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ADDENDA

ANSI/ASHRAE Addendum t to
ANSI/ASHRAE Standard 62.1-2016

Ventilation for Acceptable Indoor Air Quality

Approved by the ASHRAE Standards Committee on January 12, 2019; by the ASHRAE Technology Council on January 16, 2019; and by the American National Standards Institute on January 17, 2019.

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FOREWORD

Addendum t adds a new informative appendix that is a companion to the changes to the Natural Ventilation Procedure. It provides information for application of the new procedure.

Note: In this addendum, changes to the current standard 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 t to Standard 62.1-2016

Add a new Informative Appendix L as shown. Equations, though not underlined, are new material.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX L INFORMATION ON NATURAL VENTILATION

L1. OUTDOOR AIR QUALITY DATA

Outdoor air quality data may be considered valid if it is demonstrated that the data are both physically representative and spatially representative.

Physically representative data accurately reflect the air quality conditions at the monitoring station from which they are derived. Data are considered physically representative if they are obtained from

a. reports of historical levels of air pollutants published by the relevant local, regional, or federal entity with statutory responsibility for collecting and reporting air quality information in accordance with applicable air quality regulations, or
b. an on-site monitoring campaign that is verifiably comparable to local, regional, or federal guidelines and methods for demonstration of compliance with applicable air quality regulations.

Spatially representative data are collected from a monitoring site that may differ from the proposed project location but is informative of the air quality conditions at the proposed project location. Data may be considered spatially representative if they are

c. the same as those used by the entity charged with demonstrating regulatory compliance for the geographic region that includes the proposed project location, or
d. derived from an on-site monitoring campaign that also meets the requirement stated by criteria (b) of this annotation.

L2. NATURAL VENTILATION RATE

When calculating the ventilation rate, specific path(s) of the intended airflow passage must first be determined as well as flow directions. There are two driving forces for natural ventilation: buoyancy and wind. The two driving forces can work cooperatively or competitively based on the environmental conditions of wind speed, direction, indoor/outdoor air/surface temperatures, as well as the intentional airflow path and mechanisms.

a. In the case of an engineered natural ventilation system that results in multiple flow scenarios, each must be examined and considered separately.
b. Specific pressure-based calculation of natural ventilation flow rate is documented in 2013 *ASHRAE Handbook—Fundamentals*[L-1], Chapter 16, Section 6:
   1. Buoyancy-induced airflow can be calculated following Equation 38.
   2. Wind-driven airflow can be calculated following Equation 37.
   3. The overall pressure (driven by both wind and stack effect) converted to resulting pressure difference between openings can found in Equation 36.

For obtaining wind-driven pressure, several methods are available:

a. 2013 *ASHRAE Handbook—Fundamentals*[L-1], Chapter 24, provides a method to convert wind speed and direction into pressure coefficients that can be used to determine wind-driven pressure.
b. 2005 CIBSE AM10[L-2], Chapter 4, provides a method to account for wind-driven ventilation and outlines specific challenges to it in Section 4.4.1.
c. If the building has undergone wind tunnel test for structural stress, the same test can provide detailed pressure coefficients.
d. Outdoor airflow simulation (such as computational-fluid-dynamics-based simulation) can be used to obtain the specific flow condition at the intended openings.

For intended openings that are large, such as open atrium or open balcony, and/or when the flow path is not well defined, such as when only single or single side openings are available, the pressure based method can be invalid, and outdoor-indoor linked simulation should be used.

L3. PRESCRIPTIVE PATH A CALCULATIONS

L3.1 Ventilation Intensity. Spaces have been defined by a ventilation intensity, which represents the amount of flow rate needed per Equation 6.2.2.1, divided by the floor area of the space. Its units are $(L/s)\cdot m^2$ of floor area or cfm/ft^2 of floor area.

Table L-1 Ventilation Intensity Brackets

Bracket	(L/s)·m²	cfm/ft²	Commonly Encountered Space Typologies Bracket
1	0.0 to 1.0	0.0 to 0.2	Office, living room, main entry lobby
2	1.0 to 2.0	0.2 to 0.4	Reception area, general manufacturing, kitchen, lobby
3	2.0 to 3.0	0.4 to 0.6	Classroom, daycare
4	3.0 to 4.0	0.6 to 0.8	Restaurant dining room, places of religious worship
5	4.0 to 5.5	0.6 to 1.1	Auditorium, health club/aerobics room, bar, gambling

Not addressed: Lecture Hall and spectator areas (6 [L/s]·m²) and disco/dance floors (10.3 [L/s]·m²)

$$\text{Ventilation Intensity} = \frac{V_{bz}}{A_z} = \frac{R_p \times P_z + R_a \times A_z}{A_z} \quad \text{(L3.1)}$$

The ventilation intensity brackets in Table L-1 are used.

L3.2 Single Openings. The flow through a single sharp opening due to bidirectional buoyancy-driven flow [L-3] (V_{bd_sharp}) is expressed as follows:

$$V_{so\_sharp} = 0.21 \times A_w \times \sqrt{gH_s\frac{\Delta T}{T_{ref}}} \quad \text{(L3.1.1)}$$

where

A_w = free unobstructed area of the window, or openable area

ΔT = temperature difference between indoors and outdoors. Given the conservative nature of a prescriptive path, a temperature difference of 1°C (1.8°F) is assumed for these calculations. In reality, this temperature will depend on the internal gains in the space and will likely be higher than 1°C (1.8°F), leading to higher airflows (and a smaller window area requirement).

H_s = vertical dimension of the opening

g = gravity constant

T_{ref} = reference temperature in Kelvin (or Rankine), typically equal to T_{in}, T_{out} or an expected average. A reference temperature of 21°C (70°F, 294K) was assumed for these calculations.

A safety factor is incorporated assuming that an awning window is used. Awning (or top-hinged) windows are among the most common windows used for natural ventilation, and, because of their uneven vertical area distribution, are more inefficient than a sliding window (sharp opening) at driving flow. An efficiency ε_w of 83% is assumed, based on studies by von Grabe[L-4] comparing the loss in flow rate between a sliding window and an awning window.

$$V_{so} = V_{so\_sharp} \times \varepsilon_w \quad \text{(L3.1.2)}$$

Assuming a height-to-width ratio for the window of $R_{H/W}$ ($R = H/W$), the window area can be re-written as

$$A_w = \frac{H_S^2}{R_{H/W}} \quad \text{(L3.1.3)}$$

The required openable area as a fraction of the zone's floor area is therefore calculated by equating the bidirectional buoyancy-driven flow through a single awning opening (V_{so}) to the goal flowrate (V_{bz}) obtained from Table 6.2.2.1.

$$V_{so} = V_{bz} \quad \text{(L3.1.4)}$$

And solving for window area,

$$\frac{A_w}{A_z} = \left(\frac{V_{bz}}{0.21 \times 0.83 \times R_{H/W}^4 \times \sqrt{g\frac{\Delta T}{T_{ref}}}}\right)^{4/5} \times \frac{1}{A_z} \times 100 \quad \text{(L3.1.5)}$$

L3.3 Vertically Spaced Openings. The flowrate V_{vs} through vertically spaced openings of areas A_s (the smallest sum of opening areas, either upper openings or lower openings) and A_l (the largest sum of opening areas, either upper openings or lower openings) is obtained using the following equation:

$$V_{vs} = A_{eff} \times C_d \times \sqrt{2g\Delta H\frac{\Delta T}{T_{ref}}} \quad \text{(L3.2)}$$

where

A_{eff} = effective window area, defined as

$$A_{eff} = \frac{1}{\sqrt{\frac{1}{A_s^2} + \frac{1}{A_l^2}}} = \frac{A_s}{\sqrt{1 + R^2}} = \frac{A_w}{\sqrt{1 + R^2} \times \left(1 + \frac{1}{R}\right)} \quad \text{(L3.2.1)}$$

A_w = is the total sum of all opening areas

$$A_w = A_s + A_t \quad \text{(L3.2.2)}$$

R = area ratio between A_s and A_l

$$R = \frac{A_s}{A_l} \quad \text{(L3.2.3)}$$

ΔH is the shortest vertical distance between the center of the lowest openings and that of the upper openings.

All other constants are the same as in the single opening scenario.

The required openable area as a fraction of the zone's floor area is therefore calculated by equating the flow through two sets of vertically spaces openings V_{vs} to the goal flowrate V_{bz} obtained from Table 6.2.2.

$$V_{vs} = V_{bz} \tag{L3.2.4}$$

Solving for window area:

$$\frac{A_w}{A_z} = \frac{V_{bz}}{C_d \times \sqrt{2g\Delta H \frac{\Delta T}{T_{ref}}}} \times \sqrt{1 + R^2} \times \left(1 + \frac{1}{R}\right) \times \frac{1}{A_z} \times 100 \tag{L3.2.5}$$

L4. CONTROL AND ACCESSIBILITY (MIXED-MODE VENTILATION)

Mixed-mode ventilation is a hybrid system used to maintain indoor air quality and internal thermal temperatures year-round using both natural and mechanical ventilation systems.

a. Natural ventilation systems use natural forces such as wind and thermal buoyancy to ventilate and cool spaces.
b. Mechanical ventilation systems use mechanical systems with fans to supply and exhaust air from a space, provide humidity control, and, if required, filter possible contaminants.

By preferentially using natural ventilation when outdoor air conditions are suitable, energy costs and carbon emissions can be minimized. Sensors are used to identify when natural ventilation is less effective at providing suitable indoor temperatures, humidity levels, and contaminant levels, and indicate that a transition to mechanical ventilation should occur. The transition between modes can be manual or automatic, as dictated by the needs of the owner/occupants. The use of each mode when appropriate will ensure year-round acceptable indoor air quality.

L5. REFERENCES

L-1. ASHRAE. 2013. *ASHRAE Handbook—Fundamentals*. Atlanta: ASHRAE.

L-2. CIBSE. 2005. CIBSE AM10, *Natural Ventilation in Non-Domestic Buildings*. London, UK: Chartered Institution of Building Services Engineers.

L-3. Etheridge, D.W., and M. Sandberg. 1996. *Building Ventilation: Theory and Measurement*, Vol. 50. Chichester, UK: John Wiley & Sons.

L-4. von Grabe, J. 2013. Flow resistance for different types of windows in the case of buoyancy ventilation. *Energy and Buildings* 65:516–22.

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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.

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