Addendum *e* to
ASHRAE Guideline 36-2018

Public Review Draft

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

First Public Review (June 2019)
(Draft shows Proposed Changes to Current Guideline)

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ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305

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FOREWORD

In the current version of Guideline 36, designers must determine Vmin, the VAV box minimum for all terminal types. This was left as a variable, rather than automatically calculated by the sequences, primarily because the minimum for systems complying with ASHRAE Standard 62.1 is not readily calculated when using Section 6.2.5 of Standard 62.1 and the so-called Multiple Spaces Equation (MSE) in Appendix A. It must be determined by iterating on airflow rates and occupancy assumptions in each zone of the system, typically using the 62MZCalc spreadsheet provided with the Standard 62.1 User's Manual.

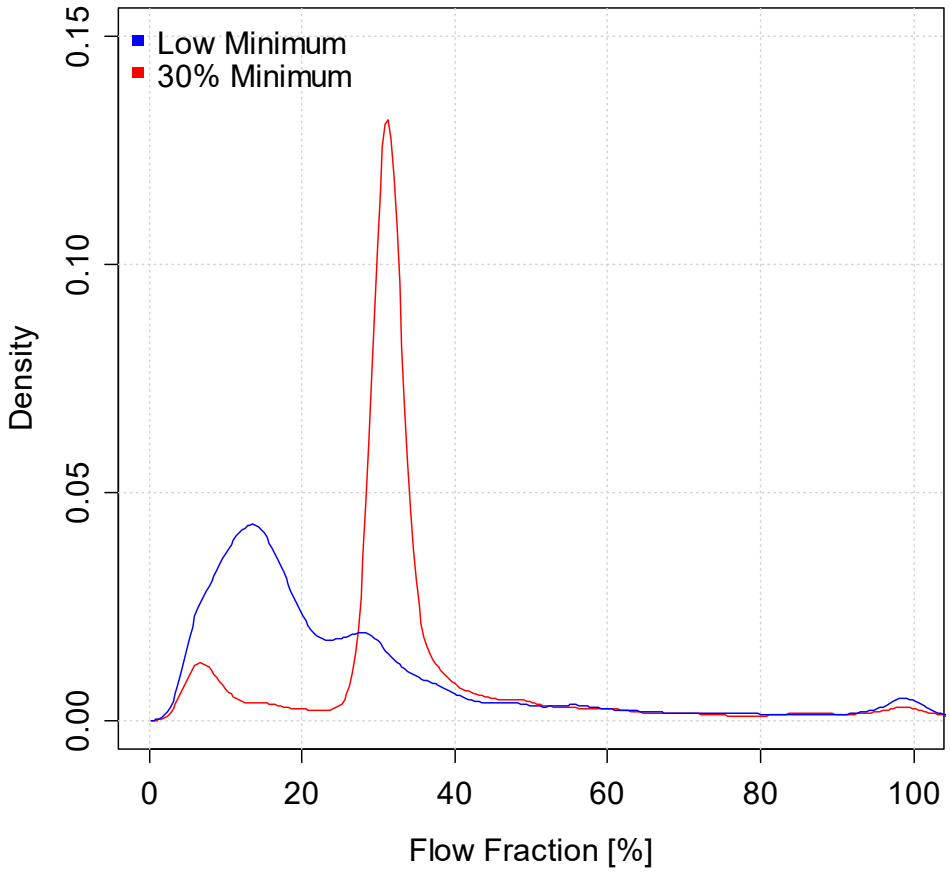
However, Addendum f to Standard 62.1-2016, approved and published in May 2018, created a Simplified Procedure for determining outdoor air rates for multiple zone recirculating air handling systems that includes a simple prescriptive requirement for calculating air handling system ventilation efficiency (which in turn is used to determine the air handler minimum outdoor air rate) as well as minimum setpoints for VAV zones. The following paraphrases the new procedure:

> **6.2.5.3 Simplified Procedure**
>
> **6.2.5.3.1 System Ventilation Efficiency.** System Ventilation Efficiency (Ev) shall be determined in accordance with Equation 6.2.5.3.1A or B as a function of occupant diversity, D.
>
> $$Ev = 0.88*D + 0.22 \text{ for } D<0.60 \qquad (6.2.5.3.1A)$$
>
> $$Ev = 0.75 \text{ for } D\geq 0.60 \qquad (6.2.5.3.1B)$$
>
> **6.2.5.3.2 Zone Minimum Primary Airflow.** For each zone, the minimum primary airflow ($V_{pz\text{-}min}$) shall be determined in accordance with Equation 6.2.5.3.2 based on zone minimum outdoor airflow rate, V_{oz}.
>
> $$V_{pz\text{-}min} = V_{oz}*1.5 \qquad (6.2.5.3.2)$$

This Simplified Procedure may be used in lieu of the more comprehensive procedure using the MSE from Appendix A to Standard 62.1. To determine VAV zone minimum setpoints using the MSE is very complicated, involving many assumptions about occupancy and airflow rates and requiring multiple iterations to find the critical zone, adjust the system outside air rate and/or zone minimum, and repeat until the perceived lowest energy solution is reached. This complexity and uncertainty is now eliminated with this addendum.

Shortly after the Standard 62.1. addendum was published, SSPC 90.1 passed Addendum au to Standard 90.1-2016. This addendum mandates the use of the new Simplified Procedure minimum in Equation 6.2.5.3.2 above in place of the previous provision in Standard 90.1-2016 that allowed VAV box minimum setpoints to be 20% of the design supply air rate. Outdoor air rates are generally much lower than 20% of the maximum rate, but designers felt they needed a higher percentage to meet the requirements of Standard

62.1 for multiple zone systems. With this addendum, designers no longer need to calculate what minimum rates are required using the Multiple Spaces Equation. Moreover, using percentages to determine minimums is problematic because VAV boxes are almost always oversized due to conservative load assumptions for occupants, lights, plug loads, etc. It is not unusual for boxes to be sized 3 or more times larger than they need to be, as was found to be the case in ASHRAE RP-1515 "Thermal and air quality acceptability in buildings that reduce energy by reducing minimum airflow from overhead diffusers." The figure below from RP-1515 shows measured frequency of airflow rates in 7 California office buildings using 30% minimums (based on earlier versions of Standard 90.1 and Title 24 Energy Standards) compared to the current "dual maximum" logic required by both Standard 90.1 and Title 24 for systems with DDC using the minimum set to the Title 24 minimum ventilation rate. (The Title 24 minimum ventilation rate is similar to the rates that result from Addendum f to Standard 62.1 described above.) The figure shows that even if the minimums were set to 20% instead of 30%, excess air would have been supplied due to the oversized cooling maximum setpoint, wasting fan energy, heating energy, and cooling energy.



This addendum to Guideline 36 implements these two Standard 62.1 and 90.1 addenda to allow minimum rates to be calculated automatically from zone occupant-based and area-based ventilation rates. Energy savings are enhanced by further adjusting rates dynamically based on zone ventilation effectiveness (Ez) as a function of zone supply air temperature and occupancy status using occupancy sensors and CO_2

sensors. Similarly, minimums can be automatically calculated using Title 24 ventilation rates for California projects.

The proposed procedure still allows users to override the automatic calculation and enter a specific airflow rate for special circumstances, such as:

- For fan-powered VAV boxes, the primary airflow minimum can often be set below the minimum ventilation rate by using transfer air to provide some or all of the ventilation requirement indirectly, as allowed by Appendix A of Standard 62.1.
- Minimum rates are sometimes determined by exhaust makeup air requirement rather than ventilation rates.

This revision also contains some clarifications and bug fixes regarding Vbz-A* and Vbz-P* which are the active area- and people- based ventilation rates adjusted for occupancy sensors and window switches. They were not properly referenced in Section 5.16.3.1.

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.

Addendum e to Guideline 36-2018

(IP and SI Units)

Revise Section 3.1.2.1 as follows:

3.1.2.1. VAV Cooling-Only Terminal Unit

1. Zone maximum cooling airflow setpoint (Vcool-max)

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

> *In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.*
> ~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

Revise Section 3.1.2.2 as follows:

3.1.2.2 VAV Reheat Terminal Unit

1. Zone maximum cooling airflow setpoint (Vcool-max)

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

> *In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.*
> ~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When*~~

~~*selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

Revise Section 3.1.2.3 as follows:

3.1.2.3 Parallel Fan-Powered Terminal Unit, Constant-Volume Fan

1. Zone maximum cooling airflow setpoint (Vcool-max)

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.
~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

Revise Section 3.1.2.4 as follows:

3.1.2.4 Parallel Fan-Powered Terminal Unit, Variable-Volume Fan

1. Zone maximum cooling airflow setpoint (Vcool-max)

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.
~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

Revise Section 3.1.2.5 as follows:

3.1.2.5 Series Fan-Powered Terminal Unit, Constant-Volume Fan

1. Zone maximum cooling airflow setpoint (Vcool-max)

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

> *In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.*
> ~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

Revise Section 3.1.2.6 as follows:

3.1.2.6 Series Fan-Powered Terminal Unit, Variable-Volume Fan

1. Zone maximum cooling airflow setpoint (Vcool-max)

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

> *In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.*
> ~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

Revise Section 3.1.2.7 as follows:

3.1.2.7 Dual-Duct VAV Terminal Unit

1. Zone maximum cooling airflow setpoint (Vcool-max)

> ~~*For ASHRAE Standard 62.1 ventilation, select Vmin to prevent creating critical zones. Critical zones are zones with the highest zone primary outdoor air fraction, Zpz, which results in lower system ventilation efficiency, Ev and higher effective minimum outdoor air setpoint, MinOAsp. For calculation of MinOAsp for Standard 62.1 ventilation, see 5.16.3.1. This will lead to Vmin being higher than code minimum ventilation for all zones that require outdoor air. For California Title 24 ventilation, Vmin should be selected as the larger of Varea-min and Vocc-min, except for zones that have CO2 DCV for which Vmin should be equal to Varea-min. When selecting Vmin, do not consider the limitations of the VAV box controller to measure and control airflow; that is addressed by the control sequences themselves; see 5.1.16.*~~

2. Zone minimum airflow setpoint (Vmin). This is an optional entry. If no value is scheduled, or a value of "AUTO" is scheduled, Vmin will be calculated automatically and dynamically to meet ventilation requirements.

> *In most cases, Vmin should be allowed to be automatically calculated. This ensures compliance with Standard 62.1 and Standard 90.1 prescriptive requirements and with California's Title 24 Energy Standards requirements, and it results in the lowest energy costs.*

Revise Section 5.2.1.3 as follows:

5.2.1.3 For compliance with the Ventilation Rate Procedure of ASHRAE Standard 62.1-2016, outdoor air and zone minimum setpoints shall be calculated as follows:

a. See Section 3.1.1.2 for zone ventilation setpoints.

b. Determine zone air distribution effectiveness Ez.

   1. If the discharge air temperature at the terminal unit is less than or equal to zone space temperature, Ez shall be equal to EzC (default to 1.0 if no value is scheduled).

   2. If the discharge air temperature at the terminal unit is greater than zone space temperature, Ez shall be equal to EzH (default to 0.8 if no value is scheduled).

c. Vbz-P* is the population component of the required breathing zone outdoor airflow. The normal value of Vbz-P* shall be Vbz-P. Vbz-A* is the area component of the required breathing zone outdoor airflow. The normal value of Vbz-A* shall be Vbz-A.

d. Vmin

   1. Shall be equal to Voz as calculated in Section 5.2.1.3f below if Vmin in Section 3.1.2 is "AUTO" and the associated air handler ~~is~~has been supplying 100% outdoor air (outdoor air damper fully open; return air damper fully closed) for 10 minutes;

   2. Else shall be equal to 1.5 * Voz as calculated in Section 5.2.1.3f below if Vmin in Section 3.1.2 is "AUTO" and the associated air handler is not supplying 100% outdoor air;

   3. Else shall be equal Vmin as entered in Section 3.1.2.

e. The occupied minimum airflow Vmin* shall be equal to Vmin except as noted in Section 5.2.1.3f below.

f. The required zone outdoor airflow Voz shall be calculated as Voz = (Vbz-A* + Vbz-P*) / Ez, where the normal values of Vbz-A* and Vbz-P* are modified if any of the following conditions are met, in order from higher to lower priority:

   1. If the zone is in any mode other than Occupied Mode and for zones that have window switches and the window is open: Vbz-P* = 0, Vbz-A* = 0, and Vmin* = 0.

   2. If the zone has an occupancy sensor, is unpopulated, and occupied-standby mode is permitted: Vbz-P* = 0, Vbz-A* = 0, and Vmin* = 0.

   3. Else, if the zone has an occupancy sensor, is unpopulated, but occupied-standby mode is not permitted: Vbz-P* = 0 and Vmin* = Vmin.

Renumber the remaining sections accordingly.

Revise Section 5.2.1.4 as follows:

5.2.1.4 For compliance with California Title 24, outdoor air setpoints shall be calculated as follows:

a. See Section 3.1.1.2~~.2~~ for zone ventilation setpoints.

b. Determine the zone minimum outdoor air setpoints Zone-Abs-OA-min and Zone-Des-OA-min.

Zone-Abs-OA-min is used in terminal unit sequences and air handler sequences. Zone-Des-OA-min is used in air handler sequences only.

   1. Zone-Abs-OA-min shall be reset based on the following conditions in order from higher to lower priority:

      i. Zero if the zone has a window switch and the window is open

      ii. 25% of Varea-min if the zone has an occupancy sensor and is unpopulated

The term "populated" is used instead of "occupied" to mean that a zone occupancy sensor senses the presence of people because the term "occupied" is used elsewhere to mean "scheduled to be occupied".

      iii. Varea-min if the zone has a CO_2 sensor

      iv. Zone-Des-OA-min otherwise

   2. Zone-Des-OA-min is equal to

      i. Zero if the zone has a window switch and the window is open

      ii. 25% of Varea-min if the zone has an occupancy sensor and is unpopulated

      iii. The larger of Varea-min and Vocc-min otherwise

c. Vmin

   1. Shall be equal to Zone-Abs-OA-min if Vmin in Section 3.1.2 is "AUTO";

2. Else shall be equal to Vmin as entered in Section 3.1.2.

Renumber the remaining sections accordingly.

Revise Section 5.16.3.1 item 3 as follows:

3. Outdoor air absolute minimum and design minimum setpoints are recalculated continuously based on the ~~Mode~~ adjusted ventilation rates Vbz-A* and Vbz-P* of the zones being served determined in accordance with Section 5.2.1.3.

> *Some diversity factor is included in Vou calculated below because the ventilation requirements have been zeroed out for unoccupied zones and those with open window switches. But there is additional diversity in areas with occupancy sensors because only one person in the room will trigger the sensor. There is also diversity in other areas without occupancy sensors. Hence operating Vou is limited to design Vou and the diversity value of D in the calculation of DesVou is not required.*

   a. Calculate the uncorrected outdoor air rate Vou for all zones in all Zone Groups that are in Occupied Mode, but note that Vou shall be no larger than the design uncorrected outdoor air rate, DesVou.

~~$V_{ou} = \text{MIN}(\text{DesV}_{ou} \mid (\sum V_{bz-A} + \sum V_{bz-P}))$~~ $V_{ou} = \text{MIN}(\text{DesV}_{ou} \mid (\sum V_{bz-A^*} + \sum V_{bz-P^*}))$