VAV W/ ACT & DPT, MSTP, B-AAC, RTC, 3 UI, 2 CO, 3 BO
ZN-T,OCC-S	14	NSB8MTN240-0	NETWORK SENSOR, 3"X4.5" MS/TP, TEMP, PIR, DISPLAY, SETPOINT,
Other Devices:			
HTG-O	14	VALVE	REFER VALVE SCHEDULE

SEQUENCE OF OPERATION

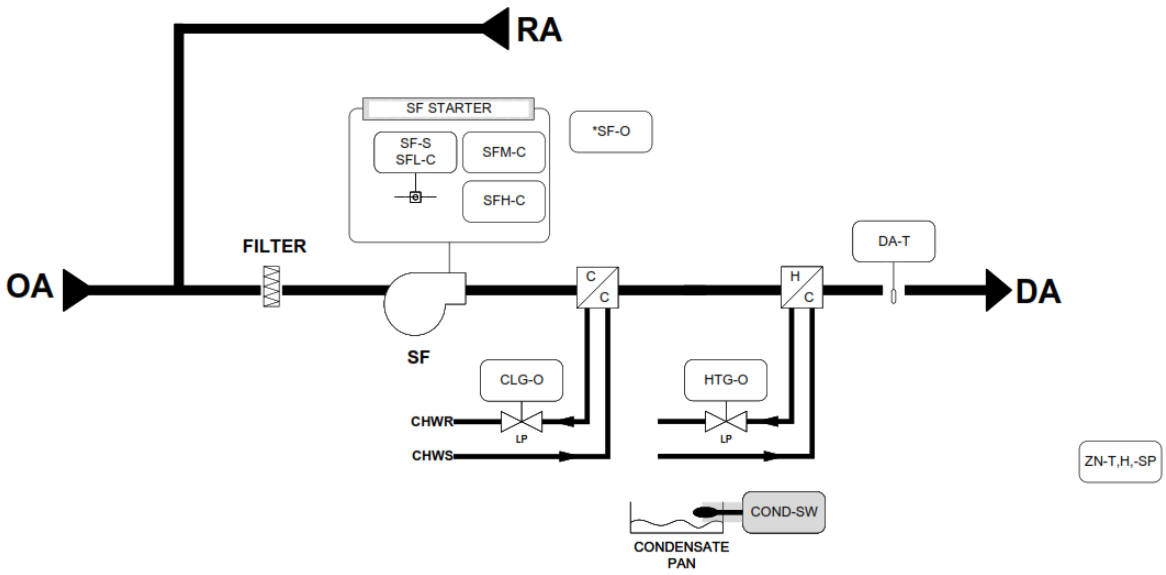
SEQUENCE OF OPERATION

EACH VAV BOX WILL BE CONTROLLED BY A UNIT MOUNTED DDC CONTROLLER. ON A CALL FOR COOLING THE AIR VALVE WILL BE MODULATED AS REQUIRED TO MAINTAIN ROOM TEMPERATURE SET POINT. AS SPACE TEMPERATURE DROPS BELOW SET POINT THE AIR VALVE WILL BE MODULATED TO MINIMUM HEATING POSITION. ON A CONTINUED DROP IN SPACE TEMPERATURE, THE HOT WATER REHEAT VALVE WILL BE MODULATED OPEN.

1 THE AIR TERMINAL UNIT AND ASSOCIATED AHU MAY BE PLACED INTO THEIR OCCUPIED MODES FOR A SCHEDULED OVERRIDE PERIOD FROM A CENTRAL COMMAND FROM THE BAS, OR THE AIR TERMINAL UNIT AND ASSOCIATED AHU MAY BE PLACED INTO THEIR OCCUPIED MODES FOR A 2-HOUR OVERRIDE PERIOD BY PUSHING THE OVERRIDE BUTTON LOCATED ON THE SPACE TEMPERATURE SENSOR SERVING THE AIR TERMINAL UNIT.

Building Automation System – Typical 4 Pipe Fan Coil Unit:

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
DA-T	1	TE-631GV-2	DUCT PROBE TEMP SENSOR 1K NICKEL SENSOR 4IN PROBE
CGM	1	M4-CGM09090-0	18 PT CNTL GENPURP, MSTP, B-AAC, RTC, 7 UI, 2 BI, 4 CO, 2 AO,
SFL-C,-S	1	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
ZN-T,H,SP	1	NSB8BHN240-0	NETWORK SENSOR, 3X4.5 MS/TP, TEMP, HUMIDITY,DISPLAY, SETPOINT, WHITE
RELAY	1	RIB24P	ENCLOSED RELAY 20 AMP DPDT WITH 24 VAC/DC COIL
SFH-C	1	RR10NN	PILOT RELAY, 10A, SPDT
SFM-C	1	RR10NN	PILOT RELAY, 10A, SPDT
Other Devices:			
CLG-O	1	VALVE	SEE VALVE SCHEDULE
HTG-O	1	VALVE	SEE VALVE SCHEDULE

SEQUENCE OF OPERATION

A. GENERAL:

1 FAN COIL UNITS WILL BE CONTROLLED BY A STANDALONE DDC CONTROLLER WITH WALL MOUNTED ROOM TEMPERATURE SENSOR/COMMAND MODULE.

2 COMMAND MODULE WILL BE PROVIDED WITH FAN SPEED OVERRIDE BUTTON THAT WILL PROVIDE LOCAL UNIT START/STOP AND FAN SPEED ADJUSTMENT FROM LOW SPEED TO MEDIUM SPEED TO HIGH SPEED. COMMAND MODULE WILL ALSO BE PROVIDED WITH SET POINT ADJUSTMENT AND DIGITAL DISPLAY FOR LOCAL READOUT OF ROOM TEMPERATURE, ROOM TEMPERATURE SET POINT AND FAN COMMAND STATUS (I.E. ON/OFF, LOW SPEED/MEDIUM SPEED/HIGH SPEED).

3 PROVIDE SUPPLY AIR DISCHARGE TEMPERATURE SENSOR FOR MONITORING ONLY.

B. START STOP:

1 EACH FCU WILL RUN CONTINUOUSLY BUT WILL HAVE THE ABILITY TO BE STARTED AND STOPPED BY THE FMS SYSTEM OR THE LOCAL FAN SPEED SWITCH.

2 EACH FCU LOCATED IN A STUDY ROOM, LIVING ROOM OR COMMUNITY ROOM WILL BE STARTED AND STOPPED BASED ON A TIME OF DAY SCHEDULE.

C. SAFETIES:

1 EACH FCU WILL BE PROVIDED WITH A DRAIN PAN FLOAT SWITCH. FLOAT SWITCH WILL BE WIRED TO ALARM AT THE CCMS AND TO SHUT OFF FAN AND CLOSE VALVES WHENEVER EXCESS WATER IS DETECTED IN DRAIN PAN.

D. TEMPERATURE CONTROL:

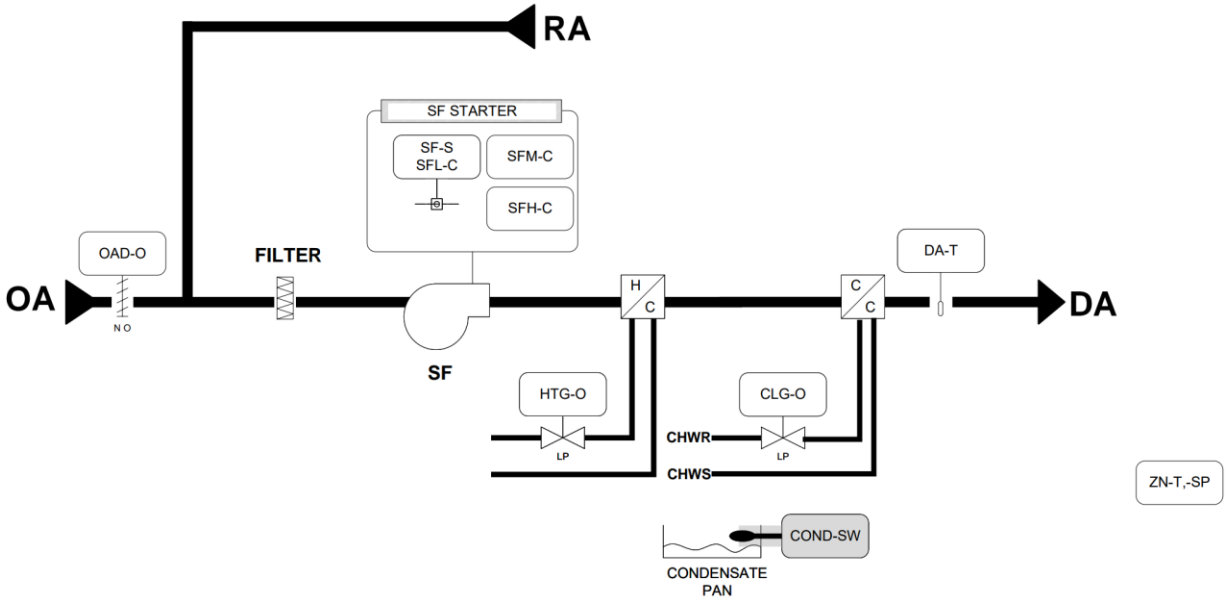
1 ROOM TEMPERATURE, AS SENSED BY WALL MOUNTED ROOM TEMPERATURE SENSOR, WILL BE CONTROLLED BY MODULATING THE FAN COIL UNIT CHW AND HW CONTROL VALVES AS REQUIRED TO MAINTAIN ROOM TEMPERATURE SET POINT.

E. DEHUMIDIFICATION CONTROL:

1. ROOM HUMIDITY, AS SENSED BY THE WALL MOUNTED ROOM HUMIDITY SENSOR, WILL BE CONTROLLED BY MODULATING THE FAN COIL UNIT CHW CONTROL VALVE OPEN TO MAINTAIN ROOM HUMIDITY SETPOINT. IF THE ROOM TEMPERATURE DROPS BELOW ROOM TEMPERATURE HEATING SETPOINT DURING DEHUMIDIFICAITON, THE HW CONTROL VALVE WILL BE MODULATED TO MAINTAIN ROOM TEMPERATURE ABOVE ROOM TEMPARATURE HEATING SETPOINT

Building Automation System – Typical 4 Pipe Fan Coil Unit with Outside Air:

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
DA-T	1	TE-631GV-2	DUCT PROBE TEMP SENSOR 1K NICKEL SENSOR 4IN PROBE
CGM	1	M4-CGM09090-0	18 PT CNTL GENPURP, MSTP, B-AAC, RTC, 7 UI, 2 BI, 4 CO, 2 AO,
SFL-C,-S	1	CSDSC-C50100L1	CURR SW SELF CAL CLMP 0.50A-100A RLY OPT 24V NO
ZN-T,H,SP	1	NSB8BHN240-0	NETWORK SENSOR, 3X4.5 MS/TP, TEMP, HUMIDITY,DISPLAY, SETPOINT, WHITE
RELAY	1	RIB24P	ENCLOSED RELAY 20 AMP DPDT WITH 24 VAC/DC COIL
SFH-C	1	RR10NN	PILOT RELAY, 10A, SPDT
SFM-C	1	RR10NN	PILOT RELAY, 10A, SPDT
Other Devices:			
CLG-O	1	VALVE	SEE VALVE SCHEDULE
HTG-O	1	VALVE	SEE VALVE SCHEDULE

SEQUENCE OF OPERATION

A. GENERAL:

1 FAN COIL UNITS WILL BE CONTROLLED BY A STANDALONE DDC CONTROLLER WITH WALL MOUNTED ROOM TEMPERATURE SENSOR/COMMAND MODULE.

2 COMMAND MODULE WILL BE PROVIDED WITH FAN SPEED OVERRIDE BUTTON THAT WILL PROVIDE LOCAL UNIT START/STOP AND FAN SPEED ADJUSTMENT FROM LOW SPEED TO MEDIUM SPEED TO HIGH SPEED. COMMAND MODULE WILL ALSO BE PROVIDED WITH SET POINT ADJUSTMENT AND DIGITAL DISPLAY FOR LOCAL READOUT OF ROOM TEMPERATURE, ROOM TEMPERATURE SET POINT AND FAN COMMAND STATUS (I.E. ON/OFF, LOW SPEED/MEDIUM SPEED/HIGH SPEED).

3 PROVIDE SUPPLY AIR DISCHARGE TEMPERATURE SENSOR FOR MONITORING ONLY.

B. START STOP:

1 EACH FCU WILL RUN CONTINUOUSLY BUT WILL HAVE THE ABILITY TO BE STARTED AND STOPPED BY THE FMS SYSTEM OR THE LOCAL FAN SPEED SWITCH.

2 EACH FCU LOCATED IN A STUDY ROOM, LIVING ROOM OR COMMUNITY ROOM WILL BE STARTED AND STOPPED BASED ON A TIME OF DAY SCHEDULE.

3. THE OUTSIDE AIR DAMPER WILL BE COMMANDED OPEN WHEN THE SUPPLY FAN IS COMMANED ON, THE OUTSIDE AIR DAMPER WILL BE COMMANDED CLOSED WHEN THE SUPPLY FAN IS COMMANDED OFF.

C. SAFETIES:

1 EACH FCU WILL BE PROVIDED WITH A DRAIN PAN FLOAT SWITCH. FLOAT SWITCH WILL BE WIRED TO ALARM AT THE CCMS AND TO SHUT OFF FAN AND CLOSE VALVES WHENEVER EXCESS WATER IS DETECTED IN DRAIN PAN.

D. TEMPERATURE CONTROL:

1 ROOM TEMPERATURE, AS SENSED BY WALL MOUNTED ROOM TEMPERATURE SENSOR, WILL BE CONTROLLED BY MODULATING THE FAN COIL UNIT CHW AND HW CONTROL VALVES AS REQUIRED TO MAINTAIN ROOM TEMPERATURE SET POINT.

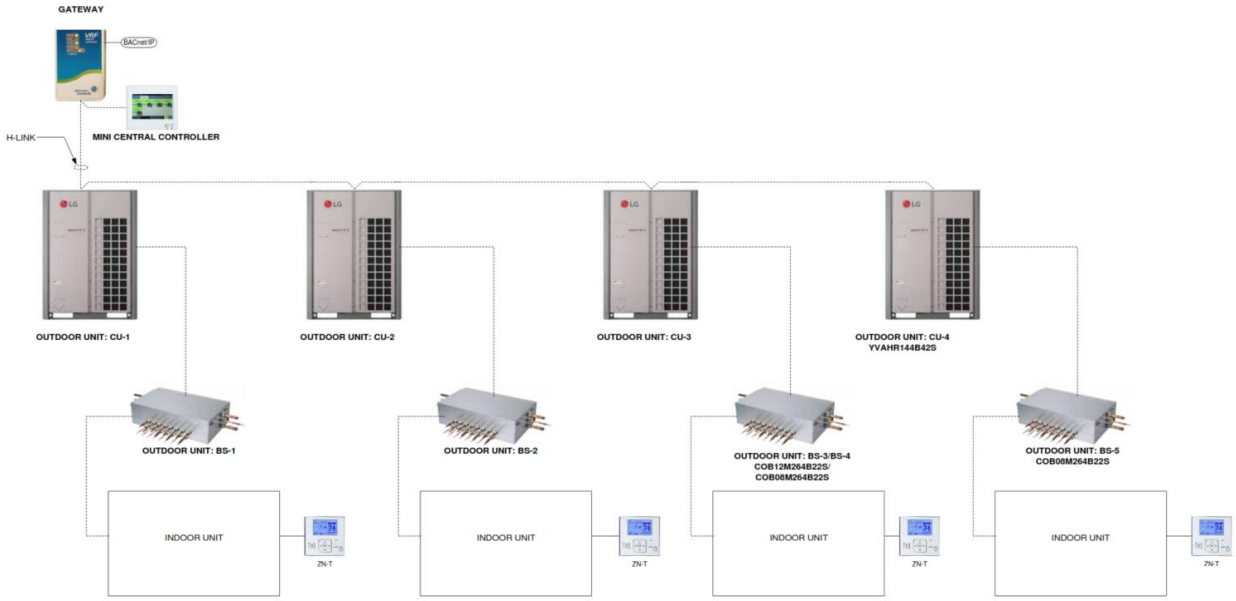
E. DEHUMIDIFICATION CONTROL:

1. ROOM HUMIDITY, AS SENSED BY THE WALL MOUNTED ROOM HUMIDITY SENSOR, WILL BE CONTROLLED BY MODULATING THE FAN COIL UNIT CHW CONTROL VALVE OPEN TO MAINTAIN ROOM HUMIDITY SETPOINT. IF THE ROOM TEMPERATURE DROPS BELOW ROOM TEMPERATURE HEATING SETPOINT DURING DEHUMIDIFICAITON, THE HW CONTROL VALVE WILL BE MODULATED TO MAINTAIN ROOM TEMPERATURE ABOVE ROOM TEMPARATURE HEATING SETPOINT

7 | VRF System

Building Automation System – Multizone VRF System:

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

1. VARIABLE REFRIGERANT FLOW (VRF) SYSTEM SEQUENCE OF OPERATION:
A. THIS SEQUENCE OF OPERATIONS DESCRIBES THE "SYSTEM-LEVEL" CONTROL FUNCTIONS OF A VARIABLE REFRIGERANT FLOW (VRF) SYSTEM, WHICH INCLUDES COORDINATING THE OPERATION OF THE OUTDOOR UNIT WITH TERMINAL UNITS DURING THE VARIOUS OPERATING MODES. THE "EQUIPMENT-LEVEL" CONTROL FUNCTIONS OF THE OUTDOOR UNIT AND THE TERMINAL UNITS ARE CONTAINED IN THEIR RESPECTIVE SEQUENCE OF OPERATIONS DOCUMENTS.

2. VARIABLE REFRIGERANT FLOW (VRF) HEAT RECOVERY SYSTEM:
A. A HEAT RECOVERY SYSTEM WILL PROVIDE SYNCHRONOUS/SIMULTANEOUS HEATING AND COOLING TO INDIVIDUAL ZONES SERVED BY THE VRF SYSTEM. THE STATE OF THE VRF SYSTEM IS OFF WHEN THE OUTDOOR UNIT IS OFF AND ALL TERMINAL UNITS ARE OFF. WHEN ANY TERMINAL UNIT TRANSITIONS TO THE ON STATE, THE OUTDOOR UNIT WILL TRANSITION TO THE ON STATE AND THE VRF SYSTEM WILL TRANSITION TO THE ON STATE.

B. WHILE THE VRF SYSTEM IS IN THE ON STATE, THE OUTDOOR UNIT SUPPLIES SUBCOOLED LIQUID AND SUPER-HEATED GAS REFRIGERANT TO THE REFRIGERANT MANIFOLD DEVICE(S). THE REFRIGERANT MANIFOLD DEVICE WILL SIMULTANEOUSLY DISTRIBUTE LIQUID REFRIGERANT TO TERMINAL UNITS REQUESTING COOLING, AND GAS REFRIGERANT TO TERMINAL UNITS REQUESTING HEAT. EACH TERMINAL UNIT WILL COMMUNICATE TO THE OUTDOOR UNIT THE NEED FOR HEATING OR COOLING.

C. WHILE THE OUTDOOR UNIT IS IN THE ON STATE, IF ALL OF THE TERMINAL UNITS TRANSITION TO THE OFF STATE, THE OUTDOOR UNIT WILL TRANSITION TO THE SHUTDOWN STATE. ENTERING THIS STATE WILL CAUSE THE OUTDOOR UNIT TO PERFORM THE NECESSARY FUNCTIONS REQUIRED TO PREPARE THE REFRIGERANT SYSTEM TO STOP OPERATION. ONCE THE REFRIGERANT SYSTEM HAS STOPPED OPERATION, THE OUTDOOR UNIT WILL TRANSITION TO THE OFF STATE AND THE VRF SYSTEM STATE WILL TRANSITION TO THE OFF STATE.

3. BUILDING AUTOMATION SYSTEM CONTROL:
A. THE BUILDING AUTOMATION SYSTEM (BAS) IS A COMPUTER BASED, APPLICATION THAT PROVIDES A METHOD FOR A BUILDING OPERATOR TO MONITOR AND CONTROL THE OPERATION OF A BUILDING. THE BAS COORDINATES THE ACTIONS OF ONE OR MORE BUILDING SUB-SYSTEMS (HVAC, LIGHTING, ETC.). THE PURPOSE OF THE SYSTEM IS TO PROVIDE A SAFE AND COMFORTABLE OCCUPANT ENVIRONMENT USING ADVANCED CONTROL STRATEGIES TO MINIMIZE THE ENVIRONMENTAL FOOTPRINT OF THE BUILDING.

B. THE BAS WILL HAVE THE ABILITY TO MONITOR AND DISPLAY DATA EMANATING FROM ANY PIECE OF EQUIPMENT CONNECTED TO THE SYSTEM IN HUMAN READABLE FORM. THE BAS WILL HAVE THE ABILITY TO PERFORM BUILDING LEVEL CONTROL FUNCTIONS SUCH AS, BUT NOT LIMITED TO, TIME SCHEDULE-BASED SYSTEM OPERATION, RECORDING OF OPERATING PARAMETER DATA VALUES AS A TIME OR SAMPLE SERIES, COLLECTION AND ANNUNCIATION FOR ALARMS GENERATED BY EQUIPMENT, AND CONTROL OF EQUIPMENT WITHIN THE BUILDING.

C. THE BAS WILL MONITOR THE STATUS OF THE ZONE(S) IN THE BUILDING SERVED BY THE VARIABLE REFRIGERANT FLOW (VRF) SYSTEM AND SEND COMMANDS TO THE VRF TERMINAL UNIT(S) TO MAINTAIN THE ENVIRONMENT IN THE ZONE.

D. THE VRF SYSTEM WILL USE THE LAST CONTROL COMMANDS AND VALUES RECEIVED FROM ANY CONTROL DEVICE (BAS, SPACE CONTROLLER, ETC.) TO MAINTAIN THE ENVIRONMENT IN THE ZONE.

4. UNOCCUPIED ZONE TEMPERATURE CONTROL:
A. UNOCCUPIED ZONE TEMPERATURE (UZT) CONTROL IS AN ENERGY MINIMIZATION STRATEGY. THE BAS WILL MONITOR THE TIME SCHEDULE(S) CONTROLLING A GROUP(S) OF TERMINAL UNITS. WHEN THE TIME SCHEDULE TRANSITIONS FROM THE OCCUPIED STATE TO THE UNOCCUPIED STATE, THE TERMINAL UNITS WILL TRANSITION FROM THE OCCUPIED STATE TO THE UNOCCUPIED STATE, AND THE UZT ALGORITHM WILL BE ENABLED.

B. WHILE ENABLED, THE UZT ALGORITHM WILL MONITOR THE AIR TEMPERATURE OF EACH ZONE IN THE GROUP, CALCULATE THE AVERAGE ZONE AIR TEMPERATURE, AND COMPARE THE AVERAGE VALUE TO THE UNOCCUPIED COOLING AND UNOCCUPIED HEATING ZONE TEMPERATURE SETPOINTS.

C. WHEN THE AVERAGE ZONE AIR TEMPERATURE IS ABOVE THE UNOCCUPIED COOLING ZONE TEMPERATURE SETPOINT, THE TERMINAL UNITS IN THE GROUP WILL TRANSITION FROM THE UNOCCUPIED STATE TO THE OCCUPIED STATE. THIS WILL CAUSE THE VRF SYSTEM TO TRANSITION FROM THE OFF STATE TO THE ON STATE, ALLOWING THE GROUP OF ZONES TO BE COOLED.

D. WHEN THE AVERAGE ZONE AIR TEMPERATURE IS BELOW THAN THE UNOCCUPIED COOLING ZONE TEMPERATURE SETPOINT MINUS A DEAD BAND VALUE, THE TERMINAL UNITS IN THE GROUP WILL TRANSITION FROM THE OCCUPIED STATE TO THE UNOCCUPIED STATE. ONCE ALL TERMINAL UNITS IN THE VRF SYSTEM ARE IN THE UNOCCUPIED STATE, THE VRF SYSTEM WILL TRANSITION FROM THE ON STATE TO THE OFF STATE.

E. CONVERSELY, WHEN THE AVERAGE ZONE AIR TEMPERATURE IS BELOW THE UNOCCUPIED HEATING ZONE TEMPERATURE SETPOINT, THE TERMINAL UNITS IN THE GROUP WILL TRANSITION FROM THE UNOCCUPIED STATE TO THE OCCUPIED STATE. THIS WILL CAUSE THE VRF SYSTEM TO TRANSITION FROM THE OFF STATE TO THE ON STATE, ALLOWING THE GROUP OF ZONES TO BE HEATED.

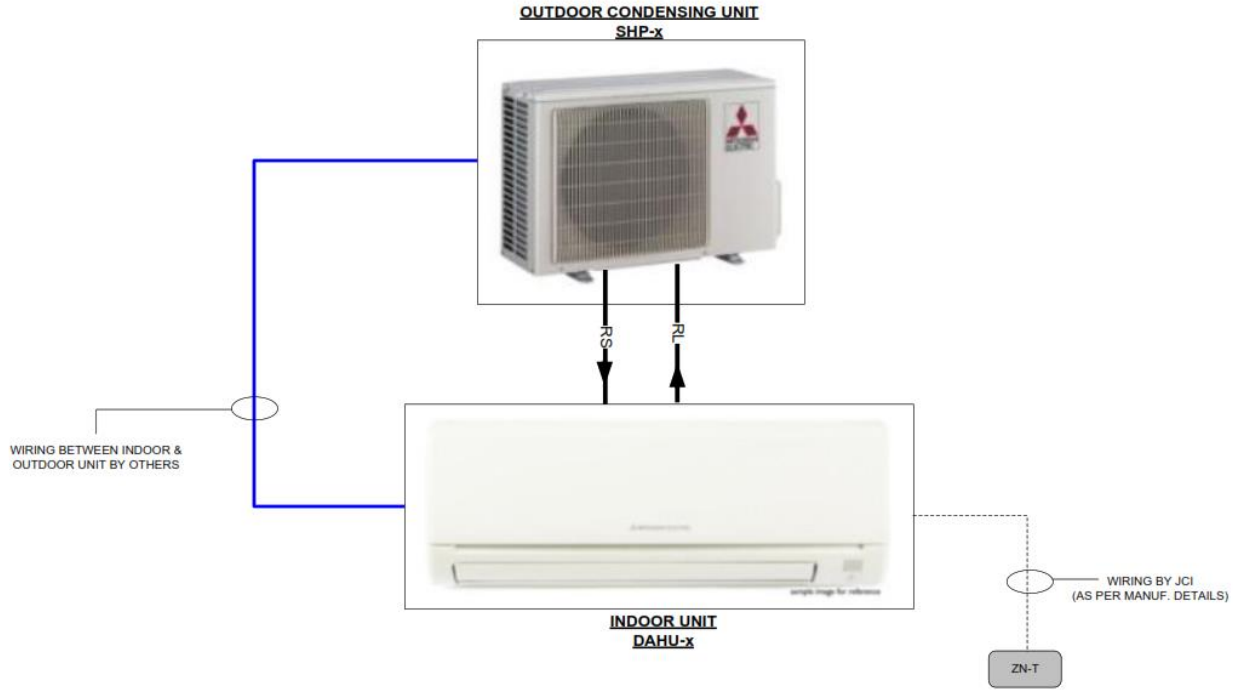
F. WHEN THE AVERAGE ZONE AIR TEMPERATURE IS ABOVE THE UNOCCUPIED HEATING ZONE TEMPERATURE SETPOINT PLUS A DEAD BAND VALUE, THE TERMINAL UNITS IN THE GROUP WILL TRANSITION FROM THE OCCUPIED STATE TO THE UNOCCUPIED STATE. ONCE ALL TERMINAL UNITS IN THE VRF SYSTEM ARE IN THE UNOCCUPIED STATE, THE VRF SYSTEM WILL TRANSITION FROM THE ON STATE TO THE OFF STATE.

G. WHEN THE TIME SCHEDULE CONTROLLING THE GROUP OF TERMINAL UNITS TRANSITIONS FROM THE UNOCCUPIED STATE TO THE OCCUPIED STATE, ALL TERMINAL UNITS WILL TRANSITION FROM THE UNOCCUPIED STATE TO THE OCCUPIED STATE AND THE UZT ALGORITHM WILL BE DISABLED. WHILE DISABLED, THE UZT ALGORITHM IS DORMANT.

5. OA TEMPERATURE CONTROL:
A. WHEN THE VRF SYSTEM TRANSITIONS TO A DEDICATED OUTDOOR AIR SYSTEM (DOAS), THE DOAS SYSTEM WILL CONDITION INTAKE AIR BY ADDING OR REMOVING HEAT SO THAT THE TEMPERATURE OF THE AIR DISCHARGED FROM THE UNIT IS EQUAL TO THE DOAS DISCHARGE TEMPERATURE SETPOINT.

Building Automation System – Typical Ductless Split:

1. Typical Flow Diagram:



2. Typical Sequence of Operations:

SEQUENCE OF OPERATION

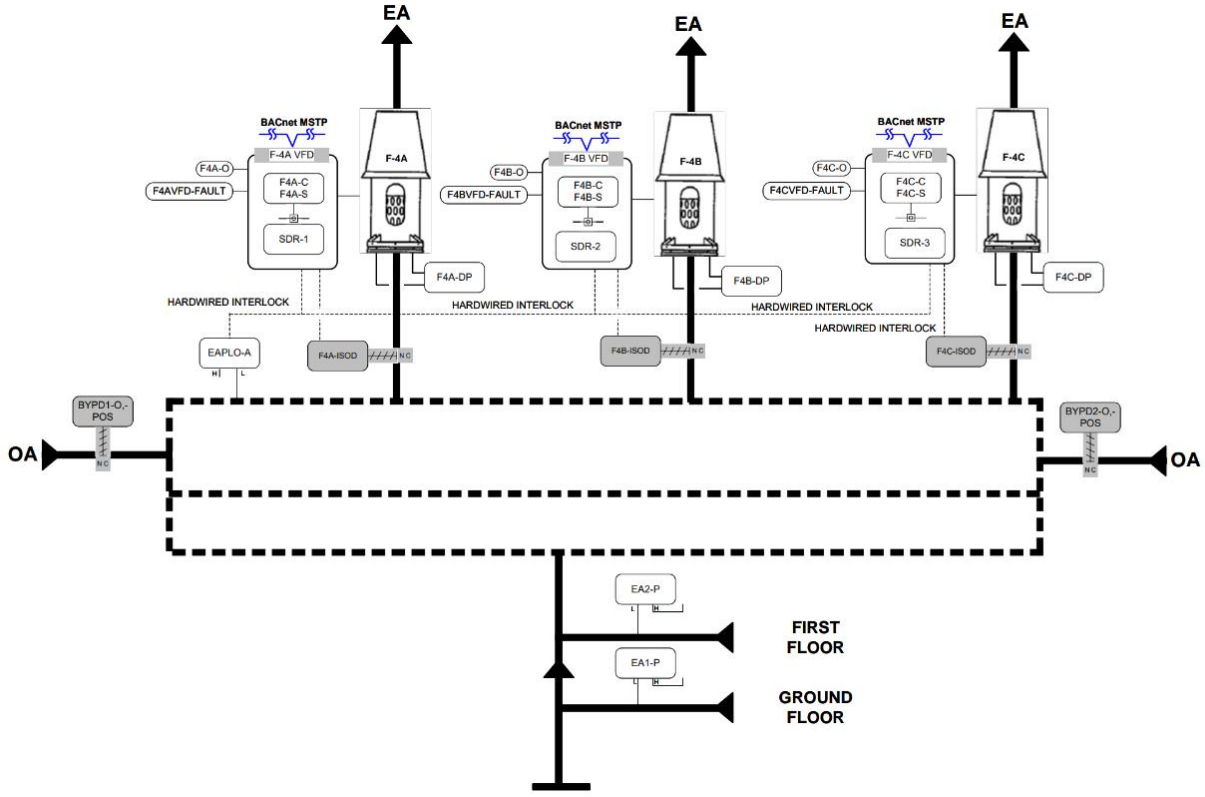
ALL CONTROLS FOR THE DUCTLESS SPLIT SYSTEM HEAT PUMP WILL BE PROVIDED BY THE EQUIPMENT MANUFACTURER. JCI WILL INSTALL AND WIRE THE ZONE TEMPERATURE (PROVIDED BY OTHERS) AS PER MANUF. RECOMMENDATION.

A) If ductless split system comes with BACnet communication, Johnson Controls will integrate to the ductless split system via the zone temperature sensor.
B) Clemson University and Engineer of record to determine if system requires network integration and system alarms.

8 | Exhaust Fans

Building Automation System – Exhaust Fans:

1. Typical Flow Diagram: Lab Exhaust Fan



2. Typical Sequence of Operations:

BILL OF MATERIAL

DESIGNATION	QTY.	CODE NUMBER.	DESCRIPTION
Field Devices:			
EAPLO-A	1	AFS-460	DIFFERENTIAL PRESSURE SWITCH, 0.06-12 WC, ADJUSTABLE, SPST (N
	1	FTG18A-600R	SENSING TUBE KIT FOR P32
EAx-P	2	FTG18A-600R	SENSING TUBE KIT FOR P32
	2	DP140005U11C	UNIDIRECTIONAL 0 TO 5IN. W.C. 0 TO 5 VDC
F4X-C,-S	3	CSDSC-VFD1	VFD AUTO CURRENT SWITCH, SPLIT CORE, 1-135A, NO 24VAC/DC
F4X-DP	3	DP140025U11D	UNIDIRECTIONAL 0 TO 25IN. W.C. 0 TO 5 VDC
	6	FTG18A-600R	SENSING TUBE KIT FOR P32
SDR-x	3	RR10NN	PILOT RELAY, 10A, SPDT
Panel Devices:			
F4-CP	1	P2DAN-BEHB2N01 36X24X6.5,P	PANEL, M4-CGM09090-0H INT DISPLAY, XPM09090-0,

SEQUENCE OF OPERATION

SEQUENCES OF CONTROL: LABORATORY EXHAUST FANS

A. GENERAL: THE VARIABLE AIR VOLUME REDUNDANT MANIFOLD EXHAUST FAN SYSTEM WILL BE FULLY CONTROLLED BY THE BAS. THIS SYSTEM WILL RUN CONTINUOUSLY AND REQUIRES OPERATOR OVERRIDE TO STOP.

B. TYPICAL EXHAUST FAN CONTROL: THE BAS WILL CONTROL THE STARTING AND STOPPING OF EACH EXHAUST FAN AS FOLLOWS.
1. START/STOP: THE BAS WILL COMMAND THE AT LEAST ONE FAN TO RUN CONTINUOUSLY. THE FANS WILL BE IN THE LEAD-LAG-STANDBY ARRANGEMENT. THE LEAD/LAG/STANDBY FANS WILL ROTATE EVERY TUESDAY AT 6:00 AM (ADJUSTABLE) OR WHEN MANUALLY SELECTED BY THE OPERATOR.
2. THE MANIFOLD EXHAUST FAN SYSTEM CONSIST OF EXHAUST FANS F-4A, 4B & 4C AND THEIR RESPECTIVE EXHAUST FAN INLET DAMPERS; D-4A, 4B & 4C AND OUTSIDE AIR INTAKE DAMPER D-1 & 2. THE FANS ARE STARTED AND STOPPED BY THE CONTROLLER. THEY ARE STARTED ON DEMAND VIA A LEAD-LAG SEQUENCE WITH A MINIMUM OF ONE FAN AND A MAXIMUM OF TWO FANS OPERATING AT ANY ONE TIME. THE CONTROLLER WILL OPEN THE FANS RESPECTIVE INLET DAMPER WHEN STARTING FAN. IF FAN INLET DAMPER STATUS SWITCH FAILS TO PROVE OPEN AFTER 30 SECONDS, FAN WILL SHUT DOWN AND AN ALARM SIGNALED. WHEN TWO OR MORE FANS ARE RUNNING, THE CONTROLLER MODULATES THEIR VFD CONTROLLERS IN UNISON IN ORDER TO MAINTAIN PRESET EXHAUST DUCT STATIC PRESSURE, AS SENSED BY DUCT STATIC PRESSURE SENSORS. THE CONTROLLER SELECTS THE LOWER OF THE TWO STATIC PRESSURE SIGNALS AS ITS CONTROLLER INPUT. WHEN ANY FAN IS STARTED ITS RESPECTIVE MOTORIZED INLET DAMPER IS OPENED. CONVERSELY, WHEN ANY FAN IS STOPPED, ITS INLET DAMPER IS CLOSED.

C. EXHAUST DUCT STATIC PRESSURE CONTROL:
1. GENERAL: THE EXHAUST FANS WILL BE RAMPED UP AND DOWN AND SEQUENCED ON/OFF BASED ON THE EXHAUST DEMAND FROM THE FUME HOODS/POINT EXHAUST IN THE STACKS. THE STACK DIFFERENTIAL PRESSURE SENSORS WILL BE MONITORED AT ALL TIMES AND THE FANS WILL BE RAMPED/STAGED TO MAINTAIN THE EXHAUST MAINS AT THE STATIC PRESSURE SETPOINT.
2. OPERATIONAL LIMITS: THE FANS WILL HAVE OPERATIONAL LIMITS AS SET DURING TESTING AND BALANCING TO THE MINIMUM AND MAXIMUM SPEEDS TO MAINTAIN THE FANS DISCHARGE STACK VELOCITY/FLOW. THESE WILL BE THE OPERATIONAL LIMITS OF EACH FAN.

SEQUENCE OF OPERATION

3. VFD CONTROL: UPON INTIAL START, EXHAUST FAN SPEED WILL BE CONSTRAINED TO MINIMUM UNTIL THE ISOLATION DAMPER LIMIT SWITCH POSITION IS PROVEN OPEN. UPON PROOF OF DAMPER POSITION, BAS WILL WILL CONTROL THE SPEED OF ALL VFD'S OF FANS IN OPERATION TO MAINTAIN EXHAUST STATIC PRESSURE SENSORS AT SET POINT. ON START AND STOP, THE VFDS WILL RAMP TO SPED AND SLOW DOWN WITHIN ADJUSTABLE ACCELERATION AND DECELERATION LIMITS. MINIMUM VFD SPEEDS WILL BE SET AT 70% OF FULL SPEED (CORRESPONDING TO A MINIMUM STACK DISCHARGE VELOCITY OF 3,000 FPM).
4. AIRFLOW MONITORING: THE BAS WILL MONITOR THE DIFFERENTIAL PRESSURE ACROSS THE INLET CONE OF THE FAN WITH THE MANUFACTURER'S FLOW EQUATION. THE BAS WILL REPORT THE FAN AIRLFOW FOR EACH FAN.

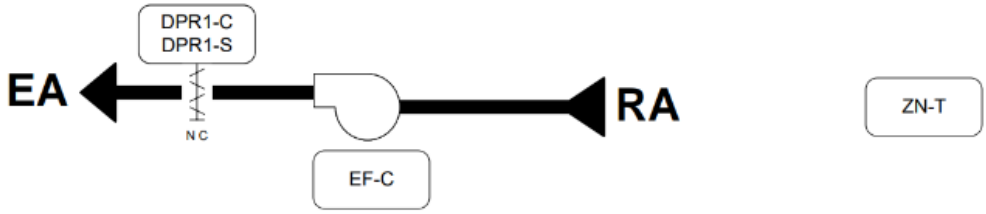
D. DAMPER CONTROL:
1. EXHAUST FAN ISOLATION DAMPER: EACH ISOLATION DAMPER WILL BE COMMANDED OPEN WHEN ITS ASSOCIATED FAN VFD IS COMMANDED TO START. UPON PROOF OF DAMPER OPENING (VIA END SWITCH), THE BAS WILL ALLOW FAN TO RAMP UP FROM ITS MINIMUM SPEED. BAS WILL MONITOR CONTACTS ON END SWITCHES AND DAMPER ACTUATORS TO REFLECT ACTUAL POSITION ON GRAPHICS. BAS WILL GENERATE AN ALARM WHEN COMMANDED DAMPER POSITION DOES NOT MATCH ACTUAL WITHIN 30 SECONDS.
2. OUTSIDE AIR BYPASS DAMPERS: UPON SYSTEM START, THE OUTSIDE AIR BYPASS DAMPERS WILL BE CLOSED. WHEN EXHAUST FAN(S) ARE OPERATING AT MINIMUM SPEED FOR 1 MINUTE (ADJUSTABLE) CONTINUOUSLY AND THE MEASURED EXHAUST DUCT STATIC PRESSURE SENSORS ARE BOTH ABOVE SET POINT, THEN THE OUTSIDE AIR BYPASS DAMPER WILL BE SLOWLY MODULATED OPEN TO MAINTAIN TOTAL AIRFLOW FOR STACK DISCHARGE VELOCITY AT SET POINT. UPON A DROP IN DUCT STATIC PRESSURE THE REVERSE WILL OCCUR.
   A. OUTSIDE AIR BYPASS DAMPERS WITH 2 FANS OPERATING: THE OUTSIDE AIR BYPASS DAMPERS WILL OPERATE IN LEAD/LAG AND BE ROTATED ONCE A WEEK. IF THE LEAD DAMPER IS OPEN FULLY, AND THE DUCT STATIC PRESSURE IS STILL ABOVE SETPOINT, THAN THE LAG DAMPER WILL BE MODULATED OPEN.

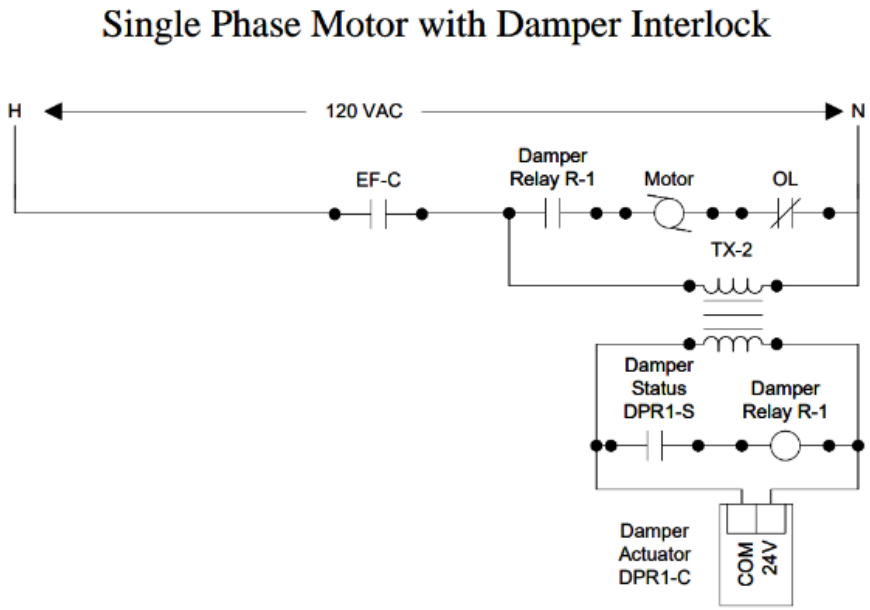
E. EXHAUST SYSTEM FAILURE SCENARIOS:
1. POWER FAILURE: ALL FANS ARE ON THE EMERGENCY POWER SYSTEM. UPON BUIDLING POWER FAILURE, AND THE START OF THE GENERATOR, THE FANS WILL RAMP BACK UP TO THEIR LAST COMMANDED POSITIONS, AND THEN OPERATE UNDER NORMAL CONTROL.
2. FAILURE OF ONE LAB EXHAUST FAN: IF ANY EXHAUST FAN FAILS TO START OF SHUTS DOWN DUE TO MECHANICAL OR ELECTRICAL MALFUNCTION, THE CONTROLLER STOPS THE FAULTY FAN, CLOSES ITS INLET DAMPER AND STARTS THE STANDBY FAN. ROTATION OF THE STANDBY FAN IS DONE WEEKLY.
3. FAILURE OF TWO LAB EXHAUST FANS: THE ONE EXHAUST FAN WILL MODULATE TO MAINTAIN DUCT STATIC PRESSURE SENSORS AT SET POINT. IF THE FAN IS UNABLE TO MAINTAIN SETPOINT, THE FAN WILL OPERATE AT ITS MAXIMUM SPEED AND A HIGH LEVEL ALARM WILL BE SENT TO THE BAS HEAD END.

F. CONTROL POINTS:
1. ALL CONTROL POINTS WILL BE SHOWN ON THE CONTROL SYSTEM GRAPHICS AND TRENDING WILL BE AVAILABLE FOR ALL POINTS.

Building Automation System – General Exhaust Fans:

1. Typical Flow Diagram:





2. Typical Sequence of Operations:

SEQUENCE OF OPERATION

EXHAUST FAN CONTROL:

- WHEN THE EXHAUST FAN IS ENABLED THE DAMPER WILL OPEN
- ONCE THE DAMPER IS PROVED OPEN, THE EXHAUST FAN WILL START
- THE SUPPLY FAN STATUS WILL BE MONITORED BY THE BAS
- WHEN THE EXHAUST FAN IS DISABLED, THE DAMPER WILL CLOSE AND THE EXHAUST FAN WILL STOP

Appendix A:
Typical Control System Actions:

Typical Trends

1. For all of the following **critical building systems**, trends shall be created for both **inputs and outputs** to ensure operational transparency, troubleshooting capability, and long-term performance tracking:
    - **Air Handling Units (AHUs)**
    - **Terminal Units** (VAVs, Fan Coil Units, etc.)
    - **Hot Water Pumps**
    - **Chilled Water Pumps**
    - **Heat Exchangers**
    - **Pneumatic Systems**
    - **Exhaust Systems**
    - **Domestic Hot Water Systems**
    - **Building Pressurization & Ventilation Systems** *(if applicable)*
2. Required trend data shall include, but is not limited to:
    - **Temperature Readings** (supply air, return air, mixed air, coil discharge, etc.)
    - **Flow Readings** (water flow rates, airflows, etc.)
    - **Pressure Readings** (differential pressure across filters, pumps, chilled/hot water systems, duct static pressure, etc.)
    - **Valve and Damper Outputs** (percent open/closed, commanded vs. actual position)
    - **Pump and Fan Monitoring** (on/off status, speed, failure indications)
    - **Airflow Setpoints & Actual Readings** (VAV box airflow, exhaust, and intake balance points)
    - **Humidity Levels** *(if applicable)*
    - **Energy Consumption Data** *(if applicable for high-energy systems such as boilers, chillers, or dedicated recovery units)*
3. **Commissioning & Owner Training:**
    - All trends shall be **programmed and activated during commissioning** to verify proper operation.
    - Trends shall be **retained and reviewed** during **owner training** to confirm system performance.
    - Upon completion of training, trends **may be removed** if directed by Clemson University. However, key long-term operational trends shall remain in place to support maintenance and optimization efforts.

Typical Alarms

1. Alarms shall be created for the following **critical systems** to ensure early detection of operational issues and minimize downtime:
    - **Air Handling Units (AHUs)**
    - **Terminal Units** (VAVs, Fan Coil Units, etc.)
    - **Chilled & Hot Water Pumping Systems** *(if applicable)*
    - **Building Exhaust & Pressurization Systems** *(if applicable)*
2. Required alarm conditions shall include, but are not limited to:
    - **Fan Failures** (loss of airflow, motor failure, VFD fault, belt failure, etc.)

- **Safety Trips** (high temperature cutouts, pressure relief trips, low/high limit violations)
- **Pump Failures** (loss of flow, motor/VFD faults)
- **Filter Change Indicators** (excessive differential pressure across filters)
- **Damper/Valve Failures** (command vs. actual position mismatch)
- **High/Low Pressure Alarms** (for chilled water, hot water, air systems, etc.)
- **High/Low Temperature Alarms** (for space temperature, mixed air, supply air, etc.)
- **Loss of Communication Alarms** (networked control devices going offline)
- **Humidity Control Failures** *(if applicable, for spaces requiring tight humidity control)*
- **Building Pressurization Failures** *(if applicable, for critical areas like labs or clean rooms)*

3. **Commissioning & Owner Training:**
   - All alarms shall be **programmed, tested, and verified during commissioning**.
   - Alarms shall be **demonstrated and reviewed** during **owner training** to ensure proper configuration and response protocols.
   - After owner training, alarms **shall remain active** unless Clemson University modifies or reconfigures them. Clemson University shall retain full editing privileges to adjust alarm thresholds, priorities, and notifications as needed.