ANSI/ASHRAE Addenda g, r, and t to ANSI/ASHRAE Standard 62.1-2007

ASHRAE STANDARD

Ventilation for Acceptable Indoor Air Quality

Approved by the ASHRAE Standards Committee on January 23, 2010; by the ASHRAE Board of Directors on January 27, 2010; and by the American National Standards Institute on January 28, 2010.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) 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 standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

ISSN 1041-2336

Approved American National Standard
ANSI
www.ansi.org

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). *Consensus* is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. 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 Standard. Every effort is made to balance the concerned interests on all Project Committees.

The Manager of Standards of ASHRAE should be contacted for:

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

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE’s Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

(This foreword 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.)

FOREWORD

This addendum has been developed in response to a change proposal; with additional changes resulting from public review comments. It provides additional information for demand controlled ventilation (DCV) systems to augment Section 6.2.7 Dynamic Reset.

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 g to Standard 62.1-2007

Note: Add the following definition to Section 3 Definitions:

demand controlled ventilation (DCV): any means by which the breathing zone outdoor air flow (V_{bz}) can be varied to the occupied space or spaces based on the actual or estimated number of occupants and/or ventilation requirements of the occupied zone.

Note: Revise Section 6.2.7 as follows:

6.2.7 Dynamic Reset. The system may be designed to reset the ~~design~~ *outdoor air intake flow* (V_{ot}) and/or ~~space or~~ *ventilation zone* airflow (V_{oz}) as operating conditions change. ~~These conditions include but are not limited to:~~

~~1. Variations in occupancy or ventilation airflow in one or more individual zones for which ventilation airflow requirements will be reset.~~

~~***Note:*** Examples of measures for estimating such variations include: occupancy scheduled by time-of-day, a direct count of occupants, or an estimate of occupancy or ventilation rate per person using occupancy sensors such as those based on indoor CO2 concentrations.~~

6.2.7.1 Demand Control Ventilation (DCV).

6.2.7.1.1 DCV shall be permitted as an optional means of dynamic reset.

Exception: CO_2-based DCV shall not be applied in zones with indoor sources of CO_2 other than occupants or with CO_2 removal mechanisms, such as gaseous air cleaners.

6.2.7.1.2 The breathing zone outdoor airflow (V_{bz}) shall be reset in response to current occupancy and shall be no less than the building component (R_a*A_z) of the DCV zone.

Note: Examples of reset methods or devices include population counters, carbon dioxide (CO_2) sensors, timers, occupancy schedules or occupancy sensors.

6.2.7.1.3 The ventilation system shall be controlled such that at steady-state it provides each zone with no less than the breathing zone outdoor airflow (V_{bz}) for the current zone population.

6.2.7.1.4 When the mechanical air-conditioning system is dehumidifying, the current total outdoor air intake flow for the building shall be no less than the coincident total exhaust airflow.

6.2.7.1.5 Documentation: A written description of the equipment, methods, control sequences, set points, and the intended operational functions shall be provided. A table shall be provided that shows the minimum and maximum outdoor intake airflow for each system.

~~2.~~ **6.2.7.2 Ventilation Efficiency.** Variations in the efficiency with which outdoor air is distributed to the occupants under different ventilation system airflows and temperatures shall be permitted as an optional basis of dynamic reset.

~~3.~~ **6.2.7.3 Outdoor Air Fraction.** A higher fraction of outdoor air in the air supply due to intake of additional outdoor air for free cooling or exhaust air makeup shall be permitted as an optional basis of dynamic reset.

Note: Modify Section 6.4 as follows:

6.4 Design Documentation Procedures. Design criteria and assumptions shall be documented and should be made available for operation of the system within a reasonable time after installation. See Sections 4.3, 5.2.3, 5.17.4, 6.2.7.1.5, and 6.3.2 regarding assumptions that should be detailed in the documentation.

(This foreword 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.)

FOREWORD

This addendum modifies the IAQ procedure in Section 6.3 and its description in Section 6.1.

- *This addendum addresses compliance issues that may result from unclear wording or phrasing.*
- *This addendum makes a mass balance analysis a required part of the IAQ procedure.*
- *This addendum requires that performance of IAQ procedure designed systems be tested similar to the requirements to test VRP designed systems or that it be based on the tested performance of a design for a similar zone, with added requirements for determining whether a zone is similar.*

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 r to Standard 62.1-2007

Note: Revise Section 6.1.2 as follows:

6.1.2 IAQ Procedure. ~~This is a~~This performance-based design procedure (presented in Section 6.3), in which the building, outdoor air intake rates and other system design parameters are based on an analysis of contaminant sources, contaminant concentration ~~target~~limits, and level of perceived indoor air acceptability ~~targets~~, shall be permitted to be used for any zone or system. ~~The IAQ Procedure allows credit to be taken for controls that remove contaminants (for example, air cleaning devices) or for other design techniques (for example, selection of materials with lower source strengths) that can be reliably demonstrated to result in indoor contaminant concentrations equal to or lower than those achieved using the Ventilation Rate Procedure. The IAQ Procedure may also be used where the design is intended to attain specific target contaminant concentrations or levels of acceptability of perceived indoor air quality.~~

Note: Revise Section 6.3 as follows:

6.3 Indoor Air Quality (IAQ) Procedure. ~~The Indoor Air Quality (IAQ) Procedure is a performance-based design approach in which the building and its ventilation system are designed to maintain the concentrations of specific contaminants at or below certain limits identified during the building design and to achieve the design target level of perceived indoor air quality acceptability by building occupants and/or visitors. For the purposes of this procedure, acceptable perceived indoor air quality excludes dissatisfaction related to thermal comfort, noise and vibration, lighting, and psychological stressors.~~

Breathing zone outdoor airflow (V_{bz}) and/or system outdoor air intake flow (V_{ot}) shall be determined in accordance with Sections 6.3.1 thru 6.3.5.

Note: Delete Section 6.3.1:

~~**6.3.1** Designs employing the IAQ Procedure shall comply with the requirements in the following sections~~.

Note: Revise Section 6.3.1.1 as follows:

6.3.1.~~1~~ Contaminant Sources. Contaminants or mixtures of concern for purposes of the design shall be identified. For each contaminant or mixture of concern, indoor sources (occupants and materials) and outdoor sources shall be identified, and the ~~strength~~ emission rate for each contaminant of concern from ~~of~~ each source shall be determined.

Note: Appendix B lists information for some potential contaminants of concern.

Note: Revise and Renumber Section 6.3.1.2 as follows:

6.3.~~1.~~2 Contaminant Concentration. For each contaminant of concern, a ~~target~~ concentration limit and its corresponding exposure period and an appropriate reference to a cognizant authority shall be specified. ~~(See Appendix B for some contaminant concentration guidelines.)~~

Note: Appendix B includes concentration guidelines for some potential contaminants of concern.

Note: Revise and Renumber Section 6.3.1.3 as follows:

6.3.~~1.~~3 Perceived Indoor Air Quality. The ~~criteria to achieve the~~ design level of indoor air acceptability shall be specified in terms of the percentage of building occupants and/or visitors expressing satisfaction with perceived IAQ.

Note: Delete existing Section 6.3.1.4 in its entirety:

~~**6.3.1.4** Design Approaches. Select one or a combination of the following design approaches to determine minimum space and system outdoor airflow rates and all other design parameters deemed relevant (e.g., air-cleaning efficiencies and supply airflow rates).~~

~~a. Mass balance analysis. The steady-state equations in Appendix D, which describe the impact of air cleaning on outdoor air and recirculation rates, may be used as part of a mass balance analysis for ventilation systems serving a single space.~~

~~b. Design approaches that have proved successful in similar buildings.~~

~~c. Approaches validated by contaminant monitoring and subjective occupant evaluations in the completed building. An acceptable approach to subjective evaluation is presented in Appendix B, which may be used to validate~~

~~the acceptability of perceived air quality in the completed building.~~

~~d. Application of one of the preceding design approaches (a, b, or c) to specific contaminants and the use of the Ventilation Rate Procedure to address the general aspects of indoor air quality in the space being designed. In this situation, the Ventilation Rate Procedure would be used to determine the design ventilation rate of the space and the IAQ Procedure would be used to address the control of the specific contaminants through air cleaning or some other means.~~

Note: Insert new Section 6.3.4 as follows:

6.3.4 Design Approach. Zone and system outdoor airflow rates shall be the larger of those determined in accordance with Section 6.3.4.1 and either 6.3.4.2 or 6.3.4.3, based on emission rates, concentration limits and other relevant design parameters (e.g., air cleaning efficiencies and supply airflow rates).

6.3.4.1 Mass Balance Analysis. Using a steady-state or dynamic mass-balance analysis, determine the minimum outdoor airflow rates required to achieve the concentration limits specified in Section 6.3.2 for each contaminant or mixture of concern, within each zone served by the system.

Notes:

1. Appendix D includes steady-state mass-balance equations which describe the impact of air cleaning on outdoor air and recirculation rates for ventilation systems serving a single zone.
2. In the completed building, measurement of the concentration of contaminants or mixtures of concern may be useful as a means of checking the accuracy of the design mass-balance analysis, but such measurement is not required for compliance.

6.3.4.2 Subjective Evaluation. Using a subjective occupant evaluation conducted in the completed building, determine the minimum outdoor airflow rates required to achieve the level of acceptability specified in Section 6.3.3 within each zone served by the system.

Notes:

1. Appendix B presents one approach to subjective occupant evaluation.
2. Level of acceptability often increases in response to increased outdoor airflow rates, increased level of indoor and/or outdoor air cleaning, or decreased indoor and/or outdoor contaminant emission rate.

6.3.4.3 Similar Zone. The minimum outdoor airflow rates shall be no less than those found in accordance with 6.3.4.2 for a substantially similar zone (i.e., in a zone with identical contaminants of concern, concentration limits, air cleaning efficiency, and specified level of acceptability; and with similar contaminant sources and emission rates).

Note: Add Section 6.3.5 as follows:

6.3.5 Combined IAQ Procedure and Ventilation Rate Procedure. The IAQ procedure in conjunction with the Ventilation Rate Procedure may be applied to a zone or system. In this case, the Ventilation Rate Procedure shall be used to determine the required zone minimum outdoor airflow, and the IAQ Procedure shall be used to determine the additional outdoor air or air cleaning necessary to achieve the concentration limits of the contaminants of concern.

Note: The improvement of indoor air quality through the use of air cleaning or provision of additional outdoor air in conjunction with minimum ventilation rates may be quantified using the IAQ procedure.

Note: Revise and Renumber Section 6.3.2 as follows:

6.3.~~2~~6 Documentation. When the IAQ Procedure is used, the following information shall be included in the design documentation: the contaminants of concern considered in the design process; the sources and ~~source strengths~~ emission rates of the contaminants of concern; the ~~target~~ concentration limits and exposure periods and the references for these limits; ~~the design approach used to control the contaminants of concern; and the background or justification for this design approach~~ and the analytical approach used to determine ventilation rates and air cleaning requirements. ~~If the design is based on an approach that has proved successful for similar buildings, the documentation shall include the basis for concluding that the design approach was successful in the other buildings and the basis for concluding that the previous buildings are relevant to the new design. If contaminant monitoring and occupant evaluation are to be used to demonstrate compliance, then t~~The contaminant monitoring and occupant and/or visitor evaluation plans shall also be included in the documentation.

(This foreword 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.)

FOREWORD

This addendum modifies Normative Appendix A, and associated Section 6.2 requirements, as follows:

- *It reduces compliance issues that may result from unclear wording or phrasing, especially for VAV systems.*
- *It improves nomenclature consistency between the body of the standard and the appendix.*
- *It moves key equations from textual definitions to the body of the Appendix.*
- *It clarifies the design conditions (including minimum expected discharge airflow and highest expected system primary airflow) used to calculate worst-case intake airflow for multiple-zone recirculating systems.*

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 62.1-2007

Note: Revise Section 3 as follows:

net occupiable ~~space~~ area: the floor area of an *occupiable space* defined by the inside surfaces of its walls but excluding shafts, column enclosures, and other permanently enclosed, inaccessible, and unoccupiable areas. Obstructions in the space such as furnishings, display or storage racks, and other obstructions, whether temporary or permanent, ~~may not be deducted from the space~~ are considered to be part of the *net occupiable* area.

occupiable space: an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time.

ventilation zone: any indoor area that requires ventilation and consists of one or more ~~occupied~~ *occupiable spaces* ~~or several occupied *spaces*~~ with similar occupancy category (see Table 6-1), *occupant density*, *zone air distribution effectiveness* (see Section 6.2.2.2), and *zone primary airflow* (see Section 6.2.5.1) per unit area.

Note: A *ventilation zone* is not necessarily an independent thermal control zone; however, spaces that can be combined for load calculation~~s~~ purposes can often be combined into a single zone for ventilation calculation~~s~~ purposes.

Note: Revise Section 6.2 as follows:

6.2 Ventilation Rate Procedure. The ~~design~~ *outdoor air intake flow* (V_{ot}) for a ventilation system shall be determined in accordance with Sections 6.2.1 through 6.2.7~~9~~.

Note: Revise Section 6.2.2 as follows:

6.2.2 Zone Calculations. *Ventilation zone* parameters shall be determined in accordance with Sections 6.2.2.1 through 6.2.2.3 for each *ventilation zone* served by the ventilation system.

~~Note: In some cases it is acceptable to determine these parameters for only selected zones as outlined in Appendix A.~~

Note: Revise Section 6.2.2.1 as follows:

6.2.2.1 Breathing Zone Outdoor Airflow. The ~~design~~ outdoor airflow required in the *breathing zone* of the *occupiable space* or spaces in a *ventilation zone*, i.e., the *breathing zone outdoor airflow* (V_{bz}), shall be no less than the value determined in accordance with Equation 6-1.

$$V_{bz} = R_p \cdot P_z + R_a \cdot A_z \quad (6\text{-}1)$$

where:

A_z = *zone floor area*: the *net occupiable* ~~floor~~ *area* of the *ventilation zone* ~~m^2, (ft^2)~~ ft^2, (m^2).

P_z = *zone population*: the ~~largest~~ number of people ~~expected to occupy~~ in the *ventilation zone* during typical usage. ~~If the number of people expected to occupy the zone fluctuates, P_z may be estimated based on averaging approaches described in Section 6.2.6.2.~~

~~**Note:** If *Pz* cannot be accurately predicted during design, it shall be an estimated value based on the zone floor area and the default occupant density listed in Table 6-1.~~

R_p = outdoor airflow rate required per person as determined from Table 6-1.

***Note**:* These values are based on adapted occupants.

R_a = outdoor airflow rate required per unit area as determined from Table 6-1.

***Note**:* Equation 6-1 ~~is the means of accounting~~ accounts for people-related sources and area-related sources ~~for determining~~ independently in the determination of the outdoor air rate required at the *breathing zone*. The use of Equation 6-1 in the context of this standard does not necessarily imply that simple addition of outdoor airflow rates for different sources can be applied to any other aspect of indoor air quality.

Note: Add a new Section 6.2.2.1.1 as follows:

6.2.2.1.1 Design Zone Population. Design *zone population (P_z)* shall equal the largest (peak) number of people expected to occupy the *ventilation zone* during typical usage.

Exceptions:

1. If the number of people expected to occupy the *ventilation zone* fluctuates, *zone population* equal to the average number of people shall be permitted, provided such average is determined in accordance with Section 6.2.6.2.
2. If the largest or average number of people expected to occupy the *ventilation zone* cannot be established for a specific design, an estimated value for *zone population* shall be permitted, provided such value is the product of the *net occupiable area* of the *ventilation zone* and the default occupant density listed in Table 6-1.

Note: Revise Sections 6.2.2.2 and 6.2.2.3 as follows:

6.2.2.2 Zone Air Distribution Effectiveness. The *zone air distribution effectiveness* (E_z) shall be no greater than the default value determined using Table 6-2.

Note: For some configurations, the default value depends upon space and supply air temperature.

6.2.2.3 Zone Outdoor Airflow. The ~~design~~ *zone outdoor airflow* (V_{oz}), i.e., the outdoor airflow rate that must be provided to the *ventilation zone* by the *supply air* distribution system, shall be determined in accordance with Equation 6-2.

$$V_{oz} = V_{bz}/E_z \qquad (6\text{-}2)$$

Note: Revise Sections 6.2.3 and 6.2.4 as follows:

6.2.3 Single-Zone Systems. ~~When~~ For ventilation systems wherein one or more air handlers supply~~ies~~ a mixture of *outdoor air* and *recirculated air* to only one *ventilation zone*, the *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Equation 6-3.

$$V_{ot} = V_{oz} \qquad (6\text{-}3)$$

6.2.4 100% Outdoor Air Systems. ~~When~~ For ventilation systems wherein one or more air handlers supply~~ies~~ only *outdoor air* to one or more *ventilation zones*, the *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Equation 6-4.

$$V_{ot} = \Sigma_{all\ zones} V_{oz} \qquad (6\text{-}4)$$

Note: Revise Section 6.2.5 as follows:

6.2.5 Multiple-Zone Recirculating Systems. ~~When~~ For ventilation systems wherein one or more air handlers supply~~ies~~ a mixture of *outdoor air* and *recirculated* ~~return~~ *air* to more than one *ventilation zone*, the *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Sections 6.2.5.1 through 6.2.5.4.

6.2.5.1 Primary Outdoor Air Fraction. ~~When Table 6-3 is used to determine *system ventilation efficiency*, the *zone*~~ *Primary outdoor air fraction* (Z_{pz}) shall be determined for *ventilation zones* in accordance with Equation 6-5.

$$Z_{pz} = V_{oz}/V_{pz} \qquad (6\text{-}5)$$

where V_{pz} is the *zone primary airflow*, i.e., the primary airflow rate to the *ventilation zone* from the air handler, including *outdoor air* and *recirculated* ~~return~~ *air*.

Note: ~~For VAV systems, V_{pz} is the minimum expected *primary airflow* for design purposes.~~ For VAV-system design purposes, V_{pz} is the lowest *zone primary airflow* value expected at the design condition analyzed.

Note: In some cases it is acceptable to determine these parameters for only selected zones as outlined in Normative Appendix A.

6.2.5.2 System Ventilation Efficiency. The *system ventilation efficiency* (E_v) shall be determined ~~using~~ in accordance with Table 6-3 or Normative Appendix A.

6.2.5.3 Uncorrected Outdoor Air Intake. The ~~design~~ *uncorrected outdoor air intake* (V_{ou}) flow shall be determined in accordance with Equation 6-6.

$$V_{ou} = D\Sigma_{all\ zones}(R_p \cdot P_z) + \Sigma_{all\ zones}(R_a \cdot A_z) \qquad (6\text{-}6)$$

6.2.5.3.1 Occupant Diversity. The *occupant diversity*~~, *D*, may be used to~~ ratio *(D)* shall be determined in accordance with Equation 6-7 to account for variations in ~~occupancy~~ population within the *ventilation zones* served by the system. ~~The *occupancy diversity* is defined as~~

$$D = P_s/\Sigma_{all\ zones} P_z \qquad (6\text{-}7)$$

where the *system population* (P_s) is the total population in the area served by the system.

Exception: Alternative methods ~~may be used~~ to account for ~~population~~ *occupant diversity* ~~when calculating V_{ou}~~ shall be permitted, provided that the resulting V_{ou} value is no less than that determined ~~by~~ using Equation 6-6.

Note: The *uncorrected outdoor air intake* (V_{ou}) is adjusted for *occupant diversity* but ~~uncorrected~~ it is not corrected for *system ventilation efficiency*.

6.2.5.3.2 Design System Population. Design *system population* (P_s) shall equal the largest (peak) number of people expected to occupy all *ventilation zones* served by the ventilation system during typical usage.

Note: *Design system population* is always equal to or less than the sum of design *zone population* for all zones in the area served by the system, since all zones may or may not be simultaneously occupied at design population.

6.2.5.4 Outdoor Air Intake. The design *outdoor air intake flow* (V_{ot}) shall be determined in accordance with Equation 6-8.

$$V_{ot} = V_{ou}/E_v \qquad (6\text{-}8)$$

Note: Revise Section 6.2.6 as follows:

6.2.6 Design for Varying Operating Conditions.

6.2.6.1 Variable Load Conditions. Ventilation systems shall be designed to be capable of providing no less than the ~~required~~ minimum ventilation rates required in the breathing zone whenever the zones served by the system are occupied, including all full- and part-load conditions.

Note: the minimum *outdoor air intake flow* may be less than the design value at part-load conditions.

6.2.6.2 Short-Term Conditions. If it is known that peak occupancy will be of short duration and/or ventilation will be varied or interrupted for a short period of time, the design may be based on the average conditions over a time period T determined by Equation 6-9a using IP units (Equation 6-9b using SI units):

$$T = 3\ v / V_{bz} \qquad \text{(6-9a IP)}$$

$$T = 50\ v / V_{bz} \qquad \text{(6-9b SI)}$$

where:

T = averaging time period, (min).

v = the volume of the *ventilation zone* for which averaging is being applied, ft^3 (m^3).

V_{bz} = the *breathing zone outdoor airflow* calculated using Equation 6-1 and the design value of the *zone population* (P_z), cfm (L/s).

Acceptable design adjustments based on this optional provision include the following:

1. Zones with fluctuating occupancy: The *zone population* (P_z) may be averaged over time T.
2. Zones with intermittent interruption of supply air: The average outdoor airflow supplied to the *breathing zone* over time T shall be no less than the *breathing zone outdoor airflow* (V_{bz}) calculated using Equation 6-1.
3. Systems with intermittent closure of the outdoor air intake: the average outdoor air intake over time T shall be no less than the *minimum outdoor air intake* (V_{ot}) calculated using Equation 6-3, 6-4, or 6-8 as appropriate.

Note: Revise Table 6-3 as follows:

TABLE 6-3 System Ventilation Efficiency

Max (Z_{pz})	E_v
≤ 0.15	1.~~0~~
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
> 0.55	Use Appendix A

1. "Max (Z_{pz})" refers to the largest value of Z_{pz}, calculated using Equation 6-5, among all the *ventilation zones* served by the system.
2. For values of Max (Z_{pz}) between 0.15 and 0.55, ~~one may determine~~ the corresponding value of E_v may be determined by interpolating the values in the table.
3. The values of E_v in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the *uncorrected outdoor air intake* (V_{ou}) to the total *zone primary airflow* for all the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table may result in unrealistically low values of E_v and the use of Appendix A may yield more practical results.

Note: Revise Normative Appendix A as follows:

(This is a normative appendix and is part of the standard.)

NORMATIVE APPENDIX A MULTIPLE-ZONE SYSTEMS

This appendix presents an alternative procedure for calculating the *system ventilation efficiency* (E_v) that must be used when Table 6-3 values are not used. In this alternative procedure, E_v is equal to the lowest calculated value of the *zone ventilation efficiency* (E_{vz}) (see Equation A-~~3~~8 below). Figure A.1 contains a ventilation system schematic depicting most of the quantities used in this appendix.

A.1 System Ventilation Efficiency. For any multiple-zone recirculating system, the *system ventilation efficiency* (E_v) shall be calculated in accordance with Sections A1.1 through A1.3.

A.1.1 Average Outdoor Air Fraction. The *average outdoor air fraction* (X_s) for the ventilation system shall be determined in accordance with Equation A-1.

$$X_s = V_{ou}/V_{ps} \qquad \text{(A-1)}$$

Where the *uncorrected outdoor air intake* (V_{ou}) is found in accordance with Section 6.2.5.3, and the *system primary airflow* (V_{ps}) is found at the condition analyzed.

Note: For VAV system design purposes, V_{ps} is the highest expected *system primary airflow* at the design condition analyzed. *System primary airflow* at design is usually less than the sum of design *zone primary airflow* values, since primary airflow seldom peaks simultaneously in all VAV zones.

A.1.2 Zone Ventilation Efficiency. The *zone ventilation efficiency* (E_{vz}), i.e., the efficiency with which a system distributes outdoor air from the intake to an individual *breathing zone*, shall be ~~calculated using Equation A-1 or A-2.~~determined in accordance with Section A.1.2.1 or A.1.2.2

~~Single Supply Systems $E_{vz} = 1 + X_s - Z_d$ (A-1)~~

A.1.2.1 Single-Supply Systems. ~~Equation A-1 (or A-2) shall be used for~~ For "single-supply" systems, wherein all of the ~~ventilation~~ air supplied to each *ventilation zone* is a mixture of *outdoor air* and system-level *recirculated air*, *zone ventilation efficiency* (E_{vz}) shall be determined in accordance with Equation A-2.~~from a single location, e.g.,~~ Examples of single-supply systems include constant volume reheat, single-duct VAV, single-fan dual-duct, and multi-zone systems.

$$E_{vz} = 1 + X_s - Z_{pz} \qquad \text{(A-2)}$$

Where the *average outdoor air fraction* (X_s) for the system is determined in accordance with Equation A-1 and the *primary outdoor air fraction* (Z_{pz}) for the zone is determined in accordance with Section 6.2.5.1.

~~General Case~~

~~$E_{vz} = (F_a + X_s \cdot F_b - Z_d \cdot F_c)/F_a$ (A-2)~~

~~Equation A-2 shall be used for systems that provide all or part of their ventilation by recirculating air from other zones without directly mixing it with outdoor air, e.g., dual-fan dual-duct, fan-powered mixing box, and transfer fans for conference rooms.~~

A.1.2.2 Secondary Recirculation Systems. For "secondary-recirculation" systems wherein all or part of the *supply air* to each *ventilation zone* is *recirculated air* (which has not been directly mixed with *outdoor air*) from other zones, *zone ventilation efficiency (E_{vz})* shall be determined in accordance with Equation A-3. Examples of secondary-recirculation systems include dual-fan dual-duct and fan-powered mixing-box systems, and systems that include transfer fans for conference rooms.

$$E_{vz} = (F_a + X_s \cdot F_b - Z_{pz} \cdot E_p \cdot F_c)/F_a \qquad \text{(A-3)}$$

Where system air fractions F_a, F_b, and F_c are determined in accordance with Equation A-4, A-5 and A-6, respectively.

$$F_a = E_p + (1 - E_p) \cdot E_r \qquad \text{(A-4)}$$

$$F_b = E_p \qquad \text{(A-5)}$$

$$F_c = 1 - (1 - E_z) \cdot (1 - E_r) \cdot (1 - E_p) \qquad \text{(A-6)}$$

Where the zone *primary air fraction* (E_p) is determined in accordance with Equation A-7; zone *secondary recirculation fraction* (E_r) is determined by the designer based on system configuration; and *zone air distribution effectiveness* (E_z) is determined in accordance with Section 6.2.2.2.

Note: For plenum return systems with secondary recirculation (e.g. fan-powered VAV with plenum return) E_r is usually less than 1.0, although values may range from 0.1 to 1.2 depending upon the location of the *ventilation zone* relative to other zones and the air handler. For ducted return systems with secondary recirculation (e.g., fan-powered VAV with ducted return), E_r is typically 0.0, while for those with system-level recirculation (e.g, dual-fan dual-duct systems with ducted return) E_r is typically 1.0. For other system types, E_r is typically 0.75.

$$E_p = V_{pz}/V_{dz} \qquad \text{(A-7)}$$

Where V_{dz} is *zone discharge airflow*

Note: For single-zone and single-supply systems, E_p *is* 1.0.

A.1.3 System Ventilation Efficiency. The *system ventilation efficiency* shall ~~be calculated using~~ equal the lowest *zone ventilation efficiency* among all ventilation zones served by the air handler, in accordance with Equation A-~~3~~8.

$$E_v = \text{minimum } (E_{vz}) \qquad \text{(A-~~3~~8)}$$

A.2 Alternative Calculations. ~~The above equations may be rearranged to calculate other design parameters of interest based on known parameters. This includes, but is not limited to, calculating minimum *zone discharge* (supply) *airflow* (V_{dz}) when the *outdoor air intake flow* V_{ot} is known.~~

~~Other m~~Mass or flow balance equations for multiple-zone systems may ~~also~~ be used to determine *system ventilation efficiency* and other design parameters, provided that they result in *outdoor air intake airflow* (V_{ot}) that is within 5% of the airflow value obtained using the *system ventilation efficiency* (E_v) calculated using Equation A-~~3~~8 or they more accurately represent a particular system configuration.

A.3 Design Process. The *system ventilation efficiency* and therefore the *outdoor air intake flow* for the system (V_{ot}) ~~are~~ determined as part of the design process are based on the design and minimum expected *supply air* flows to individual *ventilation zones* as well as the design *outdoor air* requirements to the zones. ~~In this process, the designer shall assume that the critical zone is at its minimum supply or discharge airflow in VAV systems.~~ For VAV system design purposes, *zone ventilation efficiency* (E_{vz}) for each *ventilation zone* shall be found using the minimum expected *zone primary airflow* (V_{pz}), and using the highest expected *system primary airflow* (V_{ps}) at the design condition analyzed.

Note: ~~The designer may increase~~ Increasing the zone *supply air* flows ~~values~~ during the design process, particularly to the critical zones requiring the highest fraction of outdoor air, ~~and thereby~~ reduces the system *outdoor air intake flow* requirement determined in the calculation~~, sometimes dramatically~~.

A.3.1 Selecting Zones for Calculation. *Zone ventilation efficiency* (E_{vz}) shall be calculated for all *ventilation zones*.

Exception: Since *system ventilation efficiency* (E_v) is determined by the minimum value of the *zone ventilation efficiency* (E_{vz}), in accordance with Equation A-~~3~~8, calculation of E_{vz} ~~is required only for the *zone* with the minimum value of *Evz* at ventilation design conditions. It~~ is not required for any *ventilation zone* ~~that~~which ~~clearly~~ has an E_{vz} value that is equal to or larger than that of the *ventilation zone* for which a calculation has been done.

Note: The value of E_{vz} for a *ventilation zone* will ~~have a larger (or equal) value~~ be equal to or larger than that for another *ventilation zone* if all of the following are true relative to the other *ventilation zone* ~~with minimum E_{vz}~~:

1. Floor area per occupant (A_z/P_z) is no lower
2. Minimum *zone discharge airflow* rate per unit area (V_{dz}/A_z) is no lower
3. Primary air fraction E_p is no lower
4. *Zone air distribution effectiveness* (E_z) is no lower
5. Area outdoor air rate R_a is no higher
6. People outdoor air rate R_p is no higher

~~If all of the above six parameters are the same for different spaces or areas, then those spaces or areas may be treated as a single zone for calculation of Evz.~~

Example: In office buildings it is generally only necessary to calculate E_{vz} for one typical interior *ventilation zone*, since the parameters listed above are generally equal for all interior spaces. If overhead *supply air* is used to heat the perimeter, it is generally also necessary to calculate E_{vz} for the perimeter zone

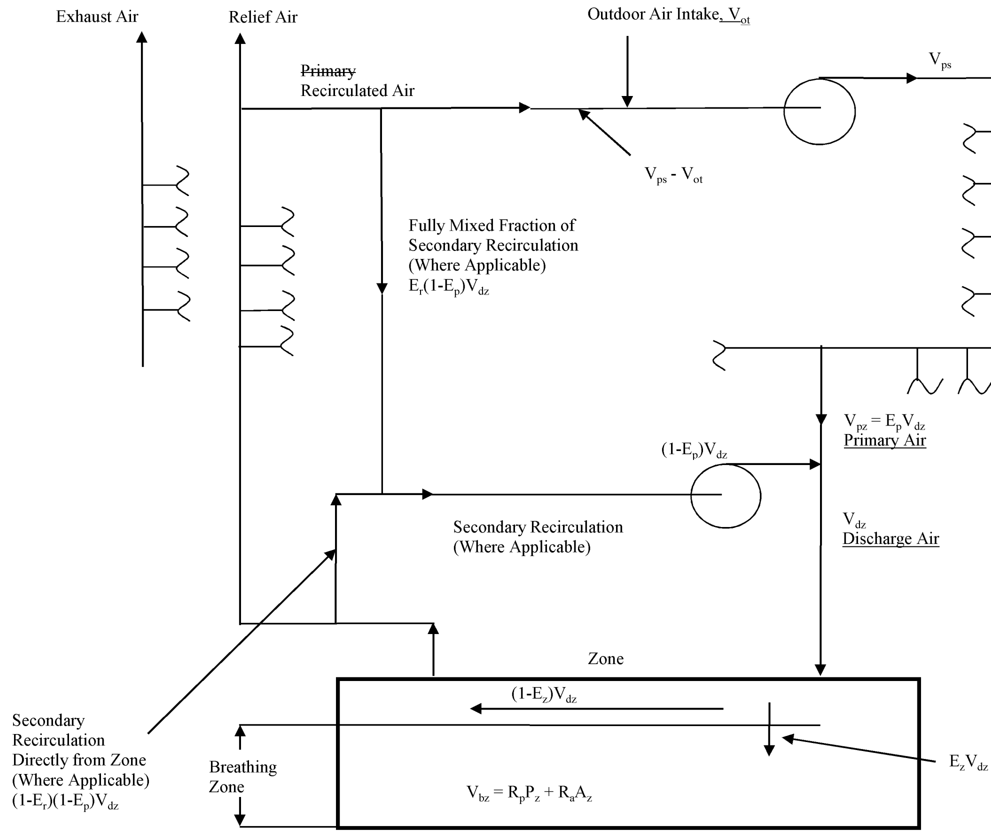

Figure A.1 Ventilation system schematic.

with the lowest expected ~~supply~~ primary or discharge airflow rate per unit area. No other calculations for E_{vz} are typically necessary, even if the building has 1,000 *ventilation zones*, provided the ventilation for any conference rooms or non-office occupancy zones are~~is~~ separately calculated.

A.4 Symbols~~Definitions~~

***A_z* Zone Floor Area:** the net occupiable floor area of the *ventilation zone* ft^2 (m^2).

***D* Occupant Diversity:** the ratio of the *system population* to the sum of the *zone populations*.~~: $D = P_s / \sum P_z$.~~

***E_p* Primary Air Fraction:** ~~Primary air~~ the fraction of *primary air* in the *discharge air* to the *ventilation zone*~~: $E_p = V_{pz}/V_{dz}$ (E_p = 1.0 for single-duct and single-*zone* systems).~~

***E_r* Secondary Recirculation Fraction:** In systems with secondary recirculation of return air, the fraction of secondary recirculated air to the zone that is representative of average system return air rather than air directly recirculated from the zone.

~~Note: For plenum return systems with local secondary recirculation (e.g., fan-powered VAV with plenum return), Er ≤ 1.0. For ducted return systems with local secondary recirculation (e.g., fan-powered VAV with ducted return), typically Er = 0.0.~~

***E_v* System Ventilation Efficiency:** the efficiency with which the system distributes air from the outdoor air intake to the *breathing zone* in the ventilation-critical zone, which requires the largest fraction of outdoor air in the primary air stream. **Note:** E_v ~~is~~ may be determined ~~from Table 6-3~~in accordance with Section 6.2.5.2 or ~~Equation A-3~~Section A.1.

***E_{vz}* Zone Ventilation Efficiency:** the efficiency with which the system distributes air from the outdoor air intake to the breathing zone in any particular *ventilation zone*. ~~E_{vz} is determined from Equations A-1 or A-2.~~

***E_z* Zone Air Distribution Effectiveness ~~(E_z)~~:** a measure of ~~how effectively~~ the effectiveness of ~~the zone~~ *supply air* distribution ~~uses its supply air to maintain acceptable air quality in~~to the *breathing zone*. **Note**: E_z is determined in accordance with Section 6.2.2.2~~from Table 6-2~~.

***F_a* Supply Air Fraction:** ~~Fraction~~ The fraction of *supply air* to the *ventilation zone* that includes ~~from~~ sources of air from outside the zone~~: $F_a = E_p + (1 - E_p) \cdot E_r$.~~

***F_b* Mixed Air Fraction**: The fraction of supply air to the *ventilation zone* from fully mixed primary air~~: $F_b = E_p$.~~

***F_c* Outdoor Air Fraction:** The fraction of outdoor air to the *ventilation zone* that includes ~~from~~ sources of air from outside the zone~~: $F_c = 1 - (1 - E_z) \cdot (1 - E_r) \cdot (1 - E_p)$.~~

***P_s* System Population**: the ~~maximum~~ simultaneous number of occupants in the area served by the ventilation system. ~~Where population fluctuates, it may be averaged as described in Section 6.2.6.2.~~

***P_z* Zone Population:** ~~the largest number of people expected to occupy the zone during typical usage. If *Pz* is not known, it is determined from the default occupant densities listed in Table 6-1. Where population fluctuates, it may be averaged as described in Section 6.2.6.2.~~see Section 6.2.2.1.

***R_a* Area Outdoor Air Rate**: ~~the outdoor airflow rate per unit area to be provided in the breathing zone to dilute contaminants that are emitted at a rate that is related more to floor area than to population. The value of *Ra* for a zone is determined from Table 6-1.~~see Section 6.2.2.1.

***R_p* People Outdoor Air Rate**: ~~the outdoor airflow rate per person to be provided in the breathing zone to dilute contaminants that are emitted at a rate that is related more to population than to floor area. The value of *Rp* for a zone is determined from Table 6-1.~~see Section 6.2.2.1.

***V_{bz}* Breathing Zone Outdoor Airflow:** ~~the outdoor airflow required in the breathing zone of an occupiable space, *Vbz =Rp · Pz + Ra · Az*.~~see Section 6.2.2.1.

***V_{dz}* Zone Discharge Airflow:** The expected discharge (supply) airflow to the zone that includes primary airflow and ~~locally~~secondary recirculated airflow, cfm (L/s).

***V_{ot}* Outdoor Air Intake Flow**: ~~the design outdoor airflow required at the ventilation system outdoor air intake.~~see Sections 6.2.3, 6.2.4, 6.2.5.4.

***V_{ou}* Uncorrected Outdoor Air Intake**: ~~The outdoor air intake flow required if the system ventilation efficiency *Ev* were 1.0. *Vou = D · ∑Rp · Pz + ∑Ra · Az*.~~see Section 6.2.5.3.

***V_{oz}* Zone Outdoor Airflow:** ~~the design outdoor airflow required in the zone, i.e., *Voz = Vbz/Ez*.~~see Section 6.2.2.3.

***V_{ps}* System Primary Airflow:** The total primary airflow supplied to all *zones* served by the system from the air-handling unit at which the outdoor air intake is located~~, $V_{ps} = \sum V_{pz}$, in cfm (L/s)~~.

***V_{pz}* Zone Primary Airflow:** ~~The primary airflow supplied to the *zone* from the air-handling unit at which the outdoor air intake is located, L/s (cfm). It includes outdoor intake air and recirculated air from that air-handling unit but does not include air transferred or air recirculated to the zone by other means.~~see Section 6.2.5.1.

***X_s* Average Outdoor Air Fraction**: At the primary air handler, the fraction of *outdoor air intake flow* in the system primary airflow~~, $X_s = V_{ou}/V_{ps}$~~.

~~***Z_d* Discharge Outdoor Air Fraction:** The outdoor air fraction required in air discharged to the zone, $Z_d = V_{oz}/V_{dz}$.~~

~~***Note:*** For VAV systems, Vdz is the minimum expected discharge airflow for design purposes.~~

***Z_{pz}* Primary Outdoor Air Fraction:** The outdoor air fraction required in the *primary air* supplied to the *ventilation zone* prior to the introduction of any secondary recirculation air

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.