ADDENDA

ASHRAE Addendum l to
ASHRAE Guideline 36-2018

High Performance Sequences of Operation for HVAC Systems

Approved by ASHRAE on August 24, 2020.

This addendum was approved by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

The latest edition of an ASHRAE Standard may be purchased on the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

 ISSN 1049-894X

SPECIAL NOTE

This Guideline was developed under the auspices of ASHRAE. ASHRAE Guidelines are developed under a review process, identifying a Guideline for the design, testing, application, or evaluation of a specific product, concept, or practice. As a Guideline it is not definitive but encompasses areas where there may be a variety of approaches, none of which must be precisely correct. ASHRAE Guidelines are written to assist professionals in the area of concern and expertise of ASHRAE's Technical Committees and Task Groups.

ASHRAE Guidelines are prepared by Project Committees appointed specifically for the purpose of writing Guidelines. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Guideline.

Development of ASHRAE Guidelines follows procedures similar to those for ASHRAE Standards except that (a) committee balance is desired but not required, (b) an effort is made to achieve consensus but consensus is not required, (c) Guidelines are not appealable, and (d) Guidelines are not submitted to ANSI for approval.

The Senior Manager of Standards of ASHRAE should be contacted for

a. interpretation of the contents of this Guideline,
b. participation in the next review of the Guideline,
c. offering constructive criticism for improving the Guideline, or
d. permission to reprint portions of the Guideline.

(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.

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.

Addendum l to Guideline 36-2018

(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 (20ºF) 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 CO_2 sensor served by the system is unpopulated. MinOA shall equal Vbz-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 (Vbz-A+Vbz-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 CO_2 sensor served by the system is unpopulated. MinOA shall equal Varea-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 Varea-min and Vocc-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 ~~3.2.2.2~~3.1.6.2) 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 Vbz-A/EzC~~

~~2. DesOA shall equal (Vbz-A+Vbz-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 Varea-min~~

~~2. DesOA shall equal the larger of Varea-min and Vocc-min~~

~~c.~~a. MinPosMin: the outdoor air damper position required to provide MinOA when the supply fan is at MinSpeed.
~~d.~~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

Re-quired ?	Description	Type	Device
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
	For units with an AFMS, include the following point		
A	Outdoor Airflow	AI	Airflow measurement station
	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 four 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 three 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
For units with a return fan and speed tracking control, include the following point			
A	Exhaust Air Damper (if applicable – damper may be barometric)	DO	Two position actuator
For units with a return fan and direct building pressure control, include the following point			
A	Return Fan Discharge Static Pressure	AI	Differential pressure transducer at fan
A	Exhaust Air Damper	AO	Modulating actuator
For units with direct building pressure control, include the following point			
A	Building Static Pressure	AI	Differential pressure transducer between representative space and outdoors

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 ~~three~~four 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.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ASHRAE · 1791 Tullie Circle NE · Atlanta, GA 30329 · www.ashrae.org

About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

To stay current with this and other ASHRAE Standards and Guidelines, visit www.ashrae.org/standards, and connect on LinkedIn, Facebook, Twitter, and YouTube.

Visit the ASHRAE Bookstore

ASHRAE offers its Standards and Guidelines in print, as immediately downloadable PDFs, and via ASHRAE Digital Collections, which provides online access with automatic updates as well as historical versions of publications. Selected Standards and Guidelines are also offered in redline versions that indicate the changes made between the active Standard or Guideline and its previous edition. For more information, visit the Standards and Guidelines section of the ASHRAE Bookstore at www.ashrae.org/bookstore.

IMPORTANT NOTICES ABOUT THIS GUIDELINE

To ensure that you have all of the approved addenda, errata, and interpretations for this Guideline, visit www.ashrae.org/standards to download them free of charge.

Addenda, errata, and interpretations for ASHRAE Standards and Guidelines are no longer distributed with copies of the Standards and Guidelines. ASHRAE provides these addenda, errata, and interpretations only in electronic form to promote more sustainable use of resources.