Addendum k to
ASHRAE Guideline 36-2021

Public Review Draft

Proposed Addendum k to Guideline 36-2021, High-Performance Sequences of Operation for HVAC Systems

First Public Review (April 2024)
(Draft shows Proposed Changes to Current Guideline)

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(This foreword is not part of this guideline. It is merely informative and does not contain requirements necessary for conformance to the guideline.)

FOREWORD

Note: In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and strikethrough (for deletions) unless the instructions specifically mention some other means of indicating the changes. Only these changes are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed substantive changes.

This addendum adds sequences of operation (SOOs) for VAV laboratory controls for 4-pipe VAV systems and 2-pipe VAV systems (more commonly called VAV Reheat systems).

The control schematics and points tables show both “slow” and “fast” labs:

- “Slow” labs are those that do not have VAV fume hoods. They can have constant volume hoods or no hoods at all. Because they do not have fast changing hood exhaust flow, they can use standard speed controls for supply and general exhaust. This applies particularly to the speed of the damper actuator, but also to the speed of the controller. Typically, standard VAV boxes with standard commercial VAV box application specific controllers may be used for supply and general exhaust, along with specialty pressure independent constant volume fume hood air valves.
- “Fast” labs have VAV fume hoods and thus must have fast-acting controls. Typically, specialty lab air valves with fast acting controls for all terminals, including supply and general exhaust as well as fume hood exhaust. These controllers are sent an airflow setpoint and have internal controls that modulate the damper to deliver that rate. Some designers use the BAS also for the direct control of these air valves, i.e. the air valves are much like those used for “slow” labs (just damper and airflow sensor) and airflow PID control loop resides in the BAS controller. The SOOs can be used with either approach– they list both options of separate on-board controller or BAS control of the air valves.

While the control schematics vary for “slow” or “fast” labs, the SOOs are exactly the same.

Addendum k to Guideline 36-2021

(IP and SI Units)

Revise Section 3.1.3 as follows:

3.1.3. Zone Group Assignments

Zones and miscellaneous associated equipment must be assigned to Zone Groups, such as by using a table (see example Informative Table 3.1.3) either on drawings or in Building Automation System (BAS) specifications. Other formats may be used if they convey the same information.

Guidance for Zone Group Assignments

1. *Each zone served by a single-zone air handler shall be its own Zone Group.*
2. *Rooms occupied 24/7, such as computer rooms, networking closets, mechanical, and electrical rooms served by the air handler shall be assigned to a single Zone Group. These rooms do not apply to the Zone Group restrictions below.*
3. *A Zone Group shall not span floors (per Section 6.4.3.3.4 of ASHRAE 90.1 2016).*
4. *A Zone Group shall not exceed 2,300 m2 (25,000 ft2) (per Section 6.4.3.3.4 of ASHRAE 90.1 2016).*
5. *If future occupancy patterns are known, a single Zone Group shall not include spaces belonging to more than one tenant.*
6. *A zone shall not be a member of more than one Zone Group.*
7. *Miscellaneous equipment, such as exhaust fans, serving spaces within a Zone Group shall be included in the Zone Group.*
8. *Miscellaneous equipment may be included in multiple Zone Group if it serves spaces in multiple Zone Groups.*
9. *Laboratory zones typically are ventilated 24/7 but if they are intermittently occupied, they should be assigned to Zone Groups with occupancy schedules like offices and any other building occupancy. This is to allow for temperature and ventilation setpoint setback.*

Add Section 3.1.10 as follows. Note that all text in this section is new but not underlined for ease of review:

3.1.10. Laboratory Zone Design Information

The engineer must provide the setpoint information in the following subsections, typically on lab room/air valve schedules on drawings.

3.1.10.1. Pressurization offset (Voffset)

a. Pressurization offsets shall be as shown on schedules. Pressurization offset setpoints are positive for positively pressurized labs and negative for negatively pressurized labs.

Pressurization offsets must be estimated during the design phase, e.g. based on the number of entry doors and wall area. For many projects, that estimate is considered sufficient, and these offsets are used for control. But offsets may also be determined empirically to achieve a specific differential pressure:

Include the following section if Voffset is also to be field verified as part of TAB work:

b. Final pressurization offsets shall be determined as specified under Testing, Adjusting, and Balancing Section.

If this section is included, Testing, Adjusting, and Balancing section must be edited to include the following:

A. Room Pressurization Balancing

1. The airflow Offset indicated in the schedule is only an initial value and the final value shall be determined by work under this section.

2. Determine airflow offsets required to achieve the room pressurization of 0.02" to 0.05" [5 Pa to 12 Pa] positive or negative as indicated in the Laboratory Zone Room Schedules. In no case, however, shall the offset be larger than 200% of scheduled offset.

3. Coordinate with BAS contractor to determine and program required room offsets.

3.1.10.2. Minimum Ventilation

a. Minimum occupied ventilation rate (Vvent-min-occ)

Vvent-min-occ is the minimum ventilation rate when the lab is occupied. This is typically expressed as air changes per hour (e.g. 6 ACH) or airflow per unit area (e.g. 5 L/s/m² [1 cfm/ft²]). In the control sequences, this minimum rate is maintained when the lab is occupied using supply air for positively pressurized labs, or exhaust air for negatively pressurized labs.

b. Minimum occupied ventilation rate (Vvent-min-unocc)

Vvent-min-unocc is the minimum ventilation rate when the lab is unoccupied. This is typically expressed as air changes per hour (e.g. 3 ACH) or airflow per unit area (e.g. 2.5 L/s/m² [0.5 cfm/ft²]). In the control sequences, this minimum rate is maintained when the lab is unoccupied using supply air for positively pressurized labs, or exhaust air for negatively pressurized labs.

3.1.10.3. Supply air valve(s)

If there is more than one supply air valve, they are assumed in these sequences to operate in parallel and be equally sized.

a. Maximum airflow setpoint (Vmax)

Vmax is the larger of: the required cooling airflow rate (Vcool-max); heating airflow rate (Vheat-max); that needed for minimum occupied ventilation rate (Vvent-min-occ + Voffset, only if Voffset < 0), and that needed for hood and other exhaust makeup with hood sashes open (sum Vhex-max for all hoods + Vother + Voffset). This setpoint could be automatically calculated by the sequences so the scheduled value of Vmax is not needed for control, but it is needed for supply air valve sizing, so it needs to also be scheduled.

b. Maximum heating airflow setpoint (Vheat-max)

Vheat-max is the rate required to meet lab heating loads at design conditions with heating coil supply air temperature equal to SATmax.

c. Design heating coil leaving air temperature (SATmax)

SAT-max is the design zone heating coil supply air temperature. This should be less than 11°C [20°F] above the heating setpoint to meet Standard 90.1 overhead heating limitations.

Include the following line for 4-pipe Lab zones. Delete for 2-pipe VAV reheat systems.

d. Design cooling coil leaving air temperature (SATmin)

SAT-min is the design zone cooling coil supply air temperature, e.g. 13°C [55°F].

3.1.10.4. Hood exhaust air valve(s)

Hood exhaust is assumed to be controlled by on-board controllers with sash sensors and fume hood monitors. None of the control logic resides in the room BAS controller, other than monitoring alarms and commissioning overrides. The following minimum and maximum setpoints must be configured in, or written to, the exhaust air valve controller. They are not used in the BAS sequences.

a. Maximum airflow setpoint (Vhex-max)

Vhex-max is the required hood exhaust with sash open to design opening. This value should also be the setpoint for a hood "purge" if the hood monitor/controller has this feature.

b. Minimum airflow setpoint (Vhex-min)

Vhex-min is the required hood exhaust with sash fully closed. This value is typically determined per ANSI Z9.5.

c. Percentage reduction multiplier to all fume hood exhaust setpoints to reduce zone pressure enough to allow for safe exit door pressures (%hood-reduction)

In hood dominated labs, if the supply air system is lost (e.g. closed fire/smoke damper, AHU tripped on smoke detector, etc.) while the exhaust system continues to operate, the lab may become excessively negative and cause exit doors to require excessive force to open, trapping occupants inside the lab. There are various means to mitigate this problem, one of which is to use automatic sash closers tied to the BAS to close the hoods in an emergency when supply air is lost. When the sashes close, exhaust rates drop to their minimums. Usually this is sufficient to allow for safe exiting. But occasionally, in labs with very exhaust rates or density of hoods, room negative pressures can still be excessive. In that case, hood exhaust rates can be further reduced below their normal minimum setpoints as needed. This temporary reduction is generally safe because the sashes are closed; note that minimum hood rates are intended to ensure pollutants do not build up inside the hood when sashes are closed for long periods so a temporary reduction of that minimum is unlikely to be unsafe, but this should be reviewed and approved by the lab EH&S authorities who are knowledgeable of the chemicals used in the hoods. These reduced rates must be determined empirically in conjunction with the BAS and TAB subcontractors. Example language for Testing, Adjusting and Balancing Section:

A. Emergency Exit Tests

1. Tests shall be performed separately for each lab with fume hoods.

2. Coordinate with BAS contractor to conduct tests.

3. Procedure:

a) Simulate failure of supply air to the lab by fully shutting off all supply air valves.

b) Verify that BAS causes hood closers to close hoods immediately after supply air failure is detected.

c) Test door opening force. If more than 15 pounds, gradually reduce minimum hood exhaust setpoints uniformly for all hoods until 15 pounds is reached.

4. Report

a) Initial door opening force at design hood exhaust rates

b) Percent of design hood exhaust rates needed to reduce door opening force to 15 pounds

c) Initials of BAS installer to indicate that percent reduction multiplier was transmitted to them

If not specified, set %hood-reduction to 100%:

3.1.10.5. General exhaust air valve

If there is more than one general exhaust air valve, they are assumed in these sequences to operate in parallel and be equally sized.

a. Maximum airflow setpoint (Vgex-max)

Vgex-max is the larger of: zero, the required cooling airflow rate (Vcool-max); heating airflow rate (Vheat-max); and that needed for minimum occupied ventilation rate (Vvent-min-occ + Voffset, only if Voffset < 0), minus: hood exhaust with hood sashes closed (sum Vhex-min for all hoods), other exhaust (Vother), and pressurization offset (Voffset). This setpoint could be automatically calculated by the sequences so the scheduled value of Vgex-max is not needed for control, but it is needed for general exhaust air valve sizing, so it needs to also be scheduled.

3.1.10.6. Other constant volume exhaust airflows, (Vother)

Vother is any other continuous and constant volume exhaust, such as for storage cabinets, snorkels, etc. if applicable.

Add 3.3.2 as follows:

3.3.2 Laboratory VAV Air Valve Controllable Minimum.
3.3.2.1 The controllable minimum for air valves using velocity pressure sensors shall be determined in accordance with Section 3.3.1.
3.3.2.2 The controllable minimum for air valves using other airflow sensing and control devices, including venturi type valves, shall be per the manufacturer.

Add 4.13 to 4.16 as follows:

4.13 "Slow" Laboratory Four-Pipe VAV Zone

"Slow" labs are those without variable volume hoods – the lab either has no hoods or constant volume hoods.

Only one controller should be used per lab so that network operation does not affect lab performance. This can be a standard VAV box controller on the supply air VAV box with an auxiliary controller on the exhaust VAV box. Alternatively, standard VAV box controllers can be provided on both with exhaust setpoint hardwired from the supply air box controller to the exhaust controller and all setpoint logic residing in the supply air box controller.

Hot water and chilled water are shown to be controlled by a 6-way valve serving a single changeover coil. Two 2-way valves serving separate hot water and chilled water coils may also be used.

Occupancy sensors are listed as an optional hardwired point. This point is also commonly a software point mapped from a networked lighting control system or security system.

Re-quired?	Description	Type	Device
R	Supply VAV Box Damper Position	AO ***OR*** two DOs	Modulating actuator ***OR*** Floating actuator
R	Exhaust VAV Box Damper Position	AO ***OR*** two DOs	Modulating actuator ***OR*** Floating actuator
R	CHW/HW valve position	AO	Modulating actuator, 6-way valve

Re-quired?	Description	Type	Device
R	Supply Airflow	AI	Differential pressure transducer connected to flow sensor
R	General Exhaust Airflow	AI	Differential pressure transducer connected to flow sensor
R	Hood Exhaust Airflow (each hood)	AI	Air valve airflow feedback
R	Discharge Air Temperature	AI	Duct temperature sensor (probe or averaging at designer's discretion)
R	Zone Temperature	AI	Room temperature sensor
O	Hood alarm (any hood)	DI	Connect to hood monitor alarm contact, in parallel if more than one hood
A	Occupancy Sensor	DI	Occupancy sensor
A	Zone Temperature Setpoint Adjustment	AI	Zone thermostat adjustment

4.14 "Fast" Laboratory Four-Pipe VAV Zone

"Fast" labs are those with variable volume hoods with fast-acting actuators on all exhaust and supply air valves. The assumption for control logic herein is that hoods have self-contained air valves, meaning the air valve has its own controller tied to the hood sash position indicator; this air valve is not directly controlled by the BAS, although the BAS will require feedback as indicated in the points table. Supply air and general exhaust air valves may also similarly have independent controls, which is what the points list and schematics show, but they can also be standard VAV boxes with fast acting actuators controlled directly by the BAS. This option is covered in the control sequences but not the points list and schematics.

Only one controller should be used per lab so that network operation does not affect lab performance. This BAS device should execute all room control functions and control logic. It may directly control supply and general exhaust valves or communicate with air flow controllers provided with these valves; the latter is reflected in the points list below. The air valves, with flow controllers separate from the room controller communicate via the points listed and provide internal closed loop control logic. Alternately, flow controllers communicate with the room controller by network that isolates communication for room pressurization from BAS traffic unrelated to the room control system, from non-BAS traffic on the building network and from network hardware faults outside the room control system.

Controllers with air flow sensors and knowledge of damper position may indicate Duct Static Pressure Requests by the usual means. Inherently pressure independent Venturi type air valves can also be used, but since damper position is not known, they must be provided with a factory installed differential pressure sensor which is used for fan static pressure reset required by Standard 90.1.

Hot water and chilled water are shown to be controlled by a 6-way valve serving a single changeover coil. Two 2-way valves serving separate hot water and chilled water coils may also be used.

Occupancy sensors are listed as an optional hardwired point. This point is also commonly a software point mapped from a networked lighting control system or security system.

Re-quired?	Description	Type	Device
R	Supply airflow setpoint	AO	To air valve controller
R	General exhaust airflow setpoint	AO	To air valve controller
R	CHW/HW valve position	AO	Modulating actuator, 6-way valve
R	Supply Airflow	AI	Air valve airflow feedback
R	General Exhaust Airflow	AI	Air valve airflow feedback

Re-quired?	Description	Type	Device
R	Hood Exhaust Airflow (each hood)	AI	Air valve airflow feedback
R	Supply Damper position	AI	Air valve feedback
R	General Exhaust Damper position	AI	Air valve feedback
R	Hood Exhaust Damper position (each hood)	AI	Air valve feedback
R	Discharge Air Temperature	AI	Duct temperature sensor (probe or averaging at designer's discretion)
R	Zone Temperature	AI	Room temperature sensor
O	Hood alarm (any hood)	DI	Connect to hood monitor alarm contact, in parallel if more than one hood
A	Occupancy Sensor	DI	Occupancy sensor
A	Zone Temperature Setpoint Adjustment	AI	Zone thermostat adjustment
O	Close sash (all hoods)	DO	Wire to sash closer controller emergency close contact; include multi-pole relay if more than one hood

4.15 "Slow" Laboratory VAV Reheat Zone

"Slow" labs are those without variable volume hoods – the lab either has no hoods or constant volume hoods.

Only one controller should be used per lab so that network operation does not affect lab performance. This can be a standard VAV box controller on the supply air VAV box with an auxiliary controller on the exhaust VAV box. Alternatively, standard VAV box controllers can be provided both with exhaust setpoint hardwired from the supply air box controller to the exhaust controller and with all setpoint logic residing in the supply air box controller.

Occupancy sensors are listed as an optional hardwired point. This point is also commonly a software point mapped from a networked lighting control system or security system.

Re-quired?	Description	Type	Device
R	Supply VAV Box Damper Position	AO ***OR*** two DOs	Modulating actuator ***OR*** Floating actuator
R	Exhaust VAV Box Damper Position	AO ***OR*** two DOs	Modulating actuator ***OR*** Floating actuator
R	HW valve position	AO	Modulating actuator
R	Supply Airflow	AI	Differential pressure transducer connected to flow sensor
R	General Exhaust Airflow	AI	Differential pressure transducer connected to flow sensor
R	Hood Exhaust Airflow (each hood)	AI	Air valve airflow feedback
R	Discharge Air Temperature	AI	Duct temperature sensor (probe or averaging at designer's discretion)
R	Zone Temperature	AI	Room temperature sensor
O	Hood alarm (any hood)	DI	Connect to hood monitor alarm contact, in parallel if more than one hood

Re-quired?	Description	Type	Device
A	Occupancy Sensor	DI	Occupancy sensor
A	Zone Temperature Setpoint Adjustment	AI	Zone thermostat adjustment

4.16 "Fast" Laboratory VAV Reheat Zone

"Fast" labs are those with variable volume hoods with fast-acting actuators on all exhaust and supply air valves. The assumption for control logic herein is that hoods have self-contained air valves, meaning the air valve has its own controller tied to the hood sash position indicator; this air valve is not directly controlled by the BAS, although the BAS will require feedback as indicated in the points table. Supply air and general exhaust air valves may also similarly have independent controls, which is what the points list and schematics show, but they can also be standard VAV boxes with fast acting actuators controlled directly by the BAS. This option is covered in the control sequences but not the points list and schematics.

Only one controller should be used per lab so that network operation does not affect lab performance. This BAS device should execute all room control functions and control logic. It may directly control supply and general exhaust valves or communicate with air flow controllers provided with these valves; the latter is reflected in the points list below. The air valves, with flow controllers separate from the room controller communicate via the points listed and provide internal closed loop control logic. Alternately, flow controllers communicate with the room controller by network that isolates communication for room pressurization from BAS traffic unrelated to the room control system, from non-BAS traffic on the building network and from network hardware faults outside the room control system.

Inherently pressure independent Venturi type air valves can also be used, but since damper position is not known, they must be provided with a factory installed differential pressure sensor which is used for fan static pressure reset required by Standard 90.1. Controllers for Venturi air valves with air flow sensors and the necessary calculations, may indicate Duct Static Pressure Request by the usual means.

Occupancy sensors are listed as an optional hardwired point. This point is also commonly a software point mapped from a networked lighting control system or security system.

Re-quired?	Description	Type	Device
R	Supply airflow setpoint	AO	To air valve controller
R	General exhaust airflow setpoint	AO	To air valve controller
R	HW valve position	AO	Modulating actuator
R	Supply Airflow	AI	Air valve airflow feedback
R	General Exhaust Airflow	AI	Air valve airflow feedback
R	Hood Exhaust Airflow (each hood)	AI	Air valve airflow feedback
R	Supply Damper position	AI	Air valve feedback
R	General Exhaust Damper position	AI	Air valve feedback
R	Hood Exhaust Damper position (each hood)	AI	Air valve feedback
R	Discharge Air Temperature	AI	Duct temperature sensor (probe or averaging at designer's discretion)
R	Zone Temperature	AI	Room temperature sensor
O	Hood alarm (any hood)	DI	Connect to hood monitor alarm contact, in parallel if more than one hood
A	Occupancy Sensor	DI	Occupancy sensor
A	Zone Temperature Setpoint Adjustment	AI	Zone thermostat adjustment

Re-quired?	Description	Type	Device
O	Close sash (all hoods)	DO	Wire to sash closer controller emergency close contact; include multi-pole relay if more than one hood

Modify Section 5.15 as follows:

5.15 Air-Handling Unit System Modes

5.15.1. If there are no laboratory zones served by the air handling unit, AHU system modes are the same as the mode of the Zone Group served by the system. When Zone Group served by an air-handling system are in different modes, the following hierarchy applies (highest one sets AHU mode):

5.15.1.1. Occupied Mode

5.15.1.2. Cooldown Mode

5.15.1.3. Setup Mode

5.15.1.4. Warmup Mode

5.15.1.5. Setback Mode

5.15.1.6. Unoccupied Mode

5.15.2. If there are any laboratory zones served by the air handling unit, AHU system mode shall be Occupied Mode regardless of Zone Group modes.

For laboratory zones, zone controls will provide the desired zone temperature and airflow setpoints based on Zone Group Mode, but AHU operation is the same (Occupied Mode) regardless.

Modify Section 5.16.3.1 as follows:

g. Calculate the effective minimum outdoor airflow setpoint MinOAsp as the uncorrected outdoor air intake divided by the system ventilation efficiency, but no larger than the design total outdoor air rate DesVot:

$$\text{MinOAsp} = \text{MIN}\left(\frac{V_{ou}}{E_v} \middle| \text{DesV}_{ot}\right)$$

h. If the AHU serves laboratory zones, the minimum outdoor airflow setpoint MinOAsp calculated above shall be increased by the sum of laboratory zone current supply airflow setpoints Vstp.

Modify Section 5.16.3.2 as follows:

c. Effective outdoor air absolute minimum and design minimum setpoints are recalculated continuously based on the mode of the zones being served.

1. AbsMinOA* is the sum of Zone-Abs-OA-min for all zones in all Zone Groups that are in Occupied Mode but shall be no larger than the absolute minimum outdoor airflow, AbsMinOA.

2. DesMinOA* is the sum of Zone-Des-OA-min for all zones in all Zone Groups that are in Occupied Mode but shall be no larger than the design minimum outdoor airflow, DesMinOA.

d. <u>If the AHU serves laboratory zones, the minimum outdoor airflow setpoints AbsMinOA* and DesMinOA* calculated above shall both be increased by the sum of laboratory zone current supply airflow setpoints Vstp.</u>

Add Section 5.23 as follows: Note: the section below is new, but additions are not underlined for ease of review.

5.23 Laboratory VAV Zone

This section applies to both "fast" and "slow" labs and includes both 2-pipe and 4-pipe terminals.

5.23.1. See "Generic Thermal Zones" (Section 5.3) for setpoints, loops, control modes, alarms, etc.

5.23.2. See Section 3.1.10 for airflow and discharge air temperature setpoints.

5.23.3. Airflow setpoints

5.23.3.1. Where there is more than one valve of the same type, for control logic herein, measured rates from each shall be added together, and setpoints for each shall be divided proportional to air valve design maximum flow.

5.23.3.2. Supply air valve minimum setpoints

a. Minimum occupied airflow setpoint, Vmin-occ = MAX (Vvent-min-occ + (Voffset only if Voffset < 0), (SUM Vhex-min for all hoods + Vother + Voffset))

b. Minimum unoccupied airflow setpoint, Vmin-unocc = MAX (Vvent-min-unocc + (Voffset only if Voffset < 0), (SUM Vhex-min for all hoods + Vother + Voffset))

5.23.3.3. Maximum setpoint check

a. Vmax-check = MAX (Vcool-max, Vheat-max, (Vvent-min-occ + (Voffset only if Voffset < 0)), (∑Vhex-max + Vother + Voffset). If Vmax-check is not equal to Vmax within 1%, generate a Level 3 alarm.

Vmax must be scheduled by the designer so that it can be used for air valve sizing, but it also can be automatically calculated as indicated. If there is a mismatch, an alarm is generated so that Vmax setpoint, and perhaps air valve selection, can be corrected by the designer.

b. Vgex-max-check = MAX (Vcool-max, Vheat-max, (Vvent-min-occ + (Voffset only if Voffset < 0))) minus (∑Vhex-min + Vother + Voffset). If Vgex-max-check is not equal to Vgex-max within 1%, generate a Level 3 alarm.

Vgex-max must be scheduled by the designer so that it can be used for air valve sizing, but it also can be automatically calculated as indicated. If there is a mismatch, an alarm is generated so that Vgex-max setpoint, and perhaps air valve selection, can be corrected by the designer.

5.23.3.4. Lab air valve controllable minimum

a. Supply air valve controllable minimum (Vctrl-min) and general exhaust air valve controllable minimum (Vgex-ctrl-min) shall be determined in accordance with Section 3.3.2.

5.23.4. Pressurization control

5.23.4.1. Sign conventions: All airflows have a positive sign, except for the room offset airflow which shall be positive for positively pressurized labs, and negative for negatively pressurized labs.

5.23.4.2. The active minimum airflow setpoint, Vmin*, shall be equal to the larger of the following but no larger than Vmax:

a. Exhaust makeup air rate, Vmu

b. Minimum ventilation rate (Vvent) equal to

1. If the zone is unpopulated as indicated by its occupancy sensor <u>and</u> the lab is scheduled to be unoccupied, Vmin-unocc.

Both the space occupancy sensor and the schedule are used to ensure that labs are unoccupied before rates are reduced to the unoccupied minimums.

2. Otherwise, Vmin-occ

c. Vctrl-min

5.23.4.3. Vgex-step shall be equal to Vgex-ctrl-minimum

This exception is to allow the general exhaust valve to fully close when no general exhaust is needed. Otherwise, it must exhaust at least its controllable minimum.

a. Exception: Vgex-step shall equal 0 if

The following condition indicates that zone thermal load does not demand an increase in airflow above the minimum for temperature control.

1. The active airflow setpoint Vspt for temperature control is equal to Vmin*, and

2. The larger of Vvent and Vctrl-min has been less than or equal to the sum of the following for 30 seconds or more:

   i. Sum of fume hood exhaust valve(s) airflow feedback

   ii. Vother

   iii. Voffset

5.23.4.4. The make-up airflow demand (Vmu) is equal to the sum of:

a. Sum of fume hood exhaust valve(s) airflow feedback

b. Vgex-step

c. Vother

d. Voffset

5.23.4.5. The active general exhaust valve setpoint Vgex-spt shall equal 0 when Vgex-step is equal 0; otherwise, it shall equal the sum of the following but no larger than Vgex-max:

a. Supply valve feedback airflow minus Vmu

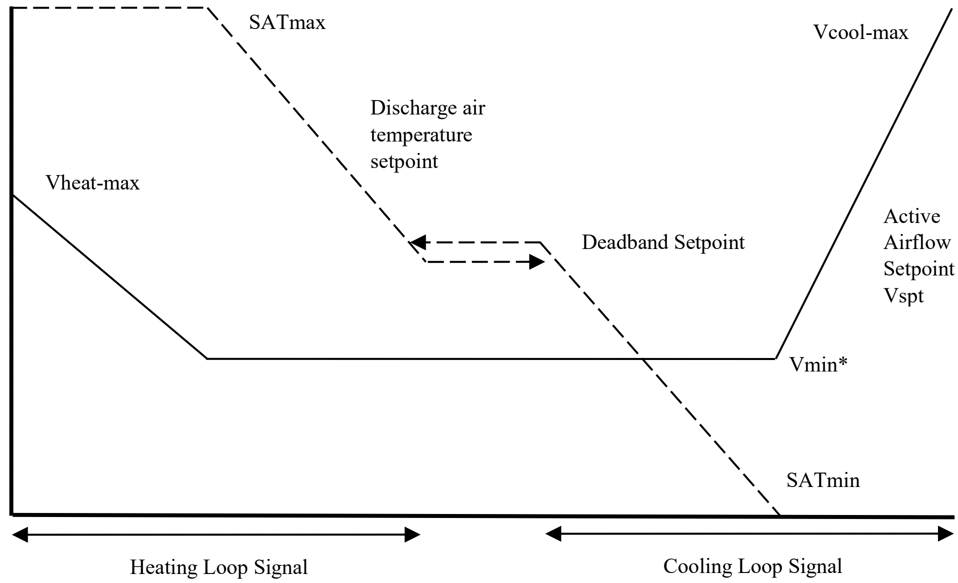
b. The general exhaust valve controllable minimum airflow, Vgex-ctrl-minimum

If there are no 4-pipe lab zone terminals, delete the following section:

5.23.5. Supply air – 4-pipe terminals

5.23.5.1. Active endpoints used in the control logic depicted in the figure below shall not vary regardless of the Mode of the Zone Group the zone is a part of.

5.23.5.2. Control logic is depicted schematically in the figure below and described in the following sections.



5.23.5.3. When the Zone State is Cooling

a. From 0-50%, the Cooling Loop output shall reset the discharge temperature setpoint from Deadband SAT Setpoint to SATmin. The active airflow setpoint shall be Vmin*.

b. From 51%-100%, if the discharge air temperature is less than room temperature minus 0.5°C (1°F), the Cooling Loop output shall reset the active airflow setpoint from the Vmin* to Vcool-max, but no lower than Vmin*.

The last clause limiting the setpoint to Vmin is required because Vmin* can be reset above Vcool-max if needed for exhaust makeup.*

5.23.5.4. When the Zone State is Deadband

a. The discharge temperature setpoint shall be the Deadband SAT Setpoint which shall be equal to the cooling space temperature setpoint when transition from cooling to deadband, and equal to the heating space temperature setpoint when transition from heating to deadband.

b. The active airflow setpoint shall be Vmin*.

5.23.5.5. When the Zone State is Heating

a. From 0-50%, the Heating Loop output shall reset the discharge temperature setpoint from Deadband SAT Setpoint to SATmax. The active airflow setpoint shall be Vmin*.

b. From 51%-100%, if the discharge air temperature is greater than room temperature plus 3°C (5°F), the Heating Loop output shall reset the active airflow setpoint from the Vmin* to Vheat-max, but no lower than Vmin*.

The last clause limiting the setpoint to Vmin is required because Vmin* can be reset above Vheat-max if needed for exhaust makeup.*

5.23.5.6. The heat coil and cooling coil shall be modulated in sequence to maintain the discharge temperature at setpoint. (Directly controlling valves off zone temperature control loop is not acceptable.)

5.23.5.7. Where drawings indicate supply air valves have on-board controllers, the airflow setpoint is sent to the controller and the controller modulates the air valve damper to maintain the measured airflow at setpoint.

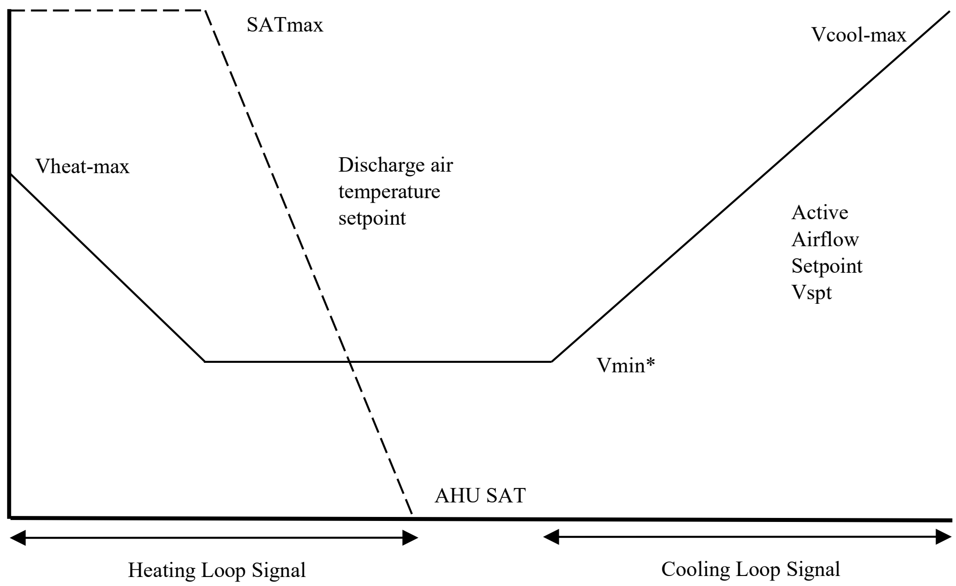
5.23.5.8. Where drawings indicate supply air valves are controlled by the BAS, the air valve damper shall be modulated to maintain the measured airflow at setpoint.

If there are no 2-pipe lab zone terminals, delete the following section:

5.23.6. Supply air – 2-pipe terminals

5.23.6.1. Active endpoints used in the control logic depicted in the figure below shall not vary regardless of the Mode of the Zone Group the zone is a part of.

5.23.6.2. Control logic is depicted schematically in the figure below and described in the following sections.



5.23.6.3. When the Zone State is Cooling, the Cooling Loop output shall be mapped to the active airflow setpoint from the Vmin* to Vcool-max, but no lower than Vmin*.

The last clause limiting the setpoint to Vmin is required because Vmin* can be reset above Vcool-max if needed for exhaust makeup.*

a. If supply air temperature from the air handler is greater than the room temperature, the active airflow setpoint shall be no higher than Vmin*

5.23.6.4. When the Zone State is Deadband, the active airflow setpoint shall be Vmin*.

5.23.6.5. When the Zone State is Heating

a. From 0-50%, the Heating Loop output shall reset the discharge temperature setpoint from the current AHU SAT setpoint to SATmax. The active airflow setpoint shall be Vmin*.

b. From 51%-100%, if the discharge air temperature is greater than room temperature plus 3°C (5°F), the Heating Loop output shall reset the active airflow setpoint from the Vmin* to Vheat-max, but no lower than Vmin*.

The last clause limiting the setpoint to Vmin is required because Vmin* can be reset above Vheat-max if needed for exhaust makeup.*

5.23.6.6. If the current supply air temperature from the AHU is less than the current heating coil discharge air setpoint, the heating coil shall be modulated to maintain the discharge temperature at setpoint. (Directly controlling heating off the zone temperature control loop is not acceptable).

5.23.6.7. Where drawings indicate supply air valves have on-board controllers, the airflow setpoint is sent to the controller and the controller modulates the VAV damper to maintain the measured airflow at setpoint.

5.23.6.8. Where drawings indicate supply air valves are controlled by the BAS, the VAV damper shall be modulated to maintain the measured airflow at setpoint.

5.23.7. General Exhaust

5.23.7.1. Where drawings indicate general exhaust air valves have on-board controllers, the active airflow setpoint Vgex-spt is sent to the controller and the controller modulates the VAV damper to maintain the measured airflow at setpoint.

5.23.7.2. Where drawings indicate general exhaust air valves are controlled by the BAS, the VAV damper shall be modulated to maintain the measured airflow at the active airflow setpoint Vgex-spt.

5.23.8. Alarms

5.23.8.1. Airflow alarm (except hoods for which setpoint is not known)

a. If the airflow feedback from any valve is 15% above or below setpoint for 5 minutes, generate a Level 3 alarm.

b. If the airflow feedback from any valve is 30% above or below setpoint for 5 minutes, generate a Level 2 alarm.

5.23.8.2. Room pressurization polarity alarm

a. Generate a Level 2 alarm if the airflow offset has incorrect polarity for 5 minutes, with airflow offset calculated as the sum of supply airflow feedback signal minus sum of general and hood exhaust airflow feedback:

1. For a room with negative offset, if supply minus exhaust ≥ 0

2. For a room with positive offset, if supply minus exhaust ≤ 0

5.23.8.3. Room low supply rate alarm

a. If the sum of exhaust feedback signals exceeds the sum of supply feedback signal by more than 4 times the absolute value of Voffset for 1 minute:

1. Generate a Level 1 alarm (high level due to problems exiting)

Include the following paragraph if there is an audible and/or visual alarm, such as wall mounted horn/strobe in the lab with signage indicating that lab should be evacuated upon alarm. Delete otherwise.

---

2. Activate lab audible/visual alarm

If hoods have sash closers with close-overrides connected to the BAS, include the following paragraph. Delete otherwise.

---

3. All fume hood sashes in room shall be commanded closed.

Sash closers are a cost-effective way to save energy and also to allow safe exiting in case of a loss of supply air (e.g. due to a AHU failure, FSD closure, etc.) in hood dominated labs where exit doors open out of the lab. Without them, some other means must be provided to relieve pressure if the supply air is lost. To be used for this purpose, the sash closer controller provided by the hood manufacturer requires a digital input that causes it to ignore the presence sensor and any delay-close timers so that it immediately closes the hood when this contact is closed. This is a standard feature of most major hood closer manufacturers.

---

4. All fume hood exhaust setpoints shall be reduced to a fixed percentage of the maximum hood rates, %hood-reduction.

This reduction is hood exhaust rates should only be done when sash closers are used and commanded to close, and should be approved by EH&S authorities. See discussion above where %hood-reduction value is determined.

5.23.8.4. Low supply air temperature

a. If heating hot water plant is proven on and the supply air temperature is 8°C (15°F) less than setpoint for 10 minutes, generate a Level 3 alarm.

b. If heating hot water plant is proven on and the supply air temperature is 17°C (30°F) less than setpoint for 10 minutes, generate a Level 2 alarm.

5.23.8.5. High supply air temperature

a. If chiller plant is proven on and the supply air temperature is 6°C (10°F) more than setpoint for 10 minutes, generate a Level 3 alarm.

b. If chiller plant is proven on and the supply air temperature is 11°C (20°F) more than setpoint for 10 minutes, generate a Level 2 alarm.

5.23.8.6. Fume hood

a. Fume hood alarm: Level 2

b. If average sash height (interpolated based on average airflow feedback through the hood and design maximum and minimum setpoints) during the last 24 hours is greater than 50% (adjustable), generate a Level 4 alarm

5.23.9. Testing/Commissioning Overrides: Provide software points that interlock to a system level point to

5.23.9.1. Force supply airflow setpoint to zero

5.23.9.2. Force supply airflow setpoint to Vmax

5.23.9.3. Force supply airflow setpoint to Vmin

5.23.9.4. Force supply damper full closed/open

5.23.9.5. Force heating valve to closed/open

If there are no 4-pipe lab zone terminals, delete the following paragraph:

5.23.9.6. Force cooling valve to closed/open

5.23.9.7. Force hood exhaust airflow setpoint to Vhex-max

5.23.9.8. Force hood exhaust airflow setpoint to Vhex-min

5.23.9.9. Force general exhaust airflow setpoint to Vgex-max

5.23.9.10. Force general exhaust airflow setpoint to Vgex-ctrl-min

5.23.9.11. Reset request-hours accumulator point to zero (provide one point for each reset type listed below)

5.23.10. System Requests

Delete the next section if there is no cooling coil in the AHU serving the lab supply air valves, as may be the case with 4-pipe VAV systems.

5.23.10.1. Cooling SAT Reset Requests

a. If the Cooling Loop is greater than 95% and the zone temperature exceeds the zone's cooling setpoint by 3°C (5°F) for 2 minutes and after suppression period due to setpoint change, send 3 Requests.

b. Else if the Cooling Loop is greater than 95% and the zone temperature exceeds the zone's cooling setpoint by 2°C (3°F) for 2 minutes and after suppression period due to setpoint change, send 2 Requests.

c. Else if the Cooling Loop is greater than 95%, send 1 Request until the Cooling Loop is less than 85%.

d. Else if the Cooling Loop is less than 95%, send 0 Requests.

Delete the next section if there are no inherently pressure independent venturi type supply air valves.

Venturi valves must include differential pressure sensors across the valve for static pressure setpoint reset logic.

5.23.10.2. Supply Static Pressure Reset Requests (Venturi type valves)

a. If the air valve differential pressure is less than 0.25" for 30 seconds, send 3 requests.

b. Else if the air valve differential pressure is less than 0.3" for 30 seconds, send 1 request.

c. Else if the air valve differential pressure is greater than 0.35", send 0 requests.

Delete the next section if there are no inherently pressure independent venturi type general or hood exhaust air valves.

Venturi valves must include differential pressure sensors across the valve for static pressure setpoint reset logic.

5.23.10.3. Exhaust Static Pressure Reset Requests (Venturi type valves)

a. If the air valve differential pressure is less than 0.25" for 30 seconds, send 3 requests.

b. Else if the air valve differential pressure is less than 0.3" for 30 seconds, send 1 request.

c. Else if the air valve differential pressure is greater than 0.35", send 0 requests.

Delete the next section if there are no supply air valves that use closed loop airflow control.

5.23.10.4. Supply Static Pressure Reset Requests (Feedback loop type valves)

a. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 requests.

b. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 requests.

c. Else if the damper position is greater than 95%, send 1 request until the damper position is less than 85%.

d. Else if the damper position is less than 95%, send 0 requests.

Delete the next section if there are no general or hood exhaust air valves that use closed loop airflow control.

5.23.10.5. Exhaust Static Pressure Reset Requests (Feedback loop type valves)

a. If the measured airflow is less than 50% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 3 requests.

b. Else if the measured airflow is less than 70% of setpoint while setpoint is greater than zero and the damper position is greater than 95% for 1 minute, send 2 requests.

c. Else if the damper position is greater than 95%, send 1 request until the damper position is less than 85%.

d. Else if the damper position is less than 95%, send 0 requests.

5.23.10.6. Hot Water Reset Requests

a. If the HW valve position is greater than 95% and the discharge air temperature is 17°C (30°F) less than setpoint for 5 minutes, send 3 Requests.

b. Else if the HW valve position is greater than 95% and the discharge air temperature is 8°C (15°F) less than setpoint for 5 minutes, send 2 Requests.

c. Else if HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 85%,

d. Else if the HW valve position is less than 95%, send 0 Requests.

5.23.10.7. Heating Hot Water Plant Requests

a. If the HW valve position is greater than 95%, send 1 Request until the HW valve position is less than 10%

b. Else if the HW valve position is less than 95%, send 0 Requests.

If there are no 4-pipe lab zone terminals, delete the following two sections:

5.23.10.8. Chilled Water Reset Requests

a. If the CHW valve position is greater than 95% and the supply air temperature is 6°C (10°F) greater than setpoint for 5 minutes, send 3 requests.

b. Else if the CHW valve position is greater than 95% and the supply air temperature is 3°C (5°F) greater than setpoint for 5 minutes, send 2 requests.

c. Else if the CHW valve is greater than 95%, send 1 request.

d. Else if the CHW valve is less than 85%, send 0 requests.

5.23.10.9. Chiller Plant Requests

a. If the CHW valve position is greater than 95%, send 1 Request until the CHW valve position is less than 10%.

b. Else if the CHW valve position is less than 95%, send 0 Requests.

Add Informative Appendix A-13 to 16 as follows: Note: the figures below are new, but additions are not underlined for ease of review.

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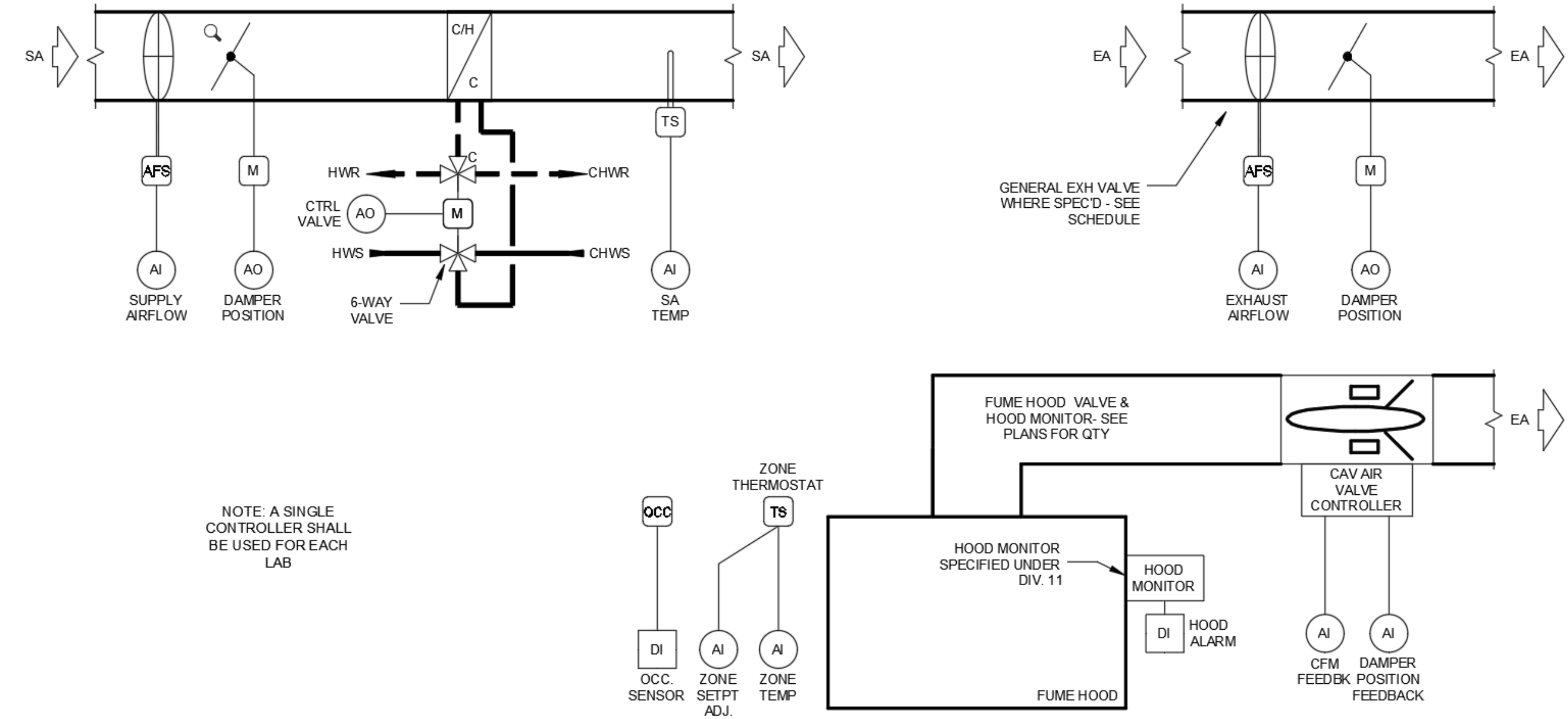
A-13. "Slow" Laboratory Four-Pipe VAV Zone



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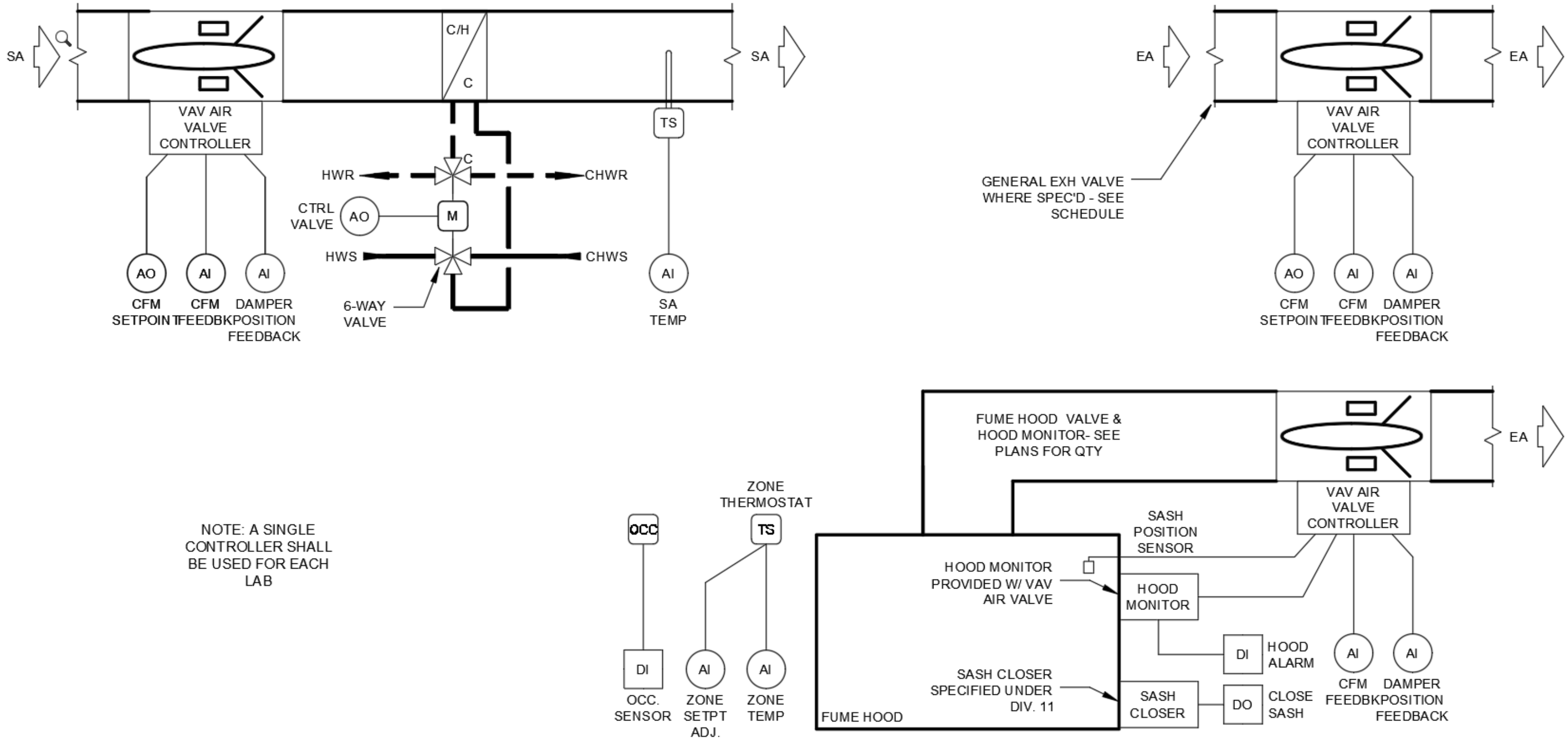
A-14 "Fast" Laboratory Four-Pipe VAV Zone



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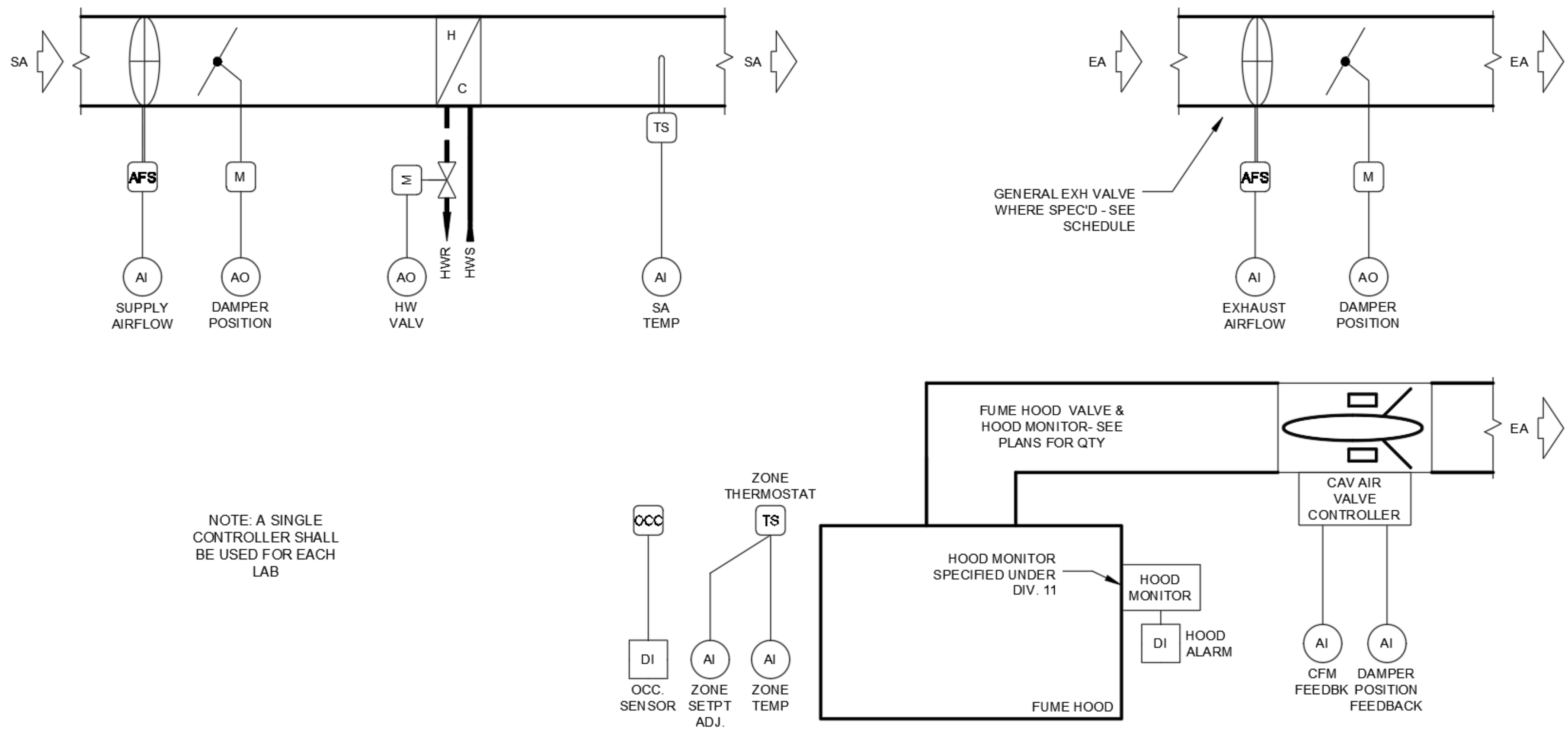
A-14 "Slow" Laboratory VAV Reheat Zone



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A-14 "Fast" Laboratory VAV Reheat Zone