



**Addendum I to
ASHRAE Guideline 36-2018**

Public Review Draft

Proposed Addendum I to Guideline 36-2018, High-Performance Sequences of Operation for HVAC Systems

**First Public Review (May 2020)
(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

This addendum includes the following changes:

- 1. Adds option for using an airflow monitoring station for single zone air handling units.*
- 2. Renames variable S-R-DIFF to S-R-SPD-DIFF to avoid confusion with a variable with the same name and different unit of measurement used in the sequence for multiple zone VAV air handling units.*
- 3. Adds dynamic reset to return fan speed tracking offset, S-R-SPD-DIFF to reduce the excess outdoor air brought through the exhaust air damper when the minimum outdoor airflow setpoint, MinOAsp, is zero.*
- 4. Relocates ventilation setpoint determination from the "Information provided by (or in conjunction with) the Test & Balance Contractor" section to the "Information provided by the designer" section.*
- 5. Adds equations for determination of the minimum outdoor air damper position, MinOA-P, to avoid misinterpretation.*
- 6. Adds option for direct building pressure control with return fans.*

The current sequences of operation for Single Zone VAV Air Handling Units only allow for minimum outdoor air damper position to be reset based on supply fan speed. This proposed addendum adds an option to use an airflow monitoring station (AFMS) as a means of measuring outdoor airflow for control of the minimum outdoor air damper position.

This addendum also adds a dynamic reset to S-R-DIFF, which is the airflow differential between supply air and return air fans required to maintain building pressure at desired pressure when using the Return Fan Tracking control option. The variable S-R-DIFF, which is a speed differential, is also changed to S-R-SPD-DIFF to differentiate between the airflow differential, S-R-DIFF used in the sequences for Multiple Zone Air Handling Units.

In Section 5.18.10.3, the AHU return fan speed is controlled so that return fan speed tracks the supply fan speed less S-R-DIFF. Issues with this logic:

- 1. This maintains a fixed speed offset even when the AHU is not in occupied mode, i.e., when minimum ventilation outdoor air is zero. During non-occupied modes (warm-up, setback, setup, and cooldown), when the outdoor air damper is closed and the fixed offset is maintained, excess outdoor air is drawn in through the exhaust air damper since the exhaust air damper is commanded open whenever the associated supply fan is proven on. Even if S-R-SPD-DIFF* were reset to 0% in these modes, a differential can also be caused if the return air fan is smaller in size than the supply air fan, which is common.*

2. *In Occupied Mode with the economizer disabled or in Occupied-Standby Mode, if the minimum outdoor airflow setpoint, MinOAsp is set to less than the airflow provided by return fan speed determined by the return fan speed differential, S-R-SPD-DIFF, excess outdoor air is drawn in through the exhaust air damper since the exhaust air damper is commanded open whenever the associated supply fan is proven on.*

This addendum addresses both issues noted above by scaling the return fan speed differential, S-R-SPD-DIFF based on the active minimum outdoor airflow setpoint, MinOAsp relative to the design outdoor airflow setpoint, DesOA. This change will automatically reset the return fan speed differential to zero when MinOAsp is zero (in non-occupied or occupied-standby modes) and will increase the differential as required to maintain building pressure when MinOAsp is increased to DesOA due to demand control ventilation (DCV).*

Note that Paragraph 5.18.10.1 which applies to single zone AHUs with return fans using speed tracking, calls for the exhaust air damper to be wide open whenever the supply fan is proven on during all operating modes, including warmup, setback, cooldown, and setup. This has the advantage of decoupling the return fan and supply fan when the S-R-SPD-DIFF is set to zero – if the exhaust air damper were closed, the fans would be in series and speed tracking would need to be exact to balance the supply and return airflow. However, having the exhaust air damper open can cause excess outdoor air intake through the exhaust air damper if there are airflow differences between the return fan and supply fan, e.g., if the return fan airflow is less than supply airflow, the remainder is non-zero outdoor airflow. This issue will be addressed by future addenda.

This addendum also addresses the issue where the ventilation setpoints for ASHRAE Standard 62.1 and California Title 24 are under the “Information Provided by (or in Conjunction with) the Test & Balance Contractor” section, while determination of ventilation setpoints should fall under the “Information Provided by the Designer” section.

An option to use direct building pressure control for units with return fans has been added. The new section references the multiple zone air handling unit sequence for return fans with direct building pressure control (5.16.10). Use of this option prevents the issue of excess outdoor air brought in through the exhaust air damper by maintaining a positive pressure in the return plenum.

Equations have also been added to Section 5.18.6 for minimum outdoor air damper position calculation for single zone air handling units without airflow monitoring stations. The current sequence describes the steps in determining minimum outdoor air damper position as an interpolation between two points. The added equation removes the possibility for misinterpretation.

Addendum I to Guideline 36-2018

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.

(IP and SI Units)

Revise Section 3.1.6 as follows:

3.1.6 Single Zone VAV Air Handler Design Information

3.1.6.1 Temperature Set Points

- a. Cool_SAT, lowest cooling supply air temperature setpoint
- b. Heat_SAT, highest heating supply air temperature setpoint

Cool_SAT is typically the design coil leaving air temperature. Heat_SAT is typically the design coil leaving air temperature, no more than 11°C (20°F) above the active heating setpoint.

- c. MaxDPT, maximum supply air dewpoint temperature

MaxDPT is used to limit supply air temperature to ensure supply air is not too humid resulting in high space humidity. This is typically only needed in humid type “A” climates, A typical

value is 17°C (62°F). For mild and dry climates, a high setpoint (e.g. 24°C (75°F)) should be entered for maximum efficiency.

3.1.6.2 Ventilation Set Points

The engineer must select between ventilation logic options:

If the project is to comply with Standard 62.1 ventilation requirements, keep subsection “a.” and delete subsection “b.”

If the project is to comply with California Title 24 ventilation requirements, keep subsection “b.” and delete subsection “a.”

- a. For projects complying with the Ventilation Rate Procedure of ASHRAE Standard 62.1:
 1. MinOA, the design outdoor air rate when the zone with a CO₂ sensor served by the system is unpopulated. MinOA shall equal V_{bz-A}/EzC .
 2. DesOA, the design outdoor air rate when the zone served by the system is occupied at its design population, including diversity where applicable. DesOA shall equal $(V_{bz-A}+V_{bz-P})/EzH$.
- b. For projects complying with the California Title 24 Ventilation Standards:
 1. MinOA, the design outdoor air rate when the zone with a CO₂ sensor served by the system is unpopulated. MinOA shall equal $V_{area-min}$.
 2. DesOA, the design outdoor air rate when the zone served by the system is occupied at its design population, including diversity where applicable. DesOA shall equal the larger of $V_{area-min}$ and $V_{occ-min}$.

~~3.1.6.2~~ 3.1.6.3 Economizer High Limit

Revise Section 3.2.2 as follows:

3.2.2 Single Zone Air Handler Information

3.2.2.1 Fan speed setpoints

- a. **MinSpeed.** The speed that provides supply airflow equal to DesOA (see ~~3.2.2.23~~.1.6.2) with the economizer outdoor air damper fully open.
- b. **MaxHeatSpeed.** The speed that provides supply airflow equal to the design heating airflow scheduled on plans. If no heating airflow is provided on plans, default to half of the maximum cooling speed.
- c. **MaxCoolSpeed.** The speed that provides supply airflow equal to the design cooling airflow scheduled on plans.

3.2.2.2 Minimum outdoor air damper positions (for systems without outdoor airflow measuring stations; See Section 5.18.6.2.)

~~The engineer must select between options for determining the outdoor airflow setpoint.~~

~~If the project is to comply with Standard 62.1 ventilation requirements, keep subsection (a) and delete subsection (b)~~

~~If the project is to comply with California Title 24, keep subsection (b) and delete subsection (a).~~

- ~~a. For projects complying with the Ventilation Rate Procedure of ASHRAE Standard 62.1, for purposes of determining Outdoor Air Damper Positions below:
 - 1. ~~MinOA shall equal V_{bz-A}/EzC~~
 - 2. ~~DesOA shall equal $(V_{bz-A} + V_{bz-P})/EzH$~~~~
- ~~b. For projects complying with the Title 24 Ventilation Rates, for purposes of determining Outdoor Air Damper Positions below:
 - 1. ~~MinOA shall equal $V_{area-min}$~~
 - 2. ~~DesOA shall equal the larger of $V_{area-min}$ and $V_{occ-min}$~~~~
- ~~e.a. MinPosMin: the outdoor air damper position required to provide MinOA when the supply fan is at MinSpeed.~~
- ~~e.b. MinPosMax: the outdoor air damper position required to provide MinOA when the supply fan is at MaxCoolSpeed.~~
- ~~e.c. DesPosMin: the outdoor air damper position required to provide DesOA when the supply fan is at MinSpeed.~~
- ~~d. DesPosMax: the outdoor air damper position required to provide DesOA when the supply fan is at MaxCoolSpeed.~~

3.2.2.3 Relief damper positions (~~if non-powered relief~~for relief using motorized dampers, see Section 5.18.9.)

- a. MinRelief: The relief damper position that maintains a building pressure of 12 Pa (0.05") while the system is at MinPosMin (i.e., the economizer damper is positioned to provide MinOA while the supply fan is at minimum speed).
- b. MaxRelief: The relief damper position that maintains a building pressure of 12 Pa (0.05") while the economizer damper is fully open and the fan speed is at cooling maximum.

3.2.2.4 Return fan speed differential. (for Return Fan Speed Tracking Control, see Section 5.18.10.~~(if return fan is used), S-R-SPD-DIFF.~~ The speed differential between supply air and return air fans, S-R-SPD-DIFF, required to maintain building pressure at desired pressure (e.g., 12 Pa (0.05")),

using a handheld sensor if a permanent sensor is not provided. All exhaust fans that normally operate with the air handler should be on.

3.2.2.5 Return fan discharge static pressure setpoints (for Return Fan Direct Building Pressure Control, see Section 5.18.11)

- a. RFDSPmin: That required to deliver the design return air volume across the return air damper when the supply air fan is at design airflow and on minimum outdoor air. This setpoint shall be no less than 2.4 Pa (0.01 inches) to ensure outdoor air is not drawn backwards thru the relief damper.
- b. RFDSPmax: That required to exhaust enough air to maintain building static pressure at setpoint 12 Pa (0.05 inches) when the supply air fan is at design airflow and on 100% outdoor air.

Revise Section 4.8 as follows:

4.8 Single Zone VAV Air Handling Unit

Re-quired ?	Description	Type	Device
R	Supply Fan Start/Stop	DO	Connect to VFD Run
R	Supply Fan Speed	AO	Connect to VFD Speed
O	Supply Fan Status	DI	Connect to VFD Status
R	Supply Air Temperature	AI	Duct temperature sensor (probe or averaging at designer’s discretion)
R	Outdoor/Return Air Damper	AO	Modulating actuators
R	Outdoor Air Temperature	AI	Temperature sensor at outdoor air intake
O	Mixed Air Temperature	AI	Averaging temperature sensor
O	Return Air Temperature	AI	Duct temperature sensor
R	Cooling Signal	AO	Modulating CHW valve OR Variable-capacity compressor
A	Heating Signal	AO	Modulating HW valve OR Modulating electric heating coil
R	Zone Temperature	AI	Room temperature sensor
A	Local Override (if applicable)	DI	Zone thermostat override switch
A	Occupancy Sensor (if applicable)	DI	Occupancy sensor
A	Window Switch (if applicable)	DI	Window switch
A	Zone Temperature Setpoint Adjustment (if applicable)	AI	Zone thermostat adjustment
A	Zone CO ₂ Level (if applicable)	AI	Room CO ₂ sensor
<u>For units with an AFMS, include the following point</u>			
A	<u>Outdoor Airflow</u>	<u>AI</u>	<u>Airflow measurement station</u>

Re- quired ?	Description	Type	Device
For units with actuated relief dampers but no relief fan, include the following points			
A	Relief Damper	AO	Modulating actuator
For units with a relief fan, include the following <u>four</u> points			
A	Relief Fan Start/Stop	DO	Connect to VFD Run
O	Relief Fan Status	DI	Connect to VFD Status
A	Relief Fan Speed	AO	Connect to VFD Speed
A	Relief Damper Open/Close	DO	Two position actuator
A	Building Static Pressure	AI	Differential pressure transducer between representative space and outdoors
For units with a return fan, include the following <u>three</u> points			
A	Return Fan Start/Stop	DO	Connect to VFD Run
O	Return Fan Status	DI	Current switch Connect to VFD Status
A	Return Fan Speed	AO	Connect to VFD Speed
<u>For units with a return fan and speed tracking control, include the following point</u>			
A	Exhaust Air Damper (if applicable – damper may be barometric)	DO	Two position actuator
<u>For units with a return fan and direct building pressure control, include the following point</u>			
<u>A</u>	<u>Return Fan Discharge Static Pressure</u>	<u>AI</u>	<u>Differential pressure transducer at fan</u>
<u>A</u>	<u>Exhaust Air Damper</u>	<u>AO</u>	<u>Modulating actuator</u>
<u>For units with direct building pressure control, include the following point</u>			
<u>A</u>	<u>Building Static Pressure</u>	<u>AI</u>	<u>Differential pressure transducer between representative space and outdoors</u>

Revise Section 5.18.6 as follows:

5.18.6 Minimum Outdoor Air Control

This section describes minimum outdoor air control logic for a unit with a single common minimum OA and economizer damper (i.e., no separate minimum OA damper) and Demand Control Ventilation.

This logic assumes that there is no airflow measurement station or differential pressure sensor across the outdoor air intake and controls OA volume directly via damper position setpoints. This works for a single zone unit because there are no downstream dampers that would change the relationship between OA damper position and OA airflow. This logic is not appropriate for a system with actuated dampers downstream of the AHU.

Other configurations are possible and would require modifications to the points list (above) and the control logic below.

5.18.6.1 See Section 5.2 for calculation of zone minimum outdoor airflow setpoint, MinOAsp.

The engineer must select among control logic options for minimum outdoor airflow control. This decision is based on whether the unit has an outdoor airflow measurement station.

Control logic selections should be made as follows:

- **For AHUs without an outdoor airflow measurement station, use Section “5.18.6.2” below and delete Section “5.18.6.3” below.**
- **For AHUs with an outdoor airflow measurement station, use Section “5.18.6.3” below and delete Section “5.18.6.2” below.**

5.18.6.2 Outdoor Air Damper Control for Units without an Outdoor Airflow Measurement Station

This section describes minimum outdoor air control logic for a unit with a single common minimum OA and economizer damper (i.e., no separate minimum OA damper) and Demand Control Ventilation.

This logic assumes that there is no airflow measurement station across the outdoor air intake and controls OA volume indirectly via damper position setpoints. This works for a single zone unit because there are no downstream dampers that would change the relationship between OA damper position and OA airflow. This logic is not appropriate for a system with actuated dampers downstream of the AHU.

Other configurations are possible and would require modifications to the points list (above) and the control logic below.

1. See 3.2.2.2 for minimum damper position setpoints, MinPosMin, MinPosMax, DesPosMin, and DesPosMax.

Add new Section 5.18.6.3 as follows:

5.18.6.3 Outdoor Air Damper Control for Units with an Outdoor Airflow Measurement Station

This section describes minimum outdoor air control logic for a unit with a single common minimum OA and economizer damper (i.e., no separate minimum OA damper) and Demand Control Ventilation.

This logic assumes that there is an airflow measurement station across the outdoor air intake and controls OA volume directly via control over the minimum OA damper position.

Other configurations are possible and would require modifications to the points list (above) and the control logic below.

- a. Minimum outdoor air control loop is enabled when the supply fan is proven on and in Occupied Mode and disabled and output set to zero otherwise.
- b. The minimum outdoor airflow rate shall be maintained at the minimum outdoor air setpoint MinOAsp by a reverse-acting control loop whose output is mapped to MinOA-P.

Revise Sections 5.18.8, 5.18.9, 5.18.10, and add Section 5.18.11 as follows:

The engineer must select among control logic options for return/relief/exhaust. This decision is based on the AHU configuration.

Control logic selections should be made as follows:

- For AHUs using actuated relief dampers without a fan, use section “5.18.8” below and delete sections “5.18.9,” and section “5.18.10,” and “5.18.11” below.
- For AHUs using actuated relief dampers with relief fan(s), use section “5.18.9” below and delete sections “5.18.8,” and section “5.18.10,” and “5.18.11” below.
- For AHUs using a return fan with speed tracking, use section “5.18.10” below and delete sections “5.18.8,” and section “5.18.9,” and “5.18.11” below.
- For AHUs using a return fan with direct building pressure control, use section “5.18.11” below and delete sections “5.18.8,” “5.18.9,” and “5.18.10” below.
- For AHUs using non-actuated barometric relief only, delete all threefour sections “5.18.8,” “5.18.9,” and “5.18.10,” and “5.18.11” below.

A building pressure sensor is required for options “5.18.9” and “5.18.11.” One is not required for options “5.18.8” or “5.18.10”

5.18.8 Control of Actuated Relief Dampers without Fans

5.18.8.1 See 3.2.2.3 for relief damper position setpoints:

5.18.8.2 Relief dampers shall be enabled when the associated supply fan is proven on and any outdoor air damper is open and disabled and closed otherwise.

5.18.8.3 Relief damper position shall be reset linearly from MinRelief to MaxRelief as the commanded economizer damper position goes from MinPos* to 100% open.

Relief fan control logic is incorporated by reference in subsection “5.18.9.1” below. If the project includes both single-zone and multiple-zone AHUs, then no change is required. However, if the project includes only single-zone AHUs, we recommend deleting section “5.18.9” below and copying the full text of 5.16.9 in its place.

5.18.9 Relief Fan Control

5.18.9.1 Refer to 5.16.9 Relief Fan Control for multiple-zone air handlers.

5.18.10 Return Fan Control – Speed Tracking

Exhaust damper may be barometric (no actuator). In that case, delete subsections “5.18.10.1” and “5.18.10.4” below.

5.18.10.1 Exhaust damper shall open whenever associated supply fan and return fan are proven on and shall be closed otherwise.

5.18.10.2 Return fan shall run whenever associated supply fan is proven on.

5.18.10.3 The active differential airflow setpoint S-R-SPD-DIFF* shall be S-R-SPD-DIFF (see Section 3.2.2.4) adjusted by the active minimum outdoor airflow setpoint, MinOAsp relative to the design outdoor airflow setpoint, DesOA.

$$S - R - SPD - DIFF^* = S - R - SPD - DIFF \frac{MinOAsp}{DesOA}$$

5.18.10.4 Return fan speed shall be ~~the same as supply fan speed with a user adjustable offset, controlled~~ to maintain return fan speed equal to supply fan speed less differential S-R-SPD-DIFF*.

~~5.18.10.3 Exhaust damper shall be closed when return fan is disabled.~~

Return fan control logic is incorporated by reference in subsection “5.18.11.1” below. If the project includes both single-zone and multiple-zone AHUs, then no change is required. However, if the project includes only single-zone AHUs, we recommend deleting section “5.18.11” below and copying the full text of 5.16.10 in its place.

5.18.11 Return Fan Control – Direct Building Pressure

5.18.11.1 Refer to 5.16.10 Return Fan Control – Direct Building Pressure for multiple-zone air handlers.

This concludes the section where the control logic for return/relief/exhaust is selected.

When the sequences are complete, at most, one of sections “5.18.8,” “5.18.9,” ~~or~~ “5.18.10,” or “5.18.11” should remain. If relief is barometric (without actuators) only, then all ~~three~~four subsections should be deleted. Delete these flag notes after the decision has been made.