**ANSI/ASHRAE Standard 62.1-2007**
**(Supersedes ANSI/ASHRAE Standard 62.1-2004)**
**Includes ANSI/ASHRAE Addenda listed in Appendix I**

# ASHRAE STANDARD

# Ventilation for Acceptable Indoor Air Quality

See Appendix I for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

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).



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**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.

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The Assistant Director of Technology for Standards and Special Projects 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.

# CONTENTS

## ANSI/ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality



**NOTE**

**When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.**

**(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

*ANSI/ASHRAE Standard 62.1-2007 is the latest edition of Standard 62. The 2007 edition combines Standard 62.1-2004 and the eight approved and published addenda to the 2004 edition, thereby providing an easy-to-use consolidated standard. Specific information on the content of each addendum and approval dates for each addendum are included in informative Appendix I at the end of this standard.*

*First published in 1973, Standard 62.1 is now updated on a regular basis using ASHRAE's continuous maintenance procedures. According to these procedures, Standard 62.1 is continuously revised by addenda that are publicly reviewed, approved by ASHRAE and ANSI, and published in a supplement approximately 18 months after each new edition of the standard, or in a new, complete edition of the standard, published every three years.*

*Standard 62.1 has undergone some key changes over the years, reflecting the ever-expanding body of knowledge, experience, and research related to ventilation and air quality. While the purpose of the standard has remained consistent—to specify minimum ventilation rates and other measures intended to provide indoor air quality that is acceptable to human occupants and that minimizes adverse health effects—the means of achieving this goal have evolved. In its first edition the standard adopted a prescriptive approach to ventilation by specifying both minimum and recommended outdoor airflow rates to obtain acceptable indoor air quality for a variety of indoor spaces. In its 1981 edition, the standard reduced minimum outdoor airflow rates and introduced an alternative performance-based approach, the Indoor Air Quality (IAQ) Procedure, which allowed for the calculation of the amount of outdoor air necessary to maintain the levels of indoor air contaminants below recommended limits. Today the standard still retains the two procedures for ventilation design, the IAQ Procedure and the Ventilation Rate Procedure.*

*In its 1989 edition, and in response to a growing number of buildings with apparent indoor air quality problems, the standard increased minimum outdoor airflow rates significantly and introduced a requirement for finding outdoor air intake flow requirements for multiple-zone, recirculating systems. The 1999 and 2001 editions made several minor changes and clarifications that did not impact the minimum required outdoor airflow rates. In its 2004 edition—the last time the standard was published in its entirety—the standard modified the IAQ Procedure to improve enforceability, but more significantly, it modified the Ventilation Rate Procedure, changing both the minimum outdoor airflow rates and the procedures for calculating both zone-level and system-level outdoor airflow rates.*

*The 2007 edition of the standard updates, revises and improves it in several ways, without changing minimum outdoor airflow rates. The standard:*

- *Clarifies dehumidification analysis requirements in Section 5.10, and offers exceptions to the 65% RH limit requirement and to the net-positive intake-airflow requirement (Addendum 62.1a).*
- *Corrects occupant category inconsistencies among Tables 5-2, 6-1, and 6-4, and provides additional information for several occupancy categories (Addendum 62.1b).*
- *Updates references and clarifies the text in informative Appendix B, particularly as related to subjective evaluation of air quality (Addendum 62.1c).*
- *Updates the information presented in Table 4-1, to be consistent with the U.S. EPA National Ambient Air Quality Standards (NAAQS) as published at the time the addendum was approved, adding PM 2.5 as a criteria pollutant and adding the eight-hour standard for ozone (Addendum 62.1d).*
- *Includes a new informative appendix, Appendix H, which summarizes the documentation requirements in the body of the standard thus providing a single point of reference for users (Addendum 62.1e).*
- *Updates the purpose and scope of the standard to make them consistent with changes that have already been incorporated into the body of the standard. Specifically, it: excludes single-family houses and multiple-family structures of three or fewer stories from the scope, removes specific minimum outdoor airflow rates for areas that contain smoking or environmental tobacco smoke (ETS), and excludes thermal comfort requirements (Addendum 62.1f).*
- *Requires proper design for buildings that contain both ETS and ETS-free areas, by requiring (briefly): classification of areas based on expected presence of ETS, pressurization of ETS-free areas, separation of ETS and ETS-free areas, and cautionary signage for ETS-areas (Addendum 62.1g).*
- *Adds requirements for residential spaces in buildings with more than three stories to Table 6-1, and deletes Tables E-2 and E-3 from Appendix E, which provided ventilation requirements for residences and vehicles (Addendum 62.1h).*

*For more specific information on these changes and on other revisions made to the standard by other addenda, refer to Informative Appendix I at the end of this standard. Users of the standard are encouraged to use the continuous maintenance procedure to suggest changes for further improvements. A form for submitting change proposals is included in the back of this edition. The project committee for Standard 62.1 will take formal action on all change proposals received.*

## 1. PURPOSE

**1.1** The purpose of this standard is to specify minimum ventilation rates and other measures intended to provide indoor

air quality that is acceptable to human occupants and that minimizes adverse health effects.

**1.2** This standard is intended for regulatory application to new buildings, additions to existing buildings, and those changes to existing buildings that are identified in the body of the standard.

**1.3** This standard is intended to be used to guide the improvement of indoor air quality in existing buildings.

## 2. SCOPE

**2.1** This standard applies to all spaces intended for human occupancy except those within single-family houses, multifamily structures of three stories or fewer above grade, vehicles, and aircraft.

**2.2** This standard defines requirements for ventilation and air-cleaning system design, installation, commissioning, and operation and maintenance.

**2.3** Additional requirements for laboratory, industrial, health care, and other spaces may be dictated by workplace and other standards, as well as by the processes occurring within the space.

**2.4** Although the standard may be applied to both new and existing buildings, the provisions of this standard are not intended to be applied retroactively when the standard is used as a mandatory regulation or code.

**2.5** This standard does not prescribe specific ventilation rate requirements for spaces that contain smoking or that do not meet the requirements in the standard for separation from spaces that contain smoking.

**2.6** Ventilation requirements of this standard are based on chemical, physical, and biological contaminants that can affect air quality.

**2.7** Consideration or control of thermal comfort is not included.

**2.8** This standard contains requirements, in addition to ventilation, related to certain sources, including outdoor air, construction processes, moisture, and biological growth.

**2.9** Acceptable indoor air quality may not be achieved in all buildings meeting the requirements of this standard for one or more of the following reasons:

a. because of the diversity of sources and contaminants in indoor air;
b. because of the many other factors that may affect occupant perception and acceptance of indoor air quality, such as air temperature, humidity, noise, lighting, and psychological stress;
c. because of the range of susceptibility in the population; and
d. because outdoor air brought into the building may be unacceptable or may not be adequately cleaned.

## 3. DEFINITIONS (SEE FIGURE 3.1)

***acceptable indoor air quality:*** air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction.

***air-cleaning system:*** a device or combination of devices applied to reduce the concentration of airborne contaminants, such as microorganisms, dusts, fumes, respirable particles, other particulate matter, gases, and/or vapors in air.

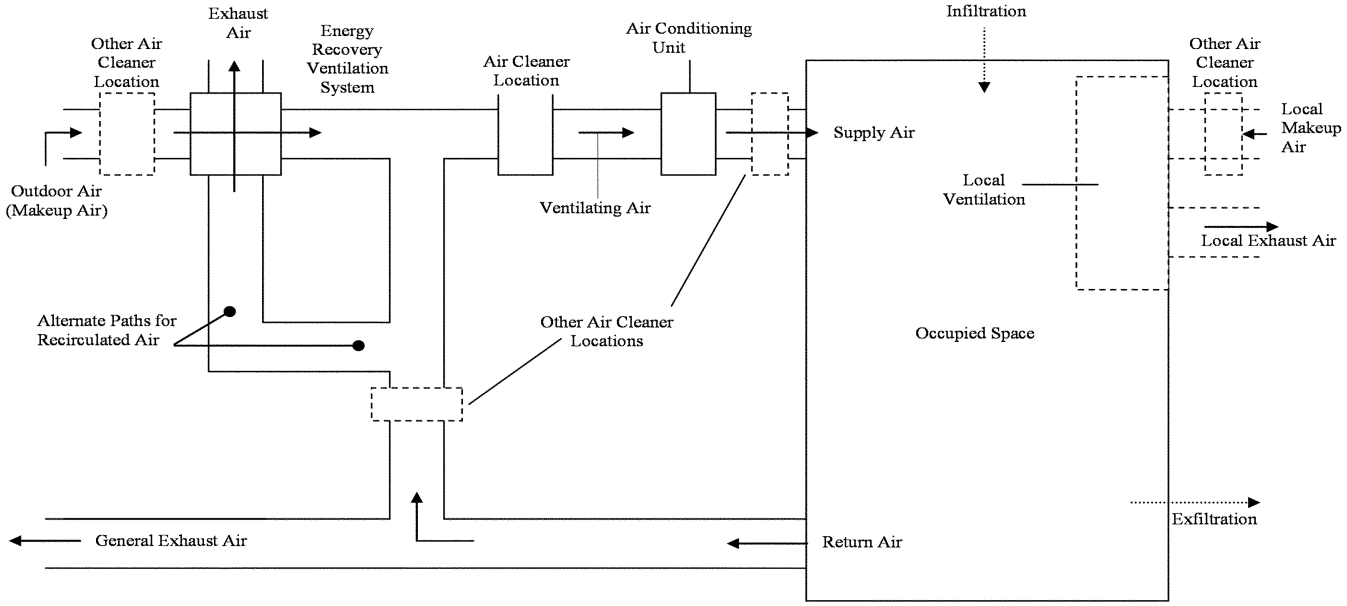


**Figure 3.1 Ventilation system.**

***air conditioning:*** the process of treating air to meet the requirements of a conditioned space by controlling its temperature, humidity, cleanliness, and distribution.

***air, ambient:*** the air surrounding a building; the source of outdoor air brought into a building.

***air, exhaust:*** air removed from a space and discharged to outside the building by means of mechanical or natural ventilation systems.

***air, indoor:*** the air in an enclosed occupiable space.

***air, makeup:*** any combination of outdoor and transfer air intended to replace exhaust air and exfiltration.

***air, outdoor:*** ambient air that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.

***air, recirculated:*** air removed from a space and reused as supply air.

***air, return:*** air removed from a space to be then recirculated or exhausted.

***air, supply:*** air delivered by mechanical or natural ventilation to a space, composed of any combination of outdoor air, recirculated air, or transfer air.

***air, transfer:*** air moved from one indoor space to another.

***air, ventilation:*** that portion of supply air that is outdoor air plus any recirculated air that has been treated for the purpose of maintaining acceptable indoor air quality.

***breathing zone:*** the region within an occupied space between planes 3 and 72 in. (75 and 1800 mm) above the floor and more than 2 ft (600 mm) from the walls or fixed air-conditioning equipment.

***cognizant authority:*** an agency or organization that has the expertise and jurisdiction to establish and regulate concentration limits for airborne contaminants; or an agency or organization that is recognized as authoritative and has the scope and expertise to establish guidelines, limit values, or concentrations levels for airborne contaminants.

***concentration:*** the quantity of one constituent dispersed in a defined amount of another.

***conditioned space:*** that part of a building that is heated or cooled, or both, for the comfort of occupants.

***contaminant:*** an unwanted airborne constituent that may reduce acceptability of the air.

***energy recovery ventilation system:*** a device or combination of devices applied to provide the outdoor air for ventilation in which energy is transferred between the intake and exhaust airstreams.

***environmental tobacco smoke (ETS):*** the "aged" and diluted combination of both side-stream smoke (smoke from the lit end of a cigarette or other tobacco product) and exhaled mainstream smoke (smoke that is exhaled by a smoker). ETS is commonly referred to as *secondhand smoke*.

***ETS-free area:*** an area where no smoking occurs and that is separated from ETS areas according to the requirements of this standard.

> ***Note:*** A no-smoking area is not necessarily an ETS-free area.

***ETS area:*** spaces where smoking is permitted, as well as those not separated from spaces where smoking is permitted in accord with the requirements of Section 5 in this standard.

***exfiltration:*** uncontrolled outward air leakage from conditioned spaces through unintentional openings in ceilings, floors, and walls to unconditioned spaces or the outdoors caused by pressure differences across these openings due to wind, inside-outside temperature differences (stack effect), and imbalances between supply and exhaust airflow rates.

***industrial space:*** an indoor environment where the primary activity is production or manufacturing processes. The processes in these spaces may generate contaminants with characteristics and in quantities dictating that principles of worker safety and industrial hygiene be used to define contaminant control strategies, including ventilation. Also, the primary occupants of these spaces consist of the individuals involved in these processes.

***infiltration:*** uncontrolled inward air leakage to conditioned spaces through unintentional openings in ceilings, floors, and walls from unconditioned spaces or the outdoors caused by the same pressure differences that induce exfiltration.

***mechanical ventilation:*** ventilation provided by mechanically powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows.

***microorganism:*** a microscopic organism, especially a bacterium, fungus, or a protozoan.

***natural ventilation:*** ventilation provided by thermal, wind, or diffusion effects through doors, windows, or other intentional openings in the building.

***net occupiable space:*** 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 area.

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

***odor:*** a quality of gases, liquids, or particles that stimulates the olfactory organ.

***readily accessible:*** capable of being reached quickly for operation without requiring those for whom ready access is required to climb over or remove obstacles or to resort to portable ladders, chairs, or other climbing aids.

***ventilation:*** the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity, or temperature within the space.

***volume, space:*** the total volume of an occupiable space enclosed by the building envelope, plus that of any spaces permanently open to the occupiable space, such as a ceiling attic used as a ceiling return plenum.

***zone:*** one occupied space 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 calculations can often be combined into a single zone for ventilation calculations.

## 4. OUTDOOR AIR QUALITY

Outdoor air quality shall be investigated in accordance with Sections 4.1 and 4.2 prior to completion of ventilation system design. The results of this investigation shall be documented in accordance with Section 4.3.

**4.1 Regional Air Quality.** The status of compliance with national ambient air quality standards shall be determined for the geographic area of the building site. In the United States, compliance status shall be either in "attainment" or "non-attainment" with the National Ambient Air Quality Standards (NAAQS)[1] for each pollutant shown in Table 4-1. In the United States, areas with no EPA compliance status designation shall be considered "attainment" areas.

**4.2 Local Air Quality.** An observational survey of the building site and its immediate surroundings shall be conducted during hours the building is expected to be normally occupied to identify local contaminants from surrounding facilities that may be of concern if allowed to enter the building.

**4.3 Documentation.** Documentation of the outdoor air quality investigation shall be reviewed with building owners or their representative and shall include the following:

1. Regional air quality compliance status.

   ***Note:*** Regional outdoor air quality compliance status for the United States is available from the U.S. Environmental Protection Agency located under www.epa.gov.
2. Local survey information, which may include the following:
   a. Date of observations
   b. Time of observations
   c. Area surveyed
   d. Description of nearby facilities
   e. Observation of odors or irritants
   f. Description of visible plumes or air contaminants
   g. Description of nearby sources of vehicle exhaust
   h. Direction of prevailing winds
3. Conclusions regarding the acceptability of outdoor air quality based on consideration of information from investigation.

## 5. SYSTEMS AND EQUIPMENT

**5.1 Natural Ventilation.** Use of natural ventilation systems designed in accordance with this section shall be permitted in lieu of or in conjunction with mechanical ventilation systems.

**Exception:** An engineered natural ventilation system when approved by the authority having jurisdiction need not meet the requirements of Sections 5.1.1 and 5.1.2.

**5.1.1 Location and Size of Openings.** Naturally ventilated spaces shall be permanently open to and within 8 m (25 ft) of operable wall or roof openings to the outdoors, the openable area of which is a minimum of 4% of the net occupiable floor area. Where openings are covered with louvers or otherwise obstructed, openable area shall be based on the free unobstructed area through the opening. Where interior spaces without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and have a free area of not less than 8% of the area of the interior room nor less than 25 $ft^2$ (2.3 $m^2$).

**5.1.2 Control and Accessibility.** The means to open required operable openings shall be readily accessible to building occupants whenever the space is occupied.

**TABLE 4-1 National Primary Ambient Air Quality Standards for Outdoor Air as Set by the U.S. Environmental Protection Agency**

| Contaminant | Long Term | | | Short Term | | |
|---|---|---|---|---|---|---|
| | Concentration Averaging | | | Concentration Averaging | | |
| | µg/$m^3$ | ppm | | µg/$m^3$ | ppm | |
| Sulfur dioxide | 80 | 0.03 | 1 year[b] | 365 | 0.14 | 24 hours[a] |
| Particles (PM 10) | 50 | — | 1 year[b,g] | 150 | — | 24 hours[a] |
| Particles (PM 2.5) | 15 | — | 1 year[b,e] | 65 | — | 24 hours[f] |
| Carbon monoxide | | | | 40,000<br>10,000 | 35<br>9 | 1 hour[a]<br>8 hours[a] |
| Oxidants (ozone) | | | | | 0.08<br>0.12 | 8 hours[c]<br>1 hour[h] |
| Nitrogen dioxide | 100 | 0.053 | 1 year[b] | | | |
| Lead | 1.5 | — | 3 months[d] | | | |

[a]Not to be exceeded more than once per year.
[b]Annual arithmetic mean.
[c]The three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
[d]Three-month period is a calendar quarter.
[e]Three-year average of the annual arithmetic mean.
[f]The three-year average of the 98th percentile of 24-hour concentrations.
[g]The annual arithmetic mean.
[h](1) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤1, as determined by Appendix H (40 CFR 50). (2) The one-hour NAAQS will no longer apply to an area one year after the effective date of the designation of that area for the eight-hour ozone NAAQS. The effective designation date for most areas is June 15, 2004 (40 CFR 50.9; see Federal Register of April 30, 2004 [69 FR 23996]).

**5.2 Ventilation Air Distribution.** Ventilating systems shall be designed in accordance with the following.

**5.2.1 Designing for Air Balancing.** The ventilation air distribution system shall be provided with means to adjust the system to achieve at least the minimum ventilation airflow as required by Section 6 under any load condition.

**5.2.2 Plenum Systems.** When the ceiling or floor plenum is used both to recirculate return air and to distribute ventilation air to ceiling-mounted or floor-mounted terminal units, the system shall be engineered such that each space is provided with its required minimum ventilation airflow.

***Note:*** Direct connection of ventilation air ducts to ventilating terminal units is an alternate method of satisfying the intent of this requirement.

**5.2.3 Documentation.** The design documents shall specify minimum requirements for air balance testing or reference applicable national standards for measuring and balancing airflow. The design documentation shall state assumptions that were made in the design with respect to ventilation rates and air distribution.

**5.3 Exhaust Duct Location.** Exhaust ducts that convey potentially harmful contaminants shall be negatively pressurized relative to spaces through which they pass, so that exhaust air cannot leak into occupied spaces; supply, return, or outdoor air ducts; or plenums.

**Exception:** Exhaust ducts that are sealed in accordance with SMACNA Seal Class A.[2]

**5.4 Ventilation System Controls.** Mechanical ventilation systems shall include controls, manual or automatic, that enable the fan system to operate whenever the spaces served are occupied. The system shall be designed to maintain the minimum outdoor airflow as required by Section 6 under any load condition.

***Note:*** VAV systems with fixed outdoor air damper positions must comply with this requirement at minimum supply airflow.

**5.5 Airstream Surfaces.** All airstream surfaces in equipment and ducts in the heating, ventilating, and air-conditioning system shall be designed and constructed in accordance with the following requirements.

**5.5.1 Resistance to Mold Growth.** Material surfaces shall be determined to be resistant to mold growth in accordance with a standardized test method, such as the "Mold Growth and Humidity Test" in UL 181,[10] ASTM C 1338,[11] or comparable test methods.

**Exception:** Sheet metal surfaces and metal fasteners.

***Note:*** Even with this resistance, any airstream surface that is continuously wetted is still subject to microbial growth.

**5.5.2 Resistance to Erosion.** Airstream surface materials shall be evaluated in accordance with the "Erosion Test" in UL 181[10] and shall not break away, crack, peel, flake off, or show evidence of delamination or continued erosion under test conditions.

**Exception:** Sheet metal surfaces and metal fasteners.

**5.6 Outdoor Air Intakes.** Ventilation system outdoor intakes shall be designed in accordance with the following.

**5.6.1 Location.** Outdoor air intakes, including doors and windows that are required as part of a natural ventilation system, shall be located such that the shortest distance from the intake to any specific potential outdoor contaminant source shall be equal to or greater than the separation distance listed in Table 5-1.

**TABLE 5-1 Air Intake Minimum Separation Distance**

| Object | Minimum Distance, ft (m) |
|---|---|
| Significantly contaminated exhaust (Note 1) | 15 (5) |
| Noxious or dangerous exhaust (Notes 2 and 3) | 30 (10) |
| Vents, chimneys, and flues from combustion appliances and equipment (Note 4) | 15 (5) |
| Garage entry, automobile loading area, or drive-in queue (Note 5) | 15 (5) |
| Truck loading area or dock, bus parking/idling area (Note 5) | 25 (7.5) |
| Driveway, street, or parking place (Note 5) | 5 (1.5) |
| Thoroughfare with high traffic volume | 25 (7.5) |
| Roof, landscaped grade, or other surface directly below intake (Notes 6 and 7) | 1 (0.30) |
| Garbage storage/pick-up area, dumpsters | 15 (5) |
| Cooling tower intake or basin | 15 (5) |
| Cooling tower exhaust | 25 (7.5) |

Note 1: Significantly contaminated exhaust is exhaust air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
Note 2: Laboratory fume hood exhaust air outlets shall be in compliance with NFPA 45-1991[3] and ANSI/AIHA Z9.5-1992.[4]
Note 3: Noxious or dangerous exhaust is exhaust air with highly objectionable fumes or gases and/or exhaust air with potentially dangerous particles, bioaerosols, or gases at concentrations high enough to be considered harmful. Information on separation criteria for industrial environments can be found in the ACGIH Industrial Ventilation Manual [5] and in the *ASHRAE Handbook—HVAC Applications*.[6]
Note 4: Shorter separation distances are permitted when determined in accordance with (a) Chapter 7 of ANSI Z223.1/NFPA 54-2002[7] for fuel gas burning appliances and equipment, (b) Chapter 6 of NFPA 31-2001[8] for oil burning appliances and equipment, or (c) Chapter 7 of NFPA 211-2003[9] for other combustion appliances and equipment.
Note 5: Distance measured to closest place that vehicle exhaust is likely to be located.
Note 6: No minimum separation distance applies to surfaces that are sloped more than 45 degrees from horizontal or that are less than 1 in. (3 cm) wide.
Note 7: Where snow accumulation is expected, distance listed shall be increased by the expected average snow depth.

**Exception:** Other minimum separation distances are acceptable if it can be shown that an equivalent or lesser rate of introduction of outdoor air contaminants will be attained.

***Note:*** Appendix F presents an acceptable alternative method of determining the minimum separation distance.

**5.6.2 Rain Entrainment.** Outdoor air intakes that are part of the mechanical ventilation system shall be designed to manage rain entrainment in accordance with any one of the following:

a. Limit water penetration through the intake to 0.07 oz/ft$^2$·h (21.5 g/m$^2$·h) of inlet area when tested using the rain test apparatus described in Section 58 of UL 1995.[12]
b. Select louvers that limit water penetration to a maximum of 0.01 oz/ft$^2$ (3 g/m$^2$) of louver free area at the maximum intake velocity. This water penetration rate shall be determined for a minimum 15-minute test duration when subjected to a water flow rate of 0.25 gal/min (16 mL/s) as described under the Water Penetration Test in AMCA 500-L-99[13] or equivalent. Manage the water that penetrates the louver by providing a drainage area and/or moisture removal devices.
c. Select louvers that restrict wind-driven rain penetration to less than 2.36 oz/ft$^2$·h (721 g/m$^2$·h) when subjected to a simulated rainfall of 3 in. (75 mm) per hour and a 29 mph (13 m/s) wind velocity at the design outdoor air intake rate with the air velocity calculated based on the louver face area.

   ***Note:*** This performance corresponds to Class A (99% effectiveness) when rated according to AMCA 511-99[14] and tested per AMCA 500-L-99.[13]
d. Use rain hoods sized for no more than 500 fpm (2.5 m/s) face velocity with a downward-facing intake such that all intake air passes upward through a horizontal plane that intersects the solid surfaces of the hood before entering the system.
e. Manage the water that penetrates the intake opening by providing a drainage area and/or moisture removal devices.

**5.6.3 Rain Intrusion.** Air-handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.[12]

**5.6.4 Snow Entrainment.** Where climate dictates, outdoor air intakes that are part of the mechanical ventilation system shall be designed to manage melted snow blown or drawn into the system as follows:

a. Suitable access doors to permit cleaning shall be provided.
b. Outdoor air ductwork or plenums shall pitch to drains designed in accordance with the requirements of Section 5.11.

**5.6.5 Bird Screens.** Outdoor air intakes shall include a screening device designed to prevent penetration by a 0.5 in. (13 mm) diameter probe. The screening device material shall be corrosion resistant. The screening device shall be located, or other measures shall be taken, to prevent bird nesting within the outdoor air intake.

***Note:*** Any horizontal surface may be subject to bird nesting.

**5.7 Local Capture of Contaminants.** The discharge from noncombustion equipment that captures the contaminants generated by the equipment shall be ducted directly to the outdoors.

**Exception:** Equipment specifically designed for discharge indoors in accordance with the manufacturer's recommendations.

**5.8 Combustion Air.** Fuel-burning appliances, both vented and unvented, shall be provided with sufficient air for combustion and adequate removal of combustion products, in accordance with manufacturer instructions. Products of combustion from vented appliances shall be vented directly outdoors.

**5.9 Particulate Matter Removal.** Particulate matter filters or air cleaners having a minimum efficiency reporting value (MERV) of not less than 6 when rated in accordance with ANSI/ASHRAE Standard 52.2[15] shall be provided upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to an occupiable space.

**5.10 Dehumidification Systems.** Mechanical air-conditioning systems with dehumidification capability shall be designed to comply with the following.

**5.10.1 Relative Humidity.** Occupied space relative humidity shall be limited to 65% or less when system performance is analyzed with outdoor air at the dehumidification design condition (that is, design dew point and mean coincident dry-bulb temperatures) and with the space interior loads (both sensible and latent) at cooling design values and space solar loads at zero.

***Note:*** System configuration and/or climatic conditions may adequately limit space relative humidity at these conditions without additional humidity-control devices. The specified conditions challenge the system dehumidification performance with high outdoor latent load and low space sensible heat ratio.

**Exception:** Spaces where process or occupancy requirements dictate higher humidity conditions, such as kitchens, hot tub rooms that contain heated standing water, refrigerated or frozen storage rooms and ice rinks, and/or spaces designed and constructed to manage moisture, such as shower rooms, pools, and spas.

**5.10.2 Exfiltration.** For a building, the design minimum outdoor air intake shall be greater than the design maximum exhaust airflow when the mechanical air-conditioning systems are dehumidifying.

**Exception:** Where excess exhaust is required by process considerations and approved by the authority having jurisdiction, such as in certain industrial facilities.

***Note:*** Although individual zones within a building may be neutral or negative with respect to outdoors or to other zones, net positive mechanical intake airflow for the building as a whole reduces infiltration of untreated outdoor air.

**5.11 Drain Pans.** Drain pans, including their outlets and seals, shall be designed and constructed in accordance with this section.

**5.11.1 Drain Pan Slope.** Pans intended to collect and drain liquid water shall be sloped at least 0.125 in. per foot (10 mm per meter) from the horizontal toward the drain outlet or shall be otherwise designed to ensure that water drains freely from the pan whether the fan is on or off.

**5.11.2 Drain Outlet.** The drain pan outlet shall be located at the lowest point(s) of the drain pan and shall be of sufficient diameter to preclude drain pan overflow under any normally expected operating condition.

**5.11.3 Drain Seal.** For configurations that result in negative static pressure at the drain pan relative to the drain outlet (such as a draw-through unit), the drain line shall include a P-trap or other sealing device designed to maintain a seal against ingestion of ambient air while allowing complete drainage of the drain pan under any normally expected operating condition, whether the fan is on or off.

**5.11.4 Pan Size.** The drain pan shall be located under the water-producing device. Drain pan width shall be sufficient to collect water droplets across the entire width of the water-producing device or assembly. For horizontal airflow configurations, the drain pan length shall begin at the leading face or edge of the water-producing device or assembly and extend downstream from the leaving face or edge to a distance of either:

a. one half of the installed vertical dimension of the water-producing device or assembly, or
b. as necessary to limit water droplet carryover beyond the drain pan to 0.0044 oz per $ft^2$ (1.5 mL per $m^2$) of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity.

**5.12 Finned-Tube Coils and Heat Exchangers**

**5.12.1 Drain Pans.** A drain pan in accordance with Section 5.11 shall be provided beneath all dehumidifying cooling coil assemblies and all condensate-producing heat exchangers.

**5.12.2 Finned-Tube Coil Selection for Cleaning.** Individual finned-tube coils or multiple finned-tube coils in series without adequate intervening access space(s) of at least 18 in. (457 mm) shall be selected to result in no more than 0.75 in. w.c. (187 Pa) combined pressure drop when dry coil face velocity is 500 fpm (2.54 m/s).

**Exception:** When clear and complete instructions for access and cleaning of both upstream and downstream coil surfaces are provided.

**5.13 Humidifiers and Water-Spray Systems.** Steam and direct evaporation humidifiers, air washers, and other water-spray systems shall be designed in accordance with this section.

**5.13.1 Water Quality.** Water shall originate directly from a potable source or from a source with equal or better water quality.

**5.13.2 Obstructions.** Air cleaners or ductwork obstructions, such as turning vanes, volume dampers, and duct offsets greater than 15 degrees, that are installed downstream of humidifiers or water spray systems shall be located a distance equal to or greater than the absorption distance recommended by the humidifier or water spray system manufacturer.

**Exception:** Equipment such as eliminators, coils, or evaporative media may be located within the absorption distance recommended by the manufacturer, provided a drain pan complying with the requirements of Section 5.11 is used to capture and remove any water that may drop out of the airstream due to impingement on these obstructions.

**5.14 Access for Inspection, Cleaning, and Maintenance**

**5.14.1 Equipment Clearance.** Ventilation equipment shall be installed with sufficient working space for inspection and routine maintenance (e.g., filter replacement and fan belt adjustment and replacement).

**5.14.2 Ventilation Equipment Access.** Access doors, panels, or other means shall be provided and sized to allow convenient and unobstructed access sufficient to inspect, maintain, and calibrate all ventilation system components for which routine inspection, maintenance, or calibration is necessary. Ventilation system components comprise, for example, air-handling units, fan-coil units, water-source heat pumps, other terminal units, controllers, and sensors.

**5.14.3 Air Distribution System.** Access doors, panels, or other means shall be provided in ventilation equipment, ductwork, and plenums, located and sized to allow convenient and unobstructed access for inspection, cleaning, and routine maintenance of the following:

a. Outdoor air intake areaways or plenums
b. Mixed air plenums
c. Upstream surface of each heating, cooling, and heat-recovery coil or coil assembly having a total of four rows or less
d. Both upstream and downstream surface of each heating, cooling, and heat-recovery coil having a total of more than four rows and air washers, evaporative coolers, heat wheels, and other heat exchangers
e. Air cleaners
f. Drain pans and drain seals
g. Fans
h. Humidifiers

**5.15 Building Envelope and Interior Surfaces.** The building envelope and interior surfaces within the building envelope shall be designed in accordance with the following.

**5.15.1 Building Envelope.** The building envelope, including roofs, walls, fenestration systems, and foundations, shall comply with the following:

1. A weather barrier or other means shall be provided to prevent liquid water penetration into the envelope.

   **Exception:** When the envelope is engineered to allow incidental water penetration to occur without resulting in damage to the envelope construction.
2. An appropriately placed vapor retarder or other means shall be provided to limit water vapor diffusion to prevent condensation on cold surfaces within the envelope.

   **Exception:** When the envelope is engineered to manage incidental condensation without resulting in damage to the envelope construction.
3. Exterior joints, seams, or penetrations in the building envelope that are pathways for air leakage shall be caulked, gasketed, weather-stripped, provided with continuous air barrier, or otherwise sealed to limit infiltration through the envelope to reduce uncontrolled entry of outdoor air moisture and pollutants.

***Note:*** Where soils contain high concentrations of radon or other soil gas contaminants, the local authority having jurisdiction may have additional requirements, such as depressurization.

**5.15.2 Condensation on Interior Surfaces.** Pipes, ducts, and other surfaces within the building whose surface temperatures are expected to fall below the surrounding dew-point temperature shall be insulated. The insulation system thermal resistance and material characteristics shall be sufficient to prevent condensation from forming on the exposed surface and within the insulating material.

**Exceptions:**

a. Where condensate will wet only surfaces that can be managed to prevent or control mold growth.
b. Where local practice has demonstrated that condensation does not result in mold growth.

**5.16 Buildings with Attached Parking Garages.** In order to limit the entry of vehicular exhaust into occupiable spaces, buildings with attached parking garages shall:

1. maintain the garage pressure at or below the pressure of the adjacent occupiable spaces, or
2. use a vestibule to provide an airlock between the garage and the adjacent occupiable spaces, or
3. otherwise be designed to minimize migration of air from the attached parking garage into the adjacent occupiable spaces of the building.

**5.17 Air Classification and Recirculation.** Air shall be classified, and its recirculation shall be limited in accordance with the following sections.

**5.17.1 Classification.** Air (return, transfer, or exhaust air) leaving each space or location shall be designated at an expected air-quality classification not less than that shown in Tables 5-2 or 6-1 or as approved by the authority having jurisdiction. The classification for air from spaces or locations that are not listed in Tables 5-2 or 6-1 shall be the same as the classification for air from the listed space type that is most similar in terms of occupant activities and building construction.

**TABLE 5-2 Airstreams**

| Description | Air Class |
|---|---|
| Diazo printing equipment discharge | 4 |
| Commercial kitchen grease hoods | 4 |
| Commercial kitchen hoods other than grease | 3 |
| Laboratory hoods | 4 |
| Residential kitchen vented hoods | 3 |

**Exception:** Classification of air from smoking spaces is not addressed. (Spaces that are expected to include smoking do not have a classification listed in Table 6-1.)

***Note:*** Classifications in Tables 5-2 and 6-1 are based on relative contaminant concentration using the following subjective criteria:

- Class 1: Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.
- Class 2: Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors. Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.
- Class 3: Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
- Class 4: Air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered harmful.

**5.17.2 Re-designation**

**5.17.2.1 Air Cleaning.** If air leaving a space or location passes through an air-cleaning system, the cleaned air may be reclassified to a cleaner classification, using the subjective criteria noted above, with the approval of the authority having jurisdiction.

**5.17.2.2 Energy Recovery.** Class 2 air may be re-designated as Class 1 air in the process of recovering energy when it is diluted with outdoor air such that no more than 10% of the resulting airstream is Class 2 air. Class 3 air may be re-designated as Class 1 air in the process of recovering energy when it is diluted with outdoor air such that no more than 5% of the resulting airstream is Class 3 air.

**5.17.2.3 Transfer.** A mixture of air that has been transferred through or returned from more than one classification of space must be re-designated with the classification appropriate for the part of the mixture that has the highest contaminant concentration. For example**,** air returned from both a Class 1 and a Class 2 space served by a common system must be designated as Class 2 air.

**5.17.3 Recirculation Limitations.** When the Ventilation Rate Procedure of Section 6 is used to determine ventilation airflow values, recirculation of air shall be limited in accordance with the requirements of this section.

**5.17.3.1 Class 1 Air.** Class 1 air may be recirculated or transferred to any space.

**5.17.3.2 Class 2 Air.** Class 2 air may be recirculated within the space of origin. Class 2 air may be transferred or recirculated to other Class 2 or Class 3 spaces utilized for the same or similar purpose or task and involving the same or similar pollutant sources. Class 2 air may be recirculated or transferred to Class 4 spaces. Class 2 air shall not be recirculated or transferred to Class 1 spaces.

***Note:*** Spaces that are normally Class 1 may be identified as "Spaces ancillary to Class 2 spaces" and as such classified as Class 2 spaces as permitted in Table 6-1.

**5.17.3.3 Class 3 Air.** Class 3 air may be recirculated within the space of origin. Class 3 air shall not be recirculated or transferred to any other space.

**5.17.3.4 Class 4 Air.** Class 4 air shall not be recirculated or transferred to any space nor recirculated within the space of origin.

**5.17.4 Documentation.** Design documentation shall indicate the justification for classification of air from any location not listed in Tables 5-2 or 6-1.

**5.18 Requirements for Buildings Containing ETS Areas and ETS-Free Areas.** The requirements of this section must be met when a building contains both ETS areas and ETS-free areas. Such buildings shall be constructed and operated in accordance with Sections 5.18.1 through 5.18.8. This section does not purport to achieve acceptable indoor air quality in ETS areas.

**5.18.1 Classification.** All spaces shall be classified as either ETS-free areas or ETS areas.

**5.18.2 Pressurization.** ETS-free areas shall be at a positive pressure with respect to any adjacent or connected ETS areas.

***Note:*** Examples of methods for demonstrating relative pressure include engineering analysis, pressure differential measurement, and airflow measurement.

**Exceptions:**

a. Dwelling units, including hotel and motel guestrooms, and adjacent properties under different ownership with separation walls that are structurally independent and that contain no openings. This exception shall apply only when:
   1. the separation walls are constructed as smoke barriers in accordance with the requirements of applicable standards;
   2. the separation walls include an air barrier consisting of a continuous membrane or surface treatment in the separation wall that has documented resistance to air leakage; continuity of the barrier shall be maintained at openings for pipes, ducts, and other conduits and at points where the barrier meets the outside walls and other barriers; and
   3. interior corridors common to ETS and ETS-free areas are mechanically supplied with outdoor air at the rate of 0.1 cfm/ft$^2$ (0.5 L/s·m$^2$).

b. Adjacent spaces otherwise required to be held at negative pressure and posted with signs due to the presence of hazardous or flammable materials or vapors.

**5.18.3 Separation.** Solid walls, floors, ceilings, and doors equipped with automatic closing mechanisms shall separate ETS areas from ETS-free areas.

**Exception:** Openings without doors are permitted in the separation where engineered systems are designed to provide airflow from ETS-free areas into ETS areas, notwithstanding eddies that may occur in the immediate vicinity of the boundary between the ETS and ETS-free areas and reverse flow that may occur due to short-term conditions such as wind gusts.

***Note:*** Examples of methods for demonstrating air motion are engineering analysis and the use of a directional airflow indicator at representative locations in the opening, such as on 1 ft (0.3 m) centers or at locations required for duct traverses in standard testing and balancing procedures, such as those described in ASHRAE Standard 111.[21]

**5.18.4 Transfer Air.** When air is transferred from ETS-free areas to ETS areas, the transfer airflow rate shall be maintained regardless of whether operable doors or windows between ETS-free and ETS areas are opened or closed. Acceptable means of doing so include fixed openings in doors, walls, or floors, transfer grilles, transfer ducts, or unducted air plenums with air pressure differentials in compliance with Section 5.18.2.

**5.18.5 Recirculation.** Air-handling and natural ventilation systems shall not recirculate or transfer air from an ETS area to an ETS-free area.

**5.18.6 Exhaust Systems.** Exhaust or relief air from an ETS area shall be discharged such that none of the air is recirculated back into any ETS-free area.

**5.18.7 Signage.** A sign shall be posted outside each entrance to each ETS area. The sign shall state, as a minimum, "This Area May Contain Environmental Tobacco Smoke" in letters at least 1 in. (25 mm) high or otherwise in compliance with accessibility guidelines.

***Note:*** Based on the definition of ETS area, such a sign may be posted outside a larger ETS area that includes the area where smoking is permitted.

**Exception:** Instead of the specified sign, equivalent notification means acceptable to the authority having jurisdiction may be used.

**5.18.8 Reclassification.** An area that was previously an ETS area, but now meets the requirements of an ETS-free area, may be classified as such after intentional or allowed smoke exposure has stopped and odor and irritation from residual ETS contaminants are not apparent.

## 6. PROCEDURES

This section is not required for natural ventilation systems; natural ventilation systems shall be designed in accordance with Section 5.1.

**6.1 General.** Either the Ventilation Rate Procedure or the IAQ Procedure shall be used to design each ventilation system in a building, subject to the following considerations and restrictions.

**6.1.1 Ventilation Rate Procedure.** This is a prescriptive procedure in which outdoor air intake rates are determined based on space type/application, occupancy level, and floor area.

***Note:*** The Ventilation Rate Procedure minimum rates are based on contaminant sources and source strengths that are typical for the listed space types.

**6.1.2 IAQ Procedure.** This is a design procedure in which outdoor air intake rates and other system design parameters are based on an analysis of contaminant sources, contaminant concentration targets, and perceived acceptability targets. 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.

**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 6.2.9.

***Note:*** Additional explanation of terms used below is contained in Appendix A, along with a ventilation system schematic (Figure A.1).

**6.2.1 Outdoor Air Treatment.** If outdoor air is judged to be unacceptable in accordance with Section 4.1, each ventilation system that provides outdoor air through a supply fan shall comply with the following sections.

**Exception:** Systems supplying air for enclosed parking garages, warehouses, storage rooms, janitor's closets, trash rooms, recycling areas, shipping/receiving/distribution areas.

***Note:*** Occupied spaces ventilated with outdoor air that is judged to be unacceptable are subject to reduced air quality when outdoor air is not cleaned prior to introduction to the occupied spaces.

**6.2.1.1 Particulate Matter.** When the building is located in an area where the national standard for PM10[1] is exceeded, particle filters or air-cleaning devices shall be provided to clean the air at any location prior to its introduction to occupied spaces. Particulate matter filters or air cleaners shall have a Minimum Efficiency Reporting Value (MERV) of 6 or higher when rated in accordance with ANSI/ASHRAE Standard 52.2.[15]

**6.2.1.2 Ozone.** Air-cleaning devices for ozone shall be provided when the second-highest daily maximum one-hour average concentration exceeds 0.160 ppm (313 μg/m$^3$). The ozone concentration for design purposes shall be determined in accordance with Appendix H to subchapter C, 40 CFR 50,[1] or equivalent.

***Note:*** Monitored values for historical one-hour average ozone concentrations are available for United States locations at the AIRData Web site, located under www.epa.gov.

Such air-cleaning devices shall have a minimum volumetric ozone removal efficiency of 40% when installed, operated, and maintained in accordance with manufacturer recommendations and shall be approved by the authority having jurisdiction. Such devices shall be operated whenever outdoor ozone levels are expected to exceed 0.160 ppm (313 μg/m$^3$).

***Note:*** For United States locations, the one-hour average ozone concentration is expected to exceed the 0.160 ppm (313 μg/m$^3$) limit when the Air Quality Index forecast exceeds 151 (category red, purple, or maroon). This forecast is available in local media or at the AIRNow Web site, located under www.epa.gov.

**Exceptions:** Air cleaning for ozone is not required when:

a. The minimum system design outdoor air intake flow results in 1.5 ach or less.
b. Controls are provided that sense outdoor ozone level and reduce intake airflow to result in 1.5 ach or less while complying with the outdoor airflow requirements of Section 6.
c. Outdoor air is brought into the building and heated by direct-fired, makeup air units.

**6.2.1.3 Other Outdoor Contaminants.** When the building is located in an area where the national standard for one or more contaminants not specifically addressed in Section 6.2.1 is exceeded, any design assumptions and/or calculations related to the impact on indoor air quality shall be included in the design documents.

**6.2.2 Zone Calculations.** *Zone* parameters shall be determined in accordance with Sections 6.2.2.1 through 6.2.2.3.

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

**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 *zone*, *i.e., the breathing zone outdoor airflow* ($V_{bz}$), shall be determined in accordance with Equation 6-1.

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

where

$A_z$ = *zone floor area*: the net occupiable floor area of the *zone* m$^2$ (ft$^2$)

$P_z$ = *zone population*: the largest number of people expected to occupy the 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 $P_z$ 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 for people-related sources and area-related sources for determining the outdoor air 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 sources can be applied to any other aspect of indoor air quality.

**6.2.2.2 Zone Air Distribution Effectiveness.** The *zone air distribution effectiveness* ($E_z$) shall be determined using Table 6-2.

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

$$V_{oz} = V_{bz}/E_z \tag{6-2}$$

**6.2.3 Single-Zone Systems.** When one air handler supplies a mixture of outdoor air and recirculated air to only one zone, the *outdoor air intake flow* ($V_{ot}$) shall be determined in accordance with Equation 6-3.

$$V_{ot} = V_{oz} \tag{6-3}$$

**6.2.4 100% Outdoor Air Systems.** When one air handler supplies only outdoor air to one or more zones, the *outdoor air intake flow* ($V_{ot}$) shall be determined in accordance with Equation 6-4.

$$V_{ot} = \Sigma_{all\ zones} V_{oz} \tag{6-4}$$

**6.2.5 Multiple-Zone Recirculating Systems.** When one air handler supplies a mixture of outdoor air and recirculated return air to more than one 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* ($Z_p$) shall be determined in accordance with Equation 6-5.

$$Z_p = V_{oz}/V_{pz} \tag{6-5}$$

where $V_{pz}$ is the zone primary airflow, i.e., the primary airflow to the 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.

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

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

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

The *occupant diversity*, $D$, may be used to account for variations in occupancy within the zones served by the system. The *occupancy diversity* is defined as

$$D = P_s/\Sigma_{all\ zones} P_z\ , \tag{6-7}$$

where the *system population* ($P_s$) is the total population in the area served by the system. Alternative methods may be used to account for population diversity when calculating $V_{ou}$, provided that the resulting value is no less than that determined by Equation 6-6.

***Note:*** The *uncorrected outdoor air intake* ($V_{ou}$) is adjusted for diversity but uncorrected for ventilation efficiency.

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

$$V_{ot} = V_{ou}/E_v \tag{6-8}$$

**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 the required ventilation rates in the breathing zone whenever the zones served by the system are occupied, including all full- and 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 6-9.

$$T = 3v/V_{bz} \tag{6-9a}$$

$$T = 50v/V_{bz} \tag{6-9b}$$

where

$T$ = averaging time period, min

$v$ = the volume of the 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.

## TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE
**(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)**

| Occupancy Category | People Outdoor Air Rate $R_p$ | | Area Outdoor Air Rate $R_a$ | | Notes | Default Values | | | Air Class |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Occupant Density (see Note 4) | Combined Outdoor Air Rate (see Note 5) | | |
| | cfm/person | L/s·person | cfm/ft$^2$ | L/s·m$^2$ | | #/1000 ft$^2$ or #/100 m$^2$ | cfm/person | L/s·person | |
| **Correctional Facilities** | | | | | | | | | |
| Cell | 5 | 2.5 | 0.12 | 0.6 | | 25 | 10 | 4.9 | 2 |
| Dayroom | 5 | 2.5 | 0.06 | 0.3 | | 30 | 7 | 3.5 | 1 |
| Guard stations | 5 | 2.5 | 0.06 | 0.3 | | 15 | 9 | 4.5 | 1 |
| Booking/waiting | 7.5 | 3.8 | 0.06 | 0.3 | | 50 | 9 | 4.4 | 2 |
| **Educational Facilities** | | | | | | | | | |
| Daycare (through age 4) | 10 | 5 | 0.18 | 0.9 | | 25 | 17 | 8.6 | 2 |
| Daycare sickroom | 10 | 5 | 0.18 | 0.9 | | 25 | 17 | 8.6 | 3 |
| Classrooms (ages 5–8) | 10 | 5 | 0.12 | 0.6 | | 25 | 15 | 7.4 | 1 |
| Classrooms (age 9 plus) | 10 | 5 | 0.12 | 0.6 | | 35 | 13 | 6.7 | 1 |
| Lecture classroom | 7.5 | 3.8 | 0.06 | 0.3 | | 65 | 8 | 4.3 | 1 |
| Lecture hall (fixed seats) | 7.5 | 3.8 | 0.06 | 0.3 | | 150 | 8 | 4.0 | 1 |
| Art classroom | 10 | 5 | 0.18 | 0.9 | | 20 | 19 | 9.5 | 2 |
| Science laboratories | 10 | 5 | 0.18 | 0.9 | | 25 | 17 | 8.6 | 2 |
| University/college laboratories | 10 | 5 | 0.18 | 0.9 | | 25 | 17 | 8.6 | 2 |
| Wood/metal shop | 10 | 5 | 0.18 | 0.9 | | 20 | 19 | 9.5 | 2 |
| Computer lab | 10 | 5 | 0.12 | 0.6 | | 25 | 15 | 7.4 | 1 |
| Media center | 10 | 5 | 0.12 | 0.6 | A | 25 | 15 | 7.4 | 1 |
| Music/theater/dance | 10 | 5 | 0.06 | 0.3 | | 35 | 12 | 5.9 | 1 |
| Multi-use assembly | 7.5 | 3.8 | 0.06 | 0.3 | | 100 | 8 | 4.1 | 1 |
| **Food and Beverage Service** | | | | | | | | | |
| Restaurant dining rooms | 7.5 | 3.8 | 0.18 | 0.9 | | 70 | 10 | 5.1 | 2 |
| Cafeteria/fast-food dining | 7.5 | 3.8 | 0.18 | 0.9 | | 100 | 9 | 4.7 | 2 |
| Bars, cocktail lounges | 7.5 | 3.8 | 0.18 | 0.9 | | 100 | 9 | 4.7 | 2 |
| **General** | | | | | | | | | |
| Break rooms | 5 | 2.5 | 0.06 | 0.3 | | 25 | 10 | 5.1 | 1 |
| Coffee stations | 5 | 2.5 | 0.06 | 0.3 | | 20 | 11 | 5.5 | 1 |
| Conference/meeting | 5 | 2.5 | 0.06 | 0.3 | | 50 | 6 | 3.1 | 1 |
| Corridors | – | – | 0.06 | 0.3 | | – | | | 1 |
| Storage rooms | – | – | 0.12 | 0.6 | B | – | | | 1 |
| **Hotels, Motels, Resorts, Dormitories** | | | | | | | | | |
| Bedroom/living room | 5 | 2.5 | 0.06 | 0.3 | | 10 | 11 | 5.5 | 1 |
| Barracks sleeping areas | 5 | 2.5 | 0.06 | 0.3 | | 20 | 8 | 4.0 | 1 |
| Laundry rooms, central | 5 | 2.5 | 0.12 | 0.6 | | 10 | 17 | 8.5 | 2 |
| Laundry rooms within dwelling units | 5 | 2.5 | 0.12 | 0.6 | | 10 | 17 | 8.5 | 1 |
| Lobbies/prefunction | 7.5 | 3.8 | 0.06 | 0.3 | | 30 | 10 | 4.8 | 1 |
| Multipurpose assembly | 5 | 2.5 | 0.06 | 0.3 | | 120 | 6 | 2.8 | 1 |

**TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE *(continued)***
**(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)**

| Occupancy Category | People Outdoor Air Rate $R_p$ | | Area Outdoor Air Rate $R_a$ | | Notes | Default Values | | | Air Class |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Occupant Density (see Note 4) | Combined Outdoor Air Rate (see Note 5) | | |
| | cfm/person | L/s·person | cfm/ft$^2$ | L/s·m$^2$ | | #/1000 ft$^2$ or #/100 m$^2$ | cfm/person | L/s·person | |
| **Office Buildings** | | | | | | | | | |
| Office space | 5 | 2.5 | 0.06 | 0.3 | | 5 | 17 | 8.5 | 1 |
| Reception areas | 5 | 2.5 | 0.06 | 0.3 | | 30 | 7 | 3.5 | 1 |
| Telephone/data entry | 5 | 2.5 | 0.06 | 0.3 | | 60 | 6 | 3.0 | 1 |
| Main entry lobbies | 5 | 2.5 | 0.06 | 0.3 | | 10 | 11 | 5.5 | 1 |
| **Miscellaneous Spaces** | | | | | | | | | |
| Bank vaults/safe deposit | 5 | 2.5 | 0.06 | 0.3 | | 5 | 17 | 8.5 | 2 |
| Computer (not printing) | 5 | 2.5 | 0.06 | 0.3 | | 4 | 20 | 10.0 | 1 |
| Electrical equipment rooms | – | – | 0.06 | 0.3 | B | – | | | 1 |
| Elevator machine rooms | – | – | 0.12 | 0.6 | B | – | | | 1 |
| Pharmacy (prep. area) | 5 | 2.5 | 0.18 | 0.9 | | 10 | 23 | 11.5 | 2 |
| Photo studios | 5 | 2.5 | 0.12 | 0.6 | | 10 | 17 | 8.5 | 1 |
| Shipping/receiving | – | – | 0.12 | 0.6 | B | – | | | 1 |
| Telephone closets | – | – | 0.00 | 0.0 | | – | | | 1 |
| Transportation waiting | 7.5 | 3.8 | 0.06 | 0.3 | | 100 | 8 | 4.1 | 1 |
| Warehouses | – | – | 0.06 | 0.3 | B | – | | | 2 |
| **Public Assembly Spaces** | | | | | | | | | |
| Auditorium seating area | 5 | 2.5 | 0.06 | 0.3 | | 150 | 5 | 2.7 | 1 |
| Places of religious worship | 5 | 2.5 | 0.06 | 0.3 | | 120 | 6 | 2.8 | 1 |
| Courtrooms | 5 | 2.5 | 0.06 | 0.3 | | 70 | 6 | 2.9 | 1 |
| Legislative chambers | 5 | 2.5 | 0.06 | 0.3 | | 50 | 6 | 3.1 | 1 |
| Libraries | 5 | 2.5 | 0.12 | 0.6 | | 10 | 17 | 8.5 | 1 |
| Lobbies | 5 | 2.5 | 0.06 | 0.3 | | 150 | 5 | 2.7 | 1 |
| Museums (children's) | 7.5 | 3.8 | 0.12 | 0.6 | | 40 | 11 | 5.3 | 1 |
| Museums/galleries | 7.5 | 3.8 | 0.06 | 0.3 | | 40 | 9 | 4.6 | 1 |
| **Residential** | | | | | | | | | |
| Dwelling unit | 5 | 2.5 | 0.06 | 0.3 | F,G | F | | | 1 |
| Common corridors | – | – | 0.06 | 0.3 | | | | | 1 |
| **Retail** | | | | | | | | | |
| Sales (except as below) | 7.5 | 3.8 | 0.12 | 0.6 | | 15 | 16 | 7.8 | 2 |
| Mall common areas | 7.5 | 3.8 | 0.06 | 0.3 | | 40 | 9 | 4.6 | 1 |
| Barbershop | 7.5 | 3.8 | 0.06 | 0.3 | | 25 | 10 | 5.0 | 2 |
| Beauty and nail salons | 20 | 10 | 0.12 | 0.6 | | 25 | 25 | 12.4 | 2 |
| Pet shops (animal areas) | 7.5 | 3.8 | 0.18 | 0.9 | | 10 | 26 | 12.8 | 2 |
| Supermarket | 7.5 | 3.8 | 0.06 | 0.3 | | 8 | 15 | 7.6 | 1 |
| Coin-operated laundries | 7.5 | 3.8 | 0.06 | 0.3 | | 20 | 11 | 5.3 | 2 |

**TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE *(continued)***
**(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)**

| Occupancy Category | People Outdoor Air Rate $R_p$ | | Area Outdoor Air Rate $R_a$ | | Notes | Default Values | | | Air Class |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Occupant Density (see Note 4) | Combined Outdoor Air Rate (see Note 5) | | |
| | cfm/person | L/s·person | cfm/ft$^2$ | L/s·m$^2$ | | #/1000 ft$^2$ or #/100 m$^2$ | cfm/person | L/s·person | |
| **Sports and Entertainment** | | | | | | | | | |
| Sports arena (play area) | – | – | 0.30 | 1.5 | E | – | | | 1 |
| Gym, stadium (play area) | – | – | 0.30 | 1.5 | | 30 | | | 2 |
| Spectator areas | 7.5 | 3.8 | 0.06 | 0.3 | | 150 | 8 | 4.0 | 1 |
| Swimming (pool & deck) | – | – | 0.48 | 2.4 | C | – | | | 2 |
| Disco/dance floors | 20 | 10 | 0.06 | 0.3 | | 100 | 21 | 10.3 | 1 |
| Health club/aerobics room | 20 | 10 | 0.06 | 0.3 | | 40 | 22 | 10.8 | 2 |
| Health club/weight rooms | 20 | 10 | 0.06 | 0.3 | | 10 | 26 | 13.0 | 2 |
| Bowling alley (seating) | 10 | 5 | 0.12 | 0.6 | | 40 | 13 | 6.5 | 1 |
| Gambling casinos | 7.5 | 3.8 | 0.18 | 0.9 | | 120 | 9 | 4.6 | 1 |
| Game arcades | 7.5 | 3.8 | 0.18 | 0.9 | | 20 | 17 | 8.3 | 1 |
| Stages, studios | 10 | 5 | 0.06 | 0.3 | D | 70 | 11 | 5.4 | 1 |

GENERAL NOTES FOR TABLE 6-1

**1 Related requirements:** The rates in this table are based on all other applicable requirements of this standard being met.

**2 Smoking:** This table applies to no-smoking areas. Rates for smoking-permitted spaces must be determined using other methods. See Section 6.2.9 for ventilation requirements in smoking areas.

**3 Air density:** Volumetric airflow rates are based on an air density of 0.075 $lb_{da}/ft^3$ (1.2 $kg_{da}/m^3$), which corresponds to dry air at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C). Rates may be adjusted for actual density but such adjustment is not required for compliance with this standard.

**4 Default occupant density:** The default occupant density shall be used when actual occupant density is not known.

**5 Default combined outdoor air rate (per person):** This rate is based on the default occupant density.

**6 Unlisted occupancies:** If the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities and building construction shall be used.

**7 Health-care facilities:** Rates shall be determined in accordance with Appendix E.

ITEM-SPECIFIC NOTES FOR TABLE 6-1

**A** For high school and college libraries, use values shown for Public Assembly Spaces—Libraries.

**B** Rate may not be sufficient when stored materials include those having potentially harmful emissions.

**C** Rate does not allow for humidity control. Additional ventilation or dehumidification may be required to remove moisture.

**D** Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.

**E** When combustion equipment is intended to be used on the playing surface, additional dilution ventilation and/or source control shall be provided.

**F** Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.

**G** Air from one residential dwelling shall not be recirculated or transferred to any other space outside of that dwelling.

**6.2.7 Dynamic Reset.** The system may be designed to reset the design *outdoor air intake flow* ($V_{ot}$) and/or space or zone airflow 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 $CO_2$ concentrations.
2. Variations in the efficiency with which outdoor air is distributed to the occupants under different ventilation system airflows and temperatures.
3. A higher fraction of outdoor air in the air supply due to intake of additional outdoor air for free cooling or exhaust air makeup.

**6.2.8 Exhaust Ventilation.** Exhaust airflow shall be provided in accordance with the requirements in Table 6-4. Exhaust makeup air may be any combination of outdoor air, recirculated air, and transfer air.

**6.2.9 Ventilation in Smoking Areas.** Smoking areas shall have more ventilation and/or air cleaning than comparable no-smoking areas. Specific ventilation rate requirements cannot be determined until cognizant authorities determine the concentration of smoke that achieves an acceptable level of risk. Air from smoking areas shall not be recirculated or transferred to no-smoking areas.

**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

**TABLE 6-2 Zone Air Distribution Effectiveness**

| Air Distribution Configuration | $E_z$ |
|---|---|
| Ceiling supply of cool air. | 1.0 |
| Ceiling supply of warm air and floor return. | 1.0 |
| Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return. | 0.8 |
| Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level. ***Note:*** For lower velocity supply air, $E_z = 0.8$. | 1.0 |
| Floor supply of cool air and ceiling return provided that the 150 fpm (0.8 m/s) supply jet reaches 4.5 ft (1.4 m) or more above the floor. ***Note:*** Most underfloor air distribution systems comply with this proviso. | 1.0 |
| Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification. | 1.2 |
| Floor supply of warm air and floor return. | 1.0 |
| Floor supply of warm air and ceiling return. | 0.7 |
| Makeup supply drawn in on the opposite side of the room from the exhaust and/or return. | 0.8 |
| Makeup supply drawn in near to the exhaust and/or return location. | 0.5 |

1. "Cool air" is air cooler than space temperature.
2. "Warm air" is air warmer than space temperature.
3. "Ceiling" includes any point above the *breathing zone.*
4. "Floor" includes any point below the *breathing zone.*
5. As an alternative to using the above values, $E_z$ may be regarded as equal to air change effectiveness determined in accordance with ANSI/ASHRAE Standard 129[16] for all air distribution configurations except unidirectional flow.

**TABLE 6-3 System Ventilation Efficiency**

| Max ($Z_P$) | $E_v$ |
|---|---|
| ≤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 $Z_p$" refers to the largest value of $Z_p$, calculated using Equation 6-5, among all the zones served by the system.
2. For values of $Z_p$ between 0.15 and 0.55, one may determine the corresponding value of $E_v$ 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.

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.

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

**6.3.1.1 Contaminant Sources.** Contaminants of concern for purposes of the design shall be identified. For each contaminant of concern, indoor and outdoor sources shall be identified, and the strength of each source shall be determined.

**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.)

**6.3.1.3 Perceived Indoor Air Quality.** The criteria to achieve the design level of acceptability shall be specified in terms of the percentage of building occupants and/or visitors expressing satisfaction with perceived IAQ.

**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.

**6.3.2 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 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. 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 the monitoring and evaluation plans shall also be included in the documentation.

**TABLE 6-4 Minimum Exhaust Rates**

| Occupancy Category | Exhaust Rate, cfm/unit | Exhaust Rate, cfm/ft$^2$ | Notes | Exhaust Rate, L/s·unit | Exhaust Rate, L/s·m$^2$ | Air Class |
|---|---|---|---|---|---|---|
| Arenas | – | 0.50 | B | – | – | 1 |
| Art classrooms | – | 0.70 | | – | 3.5 | 2 |
| Auto repair rooms | – | 1.50 | A | – | 7.5 | 2 |
| Barber shops | – | 0.50 | | – | 2.5 | 2 |
| Beauty and nail salons | – | 0.60 | | – | 3.0 | 2 |
| Cells with toilet | – | 1.00 | | – | 5.0 | 2 |
| Copy, printing rooms | – | 0.50 | | – | 2.5 | 2 |
| Darkrooms | – | 1.00 | | – | 5.0 | 2 |
| Educational science laboratories | – | 1.00 | | – | 5.0 | 2 |
| Janitor closets, trash rooms, recycling | – | 1.00 | | – | 5.0 | 3 |
| Kitchenettes | – | 0.30 | | – | 1.5 | 2 |
| Kitchens—commercial | – | 0.70 | | – | 3.5 | 2 |
| Locker/dressing rooms | – | 0.25 | | – | 1.25 | 2 |
| Locker rooms | – | 0.50 | | – | 2.5 | 2 |
| Paint spray booths | – | – | F | – | – | 4 |
| Parking garages | – | 0.75 | C | – | 3.7 | 2 |
| Pet shops (animal areas) | – | 0.90 | | – | 4.5 | 2 |
| Refrigerating machinery rooms | – | – | F | – | – | 3 |
| Residential kitchens | 50/100 | – | G | 25/50 | – | 2 |
| Soiled laundry storage rooms | – | 1.00 | F | – | 5.0 | 3 |
| Storage rooms, chemical | – | 1.50 | F | – | 7.5 | 4 |
| Toilets—private | 25/50 | – | E | 12.5/25 | – | 2 |
| Toilets—public | 50/70 | – | D | 25/35 | – | 2 |
| Woodwork shop/classrooms | – | 0.50 | | – | 2.5 | 2 |

A Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.
B When combustion equipment is intended to be used on the playing surface additional dilution ventilation and/or source control shall be provided.
C Exhaust not required if two or more sides comprise walls that are at least 50% open to the outside.
D Rate is per water closet and/or urinal. Provide the higher rate where periods of heavy use are expected to occur, e.g., toilets in theatres, schools, and sports facilities. The lower rate may be used otherwise.
E Rate is for a toilet room intended to be occupied by one person at a time. For continuous system operation during normal hours of use, the lower rate may be used. Otherwise use the higher rate.
F See other applicable standards for exhaust rate.
G For continuous system operation, the lower rate may be used. Otherwise use the higher rate.

**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, and 6.3.2 regarding assumptions that should be detailed in the documentation.

## 7. CONSTRUCTION AND SYSTEM START-UP

### 7.1 Construction Phase

**7.1.1 Application.** The requirements of this section apply to ventilation systems and the spaces they serve in new buildings and additions to or alterations in existing buildings.

**7.1.2 Filters.** Systems designed with particle filters shall not be operated without filters in place.

**7.1.3 Protection of Materials.** When recommended by the manufacturer, building materials shall be protected from rain and other sources of moisture by appropriate in-transit and on-site procedures. Porous materials with visible microbial growth shall not be installed. Nonporous materials with visible microbial growth shall be decontaminated.

**7.1.4 Protection of Occupied Areas**

**7.1.4.1 Application.** The requirements of Section 7.1.4 apply when construction requires a building permit and entails sanding, cutting, grinding, or other activities that generate significant amounts of airborne particles or procedures that generate significant amounts of gaseous contaminants.

**7.1.4.2 Protective Measures.** Measures shall be employed to reduce the migration of construction-generated contaminants to occupied areas. Examples of acceptable measures include, but are not limited to, sealing the construction area using temporary walls or plastic sheathing, exhausting

the construction area, and/or pressurizing contiguous occupied areas.

**7.1.5 Air Duct System Construction.** Air duct systems shall be constructed in accordance with the following standards, as applicable:

a. The following sections of SMACNA's *HVAC Duct Construction Standards—Metal and Flexible*:[17]
   - Section S1.9j of Section 1.6, Duct Construction and Installation Standards
   - Section 2.6, Installation Standards for Rectangular Ducts Using Flexible Liner
   - Section 3.5, Duct Installation Standards
   - Section 3.6, Specification for Joining and Attaching Flexible Duct
   - Section 3.7, Specification for Supporting Flexible Duct
   - Sections S6.1, S6.3, S6.4, and S6.5 of Section 6.1, Casing and Plenum Construction Standards

b. All sections of SMACNA's *Fibrous Glass Duct Construction Standards*[18]

c. *NFPA 90A,*[19] *Standard for the Installation of Air-Conditioning and Ventilating Systems*, and *NFPA 90B,*[20] *Standard for the Installation of Warm Air Heating and Air-Conditioning Systems*

### 7.2 System Start-Up

**7.2.1 Application.** The requirements of this section apply to the following ventilation systems:

a. Newly installed air-handling systems.

b. Existing air-handling systems undergoing supply air or outdoor airflow reduction—only the requirements of Section 7.2.2 shall apply to these altered systems.

c. Existing air-handling distribution systems undergoing alterations affecting more than 25% of the floor area served by the systems—only the requirements of Section 7.2.2 shall apply to these altered systems.

**7.2.2 Air Balancing.** Ventilation systems shall be balanced in accordance with ASHRAE Standard 111,[21] SMACNA's *HVAC Systems—Testing, Adjusting and Balancing*,[22] or equivalent at least to the extent necessary to verify conformance with the total outdoor air flow and space supply airflow requirements of this standard.

**7.2.3 Testing of Drain Pans.** To minimize conditions of water stagnation that may result in microbial growth, drain pans shall be field tested under normal operating conditions to ensure proper drainage.

**Exception:** Field testing of drain pans is not required if units with factory-installed drain pans have been certified (attested in writing) by the manufacturer for proper drainage when installed as recommended.

**7.2.4 Ventilation System Start-Up.** Ventilation air distribution systems shall be clean of dirt and debris.

**7.2.5 Outdoor Air Dampers.** Prior to occupancy, each ventilation system shall be tested to ensure that outdoor air dampers operate properly in accordance with the system design.

**7.2.6 Documentation.** The following ventilation system documentation shall be provided to the building owner or his/her designee, retained within the building, and made available to the building operating personnel:

a. An operating and maintenance manual describing basic data relating to the operation and maintenance of ventilation systems and equipment as installed.

b. HVAC controls information consisting of diagrams, schematics, control sequence narratives, and maintenance and/or calibration information.

c. An air balance report documenting the work performed for Section 7.2.2.

d. Construction drawings of record, control drawings, and final design drawings.

e. Design criteria and assumptions.

## 8. OPERATIONS AND MAINTENANCE

### 8.1 General

**8.1.1 Application.** The requirements of this section apply to buildings and their ventilation systems and their components constructed or renovated after the adoption date of this section.

**8.1.2 Operations and Maintenance.** The ventilation system shall be operated and maintained at a minimum in accordance with the provisions of this standard.

**8.1.3 Building Alterations or Change-of-Use.** Ventilation system design, operation, and maintenance shall be reevaluated when changes in building use or occupancy category, significant building alterations, significant changes in occupant density, or other changes inconsistent with system design assumptions are made.

**8.2 Operations and Maintenance Manual.** An Operations and Maintenance (O&M) Manual, either written or electronic, shall be developed and maintained on site or in a centrally accessible location for the working life of the applicable ventilation system equipment or components. This manual shall be updated as necessary. The manual shall include, at a minimum, the O&M procedures, final design drawings, O&M schedules and any changes made thereto, and the maintenance requirements and frequencies detailed in Section 8.4.

**8.3 Ventilation System Operation.** Mechanical and natural ventilation systems shall be operated in a manner consistent with the O&M Manual.

### 8.4 Ventilation System Maintenance

**8.4.1 Ventilation System Components.** The building ventilation system components shall be maintained in accordance with the O&M Manual or as required by this section and summarized in Table 8-1.

**8.4.1.1 Filters and Air-Cleaning Devices.** All filters and air-cleaning devices shall be replaced or maintained as specified by the O&M Manual.

**TABLE 8-1 Minimum Maintenance Activity and Frequency**

| Item | Activity Code | Minimum Frequency* |
|---|---|---|
| Filters and air-cleaning devices | A | According to O&M Manual |
| Outdoor air dampers and actuators | B | Every three months or in accordance with O&M Manual |
| Humidifiers | C | Every three months of use or in accordance with O&M Manual |
| Dehumidification coils | D | Regularly when it is likely that dehumidification occurs but no less than once per year or as specified in the O&M Manual |
| Drain pans and other adjacent surfaces subject to wetting | D | Once per year during cooling season or as specified in the O&M Manual |
| Outdoor air intake louvers, bird screens, mist eliminators, and adjacent areas | E | Every six months or as specified in the O&M Manual |
| Sensors used for dynamic minimum outdoor air control | F | Every six months or periodically in accordance with O&M Manual |
| Air-handling systems except for units under 2000 cfm (1000 L/s) | G | Once every five years |
| Cooling towers | H | In accordance with O&M Manual or treatment system provider |
| Floor drains located in plenums or rooms that serve as air plenums | I | Periodically according to O&M Manual |
| Equipment/component accessibility | J | |
| Visible microbial contamination | K | |
| Water intrusion or accumulation | K | |

ACTIVITY CODE:
A Maintain according to O&M Manual.
B Visually inspect or remotely monitor for proper function.
C Clean and maintain to limit fouling and microbial growth.
D Visually inspect for cleanliness and microbial growth and clean when fouling is observed.
E Visually inspect for cleanliness and integrity and clean when necessary.
F Verify accuracy and recalibrate or replace as necessary.
G Measure minimum quantity of outdoor air. If measured minimum airflow rates are less than 90% of the minimum outdoor air rate in the O&M Manual, they shall be adjusted or modified to bring them above 90% or shall be evaluated to determine if the measured rates are in conformance with this standard.
H Treat to limit the growth of microbiological contaminants.
I Maintain to prevent transport of contaminants from the floor drain to the plenum.
J Keep clear the space provided for routine maintenance and inspection around ventilation equipment.
K Investigate and rectify.

* Minimum frequencies may be increased or decreased if indicated in the O&M Manual.

**8.4.1.2 Outdoor Air Dampers.** At a minimum of once every three months or as specified in the O&M Manual, the outdoor air dampers and actuators shall be visually inspected or remotely monitored to verify that they are functioning in accordance with the O&M Manual.

**8.4.1.3 Humidifiers.** Humidifiers shall be cleaned and maintained to limit fouling and microbial growth. These systems shall be inspected at a minimum of once every three months of operation and/or treated as specified in the O&M Manual.

**8.4.1.4 Dehumidification Coils.** All dehumidifying cooling coils shall be visually inspected for cleanliness and microbial growth regularly when it is likely that dehumidification occurs but no less than once per year or as specified in the O&M Manual and shall be cleaned when fouling or microbial growth is observed.

**8.4.1.5 Drain Pans.** Drain pans shall be visually inspected for cleanliness and microbial growth at a minimum of once per year during the cooling season or as specified in the O&M Manual and shall be cleaned if needed. Areas adjacent to drain pans that were subjected to wetting shall be investigated, cleaned if necessary, and the cause of unintended wetting rectified.

**8.4.1.6 Outdoor Air Intake Louvers.** Outdoor air intake louvers, bird screens, mist eliminators, and adjacent areas shall be visually inspected for cleanliness and integrity at a minimum of once every six months or as specified in the O&M Manual and cleaned as needed. When visible debris or visible biological material is observed, it shall be removed. Physical damage to louvers, screens, or mist eliminators shall be repaired if such damage impairs their function in preventing contaminant entry.

**8.4.1.7 Sensors.** Sensors whose primary function is dynamic minimum outdoor air control, such as flow stations at an air handler and those used for demand control ventilation, shall have their accuracy verified as specified in the O&M Manual. This activity shall occur at a minimum of once every six months or periodically in accordance with the O&M

Manual. A sensor failing to meet the accuracy specified in the O&M Manual shall be recalibrated or replaced.

**8.4.1.8 Outdoor Airflow Verification.** The total quantity of outdoor air to air handlers except for units under 2000 cfm (1000 L/s) of supply air shall be measured in minimum outdoor air mode once every five years. If measured minimum airflow rates are less than the design minimum rate (±10% balancing tolerance) documented in the O&M Manual, they shall be adjusted or modified to bring them to the minimum design rate or evaluated to determine if the measured rates are in compliance with this standard.

**8.4.1.9 Cooling Towers.** Cooling tower water systems shall be treated to limit the growth of microbiological contaminants including *legionella sp.* in accordance with the O&M Manual or the water treatment program.

**8.4.1.10 Equipment/Component Accessibility.** The space provided for routine maintenance and inspection around ventilation equipment shall be kept clear.

**8.4.1.11 Floor Drains.** Floor drains located in air plenums or rooms that serve as plenums shall be maintained to prevent transport of contaminants from the floor drain to the plenum.

**8.4.2 Microbial Contamination.** Visible microbial contamination shall be investigated and rectified.

**8.4.3 Water Intrusion.** Water intrusion or accumulation in ventilation system components such as ducts, plenums, and air handlers shall be investigated and rectified.

## 9. REFERENCES


[1] *National Primary and Secondary Ambient Air Quality Standards*, Code of Federal Regulations, Title 40 Part 50 (40 CFR 50), as amended July 1, 2004. U.S. Environmental Protection Agency. www.epa.gov/air/criteria.html, accessed June 25, 2005.

[2] *HVAC Air Duct Leakage Test Manual,* First Edition, 1985. Sheet Metal and Air Conditioning Contractors' Association, Inc. (SMACNA), Chantilly, VA.

[3] *NFPA-45-1991, Standard on Fire Protection for Laboratories Using Chemicals.* National Fire Protection Association, Quincy, MA.

[4] *ANSI/AIHA Z9.5-1992, Standard for Laboratory Ventilation.* American Industrial Hygiene Association, Fairfax, VA.

[5] *Industrial Ventilation: A Manual of Recommended Practice,* 23rd Edition, 1988. American Conference of Governmental Industrial Hygienists (ACGIH), Committee on Industrial Ventilation, Lansing, MI.

[6] *2003 ASHRAE Handbook—Heating, Ventilating, and Air-Conditioning Applications.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

[7] *ANSI Z223.1/NFPA-54-2002, National Fuel Gas Code*. National Fire Protection Association, Quincy, MA.

[8] *NFPA-31-2001, Installation of Oil-Burning Equipment*. National Fire Protection Association, Quincy, MA.

[9] *NFPA-211-2003, Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*. National Fire Protection Association, Quincy, MA.

[10] *UL 181, Factory-Made Air Ducts and Air Connectors*, 9th Edition, 1996. Underwriters' Laboratories, Inc., Northbrook, IL.

[11] *ASTM C 1338-00, Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings*. American Society for Testing and Materials, West Conshohocken, PA.

[12] *UL 1995, Heating and Cooling Equipment,* 2nd Edition, 1995. Underwriters Laboratories, Inc., Northbrook, IL.

[13] *AMCA 500-L-99, Laboratory Methods of Testing Louvers for Rating.* Air Movement and Control Association International, Inc. Arlington Heights, IL.

[14] *AMCA 511-99, Certified Ratings Program for Air Control Devices*. Air Movement and Control Association International, Inc. Arlington Heights, IL.

[15] *ANSI/ASHRAE Standard 52.2-1999, Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

[16] *ANSI/ASHRAE 129-1997 (RA 02), Measuring Air Change Effectiveness.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

[17] *HVAC Duct Construction Standards—Metal and Flexible*, 2nd Edition, 1995. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA), Chantilly, VA.

[18] *Fibrous Glass Duct Construction Standards*, 6th Edition, 1992. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA), Chantilly, VA.

[19] *NFPA-90A-2002, Standard for the Installation of Air-Conditioning and Ventilating Systems.* National Fire Protection Association, Quincy, MA.

[20] *NFPA-90B-2002, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.* National Fire Protection Association, Quincy, MA.

[21] *ASHRAE Standard 111-1988, Practices for Measurement, Testing, Adjusting, and Balancing of Building, Heating, Ventilation, Air-Conditioning and Refrigeration Systems.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA.

[22] *HVAC Systems–Testing, Adjusting and Balancing*, 3rd Edition, 2002. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA), Chantilly, VA.


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**(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 below). Figure A.1 contains a ventilation system schematic depicting most of the quantities used in this appendix.

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.

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

Equation A-1 (or A-2) shall be used for "single supply" systems, where all the ventilation air is a mixture of outdoor air and recirculated air from a single location, e.g., Reheat, Single-Duct VAV, Single-Fan Dual-Duct, and Multizone.

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

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.

The system ventilation efficiency shall be calculated using Equation A-3.

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

## 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 mass or flow balance equations for multiple zone systems may also be used 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* calculated using Equation A-3 or they more accurately represent a particular system configuration.

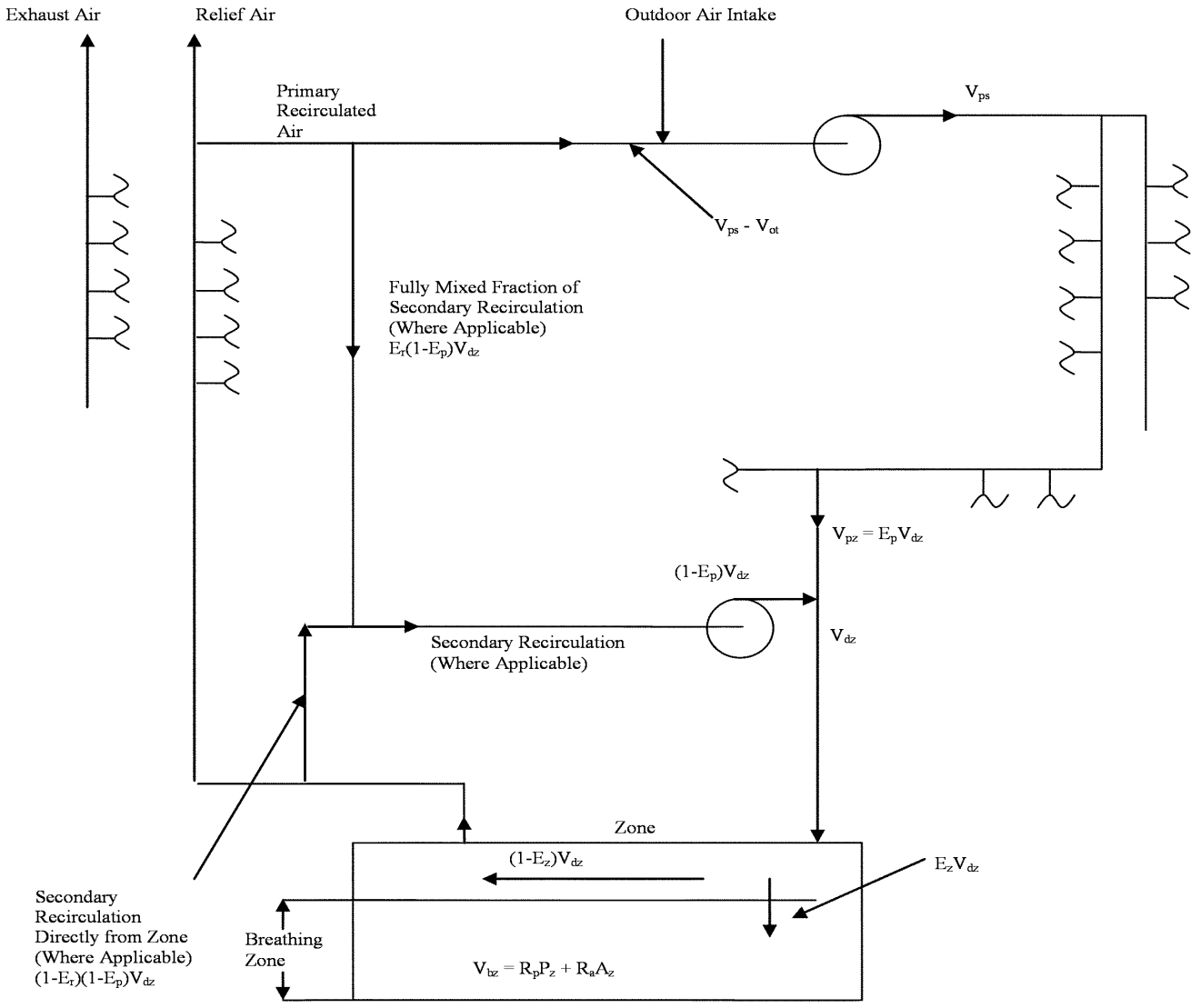


**Figure A.1 Ventilation system schematic.**

## Design Process

The *system ventilation efficiency* and, therefore, the outdoor air intake for the system ($V_{ot}$) are determined as part of the design process based on the design and minimum supply flows to individual zones as well as the 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.

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

## Selecting Zones for Calculation

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, calculation of $E_{vz}$ is required only for the *zone* with the minimum value of $E_{vz}$ at ventilation design conditions. It is not required for any zone that clearly has an $E_{vz}$ that is equal to or larger than that of the zone for which a calculation has been done. $E_{vz}$ for a zone will have a larger (or equal) value if all of the following are true relative to the 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 $E_{vz}$.

**Example:** In office buildings it is generally necessary to calculate $E_{vz}$ for one typical interior zone. If overhead supply air is used to heat the perimeter, it is also necessary to calculate for the perimeter zone with the lowest supply airflow rate per unit area. No other calculations for $E_{vz}$ are typically necessary, even if the building has 1000 zones, provided the ventilation for any conference rooms is separately calculated.

## Definitions

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

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

$E_p$ Primary air fraction to the *zone*: $E_p = V_{pz}/V_{dz}$ ($E_p = 1.0$ for single-duct and single-*zone* systems).

$E_r$ In systems with secondary recirculation of return air, 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), $E_r \le 1.0$. For ducted return systems with local secondary recirculation (e.g., fan-powered VAV with ducted return), typically $E_r = 0.0$.

$E_v$ **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. $E_v$ is determined from Table 6-3 or Equation A-3.

$E_{vz}$ **Zone Ventilation Efficiency:** the efficiency with which the system distributes air from the outdoor air intake to the breathing zone in a particular 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 zone air distribution uses its supply air to maintain acceptable air quality in the *breathing zone*. $E_z$ is determined from Table 6-2.

$F_a$ Fraction of supply air to the *zone* from sources outside the *zone*: $F_a = E_p + (1 - E_p) \cdot E_r$.

$F_b$ Fraction of supply air to the *zone* from fully mixed primary air: $F_b = E_p$ .

$F_c$ Fraction of outdoor air to the *zone* from sources 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 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 $P_z$ 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.

$R_a$ **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 $R_a$ for a zone is determined from Table 6-1.

$R_p$ **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 $R_p$ for a zone is determined from Table 6-1.

$V_{bz}$ **Breathing Zone Outdoor Airflow:** the outdoor airflow required in the breathing zone of an occupiable space, $V_{bz} = R_p \cdot P_z + R_a \cdot A_z$ .

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

$V_{ot}$ **Outdoor Air Intake Flow:** the design outdoor airflow required at the ventilation system outdoor air intake.

$V_{ou}$ **Uncorrected Outdoor Air Intake:** The outdoor air intake flow required if the system ventilation efficiency $E_v$ were 1.0. $V_{ou} = D \cdot \Sigma(R_p \cdot P_z) + \Sigma(R_a \cdot A_z)$ .

$V_{oz}$ **Zone Outdoor Airflow:** the design outdoor airflow required in the zone, i.e., $V_{oz} = V_{bz}/E_z$ .

$V_{ps}$ **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, $V_{ps} = \Sigma V_{pz}$, 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.

$X_s$ **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, $V_{dz}$ is the minimum expected discharge airflow for design purposes.

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**(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 B SUMMARY OF SELECTED AIR QUALITY GUIDELINES

If particular contaminants are of concern or if the IAQ Procedure is to be used, acceptable indoor concentrations and exposures are needed for the particular contaminants. When using this procedure, these concentration and exposure values need to be documented and justified by reference to a cognizant authority as defined in the standard. Such guidelines or other limiting values can also be useful for diagnostic purposes. At present, no single organization develops acceptable concentrations or exposures for all indoor air contaminants, nor are values available for all contaminants of potential concern. A number of organizations offer guideline values for selected indoor air contaminants. These values have been developed primarily for ambient air, occupational settings, and, in some cases, for residential settings. They should be applied with an understanding of their basis and applicability to the indoor environment of concern. If an acceptable concentration or exposure has not been published for a contaminant of concern, a value may be derived through review of the toxicological and epidemiological evidence using appropriate consultation. However, the evidence with respect to health effects is likely to be insufficient for many contaminants. At present, there is no quantitative definition of acceptable IAQ that can necessarily be met by measuring one or more contaminants.

Table B-1 presents selected standards and guidelines used in Canada, Germany, Europe, and the United States for acceptable concentrations of substances in ambient air, indoor air, and industrial workplace environments. These values are issued by cognizant authorities and have not been developed or endorsed by ASHRAE. The table is presented only as background information when using the IAQ Procedure. Specialized expertise should be sought before selecting a value for use in estimating outdoor airflow rates using the IAQ Procedure or for building design or diagnostics purposes. Meeting one, some, or all of the listed values does not ensure that acceptable IAQ (as defined in this standard) will be achieved.

Table B-2 lists concentration values of interest for selected contaminants as general guidance for building design, diagnostics, and ventilation system design using the IAQ Procedure. The values in the table are based on cognizant authorities and studies reported in peer-reviewed scientific publications; ASHRAE does not recommend their adoption as regulatory values, standards, or guidelines. The table is presented as further background when using the IAQ Procedure. Consultation should be sought before selecting a particular value for use in calculating ventilation using the IAQ Procedure. Meeting one, some, or all of the listed values does not ensure that acceptable IAQ will be achieved.

Selection of a specific target concentration and exposure is best made by a team with wide experience in toxicology, industrial hygiene, and exposure assessment. As they review the specific concentrations listed in Tables B-1 and B-2, or others taken from other sources, designers should be mindful of the following:

- Standards and guidelines are developed for different purposes and should be interpreted with reference to the setting and purpose for which they were developed compared to that to which they are being applied.
- Not all standards and guideline values recognize the presence of susceptible groups or address typical populations found in occupancies listed in this standard.
- Most standards and guidelines do not consider interactions between and among various contaminants of concern.
- The assumptions and conditions set forth by the standard or guideline may not be met in the space or for the occupants being considered (such as 8-hour day, 40-hour work week).

When many chemicals are present in the air, as they almost always are in indoor air, then some way of addressing potential interaction of these chemicals is warranted. For additive effects and exceptions, the reader is referred to ACGIH for guidance on the subject.[B-1]

### Guideline Values for Industrial Environments

ACGIH threshold limit values, or TLVs®, have been applied to industrial workplace air contaminants.[B-1] (Reference B-2 is the German counterpart.) The ACGIH TLVs® represent maximum acceptable 8-hour, time-weighted average (TWA), 15-minute short-term exposure limit (STEL) and instantaneous (ceiling) case limits. It is a source of concentration limits for many chemical substances and physical agents for industrial use. In light of the constantly changing state of knowledge, the document is updated annually. It cautions the user, "The values listed in this book are intended for use in the

practice of industrial hygiene as guidelines or recommendations to assist in the control of potential health hazards and for no other use."

Caution must be used in directly extending the ACGIH TLVs® or other workplace guidelines to spaces covered by this standard and to population groups other than workers. Industrial health practice attempts to limit worker exposure to injurious substances at levels that do not interfere with the industrial work process and do not risk the workers' health and safety. There is not an intention to eliminate all effects, such as unpleasant smells or mild irritation. Further, the health criteria are not uniformly derived for all contaminants. Irritation, narcosis, and nuisance or other forms of stress are not uniformly considered as the basis for the concentration limits. This is because different organizations use different end points and different contaminants have more or less information available on diverse end points of interest. The target population is also different from the occupants found in the spaces covered by this standard. Healthy industrial workers tend to change jobs or occupations if an exposure becomes intolerable. In contrast, workers in commercial environments such as offices often do not expect elevated concentrations of potentially harmful substances in their work environments. Also, monitoring programs are unlikely to be in place, as may be the case with industrial workplaces. In addition, the general population may have less choice about where they spend most of their time and includes those who may be more sensitive, such as children, asthmatics, allergic individuals, the sick, and the elderly.

### Guidelines for Substances in Outdoor Air

Guidelines have been developed for outdoor air for a number of chemicals and metals, as shown in many of the references. These values, including some for metals, may be appropriate for some indoor environments, but they should be applied only after appropriate consultation. These guidelines also provide guidance concerning the quality of outside air if there is suspicion that outdoor air may be contaminated with specific substances or if there is a known source of contamination nearby.[B-3]

### Regulation of Occupational Exposure to Airborne Contaminants

Regulations of occupational exposure to workplace hazards are based on the results of accumulated experience with worker health and toxicological research and carefully evaluated by groups of experts. Effects are examined in relation to exposure to the injurious substance. Exposure is defined as the mathematical product of the concentration of the contaminant and the time during which a person is exposed to this concentration. Since concentration may vary with time, exposure is typically calculated across the appropriate averaging time, expressed as a TWA concentration, STEL, or ceiling limit. Regulations of the U.S. Occupational Safety and Health Administration (OSHA) are TWAs in most cases.

Industrial exposures are regulated on the basis of a 40-hour workweek with 8- to 10-hour days. During the remainder of the time, exposure is anticipated to be substantially lower for the contaminants of concern. Application of industrial exposure limits would not necessarily be appropriate for other indoor settings, occupancies, and exposure scenarios. However, for certain contaminants that lack exposure limits for a specific nonindustrial target population, substantial downward adjustments to occupational limits have sometimes been used.

### Substances Lacking Guidelines and Standards

For indoor contaminants for which an acceptable concentration and exposure value has not been established by a cognizant authority, one approach has been to assume that some fraction of TLV® is applicable and would not lead to adverse health effects or complaints in general populations. This approach should not be used without first assessing its suitability for the contaminant of concern. In any event, if appropriate standards or guidelines do not exist, expertise must be sought or research needs to be conducted to determine contaminant concentrations and exposures that are acceptable.

### Subjective Evaluation

Indoor air often contains complex mixtures of contaminants of concern such as environmental tobacco smoke,[B-30,B-31] infectious and allergenic biological aerosols,[B-32] and emissions of chemicals from commercial and consumer products. Precise quantitative treatment of these contaminants can be difficult or impossible in most cases. Chemical composition alone may not always be adequate to reliably predict the reaction of building occupants exposed to most common mixtures of substances found in indoor air. There are many toxicological endpoints used in assessing the effects from exposure to air contaminants.

Irritation of mucosal tissue such as that found in the human nose, eyes, and the upper airways is one of the endpoints often used in assessing short-term exposure to air contaminants. These irritation responses can occur after the "irritant receptor" is exposed to nonreactive compounds, to reactive compounds with a different pattern of dose-response relationships, and through allergic and other immunologic effects for which dose-response relationships have not been well defined. Susceptible populations, i.e., individuals with atopy ("allergies") may report irritation at lower levels of exposures than individuals without allergies. Other susceptible populations, such as the elderly and the young, may differ from healthy adults in their response to irritating and odorous substances.

To some degree, adequacy of control may rest upon subjective evaluation. Panels of observers have been used to perform subjective evaluation of IAQ in buildings. Many contaminants have odors or are irritants that may be detected by human occupants or visitors to a space. Generally the air can be considered acceptably free of annoying contaminants if 80% of a panel consisting of a group of untrained subjects exposed to known concentrations of contaminants under representative controlled conditions of use and occupancy deems the air not to be objectionable.

When performing a subjective evaluation, an observer should enter the space in the manner of a normal visitor and

should render a judgment of acceptability within 15 seconds. Each observer should make the evaluation independently of other observers and without influence from a panel leader. Users of subjective evaluation methods are cautioned that they only test odor and sensory responses. Some harmful contaminants will not be detected by such tests. Carbon monoxide and radon are two examples of odorless contaminants that pose significant health risks. To evaluate the acceptability of adapted persons (occupants), an observer should spend at least six minutes in the space before rendering a judgment of acceptability.[B-29]

### Guide for Using TABLE B-1

The substances listed in Table B-1 are common air contaminants in industrial and nonindustrial environments. The values summarized in this table are from various sources with diverse procedures and criteria for establishing the values. Some are for industrial environments (OSHA, MAK, NIOSH, ACGIH), some are for outdoor environments (NAAQS), and others are general (WHO) or indoor residential environment-related (Canadian) values. The following explanations are intended to assist the reader by providing a brief description of the criteria each agency used in adopting its guideline values.

- NAAQS: Outdoor air standards developed by the U.S. EPA under the Clean Air Act. By law, the values listed in these regulations must be reviewed every five years. These concentrations are selected to protect not only the general population but also the most sensitive individuals.
- OSHA: Enforceable maximum exposures for industrial environments developed by OSHA (U.S. Department of Labor) through a formal rule-making process. Once an exposure limit has been set, levels can be changed only through reopening the rule-making process. These permissible exposure limits (PELs) are not selected to protect the most sensitive individuals.
- MAK: Recommended maximum exposures for industrial environments developed by the Deutsche Forschungs Gemeinschaft, a German institution similar to the U.S. National Institutes of Health and NIOSH. Levels are set on a regular basis, with annual reviews and periodic republication of criteria levels. These levels are enforceable in Germany and are not selected to protect the most sensitive individuals.
- Canadian: Recommended maximum exposures for residences developed in 1987 and reaffirmed in 1995 by a committee of provincial members convened by the federal government to establish consensus guideline-type levels. A revised version is being considered. These are not intended to be enforced.
- WHO/Europe: Environmental (nonindustrial) guidelines developed in 1987 and updated in 1999 by the WHO Office for Europe (Denmark). Intended for application both to indoor and outdoor exposure.
- NIOSH: Recommended maximum exposure guidelines for industrial environments are developed by NIOSH (Centers for Disease Control) and published in a series of criteria documents. NIOSH criteria documents contain both a review of the literature and a recommended exposure limit (REL) guideline. These are not enforceable, are not reviewed regularly, and are not selected to protect the most sensitive individuals. In some cases, they are set at levels above those deemed protective of health because commonly available industrial hygiene practice does not reliably detect the substances at lower levels. (Note that methods used in nonindustrial settings are often more sensitive than NIOSH methods for industrial hygiene measurements.)
- ACGIH: Recommended maximum exposures for industrial environments developed by ACGIH's Threshold Limit Values (TLVs®) Committee. The committee reviews the scientific literature and recommends exposure guidelines. The assumptions are for usual industrial working conditions, 40-hour weeks, and single exposures. Surveillance practices for both exposures and biological responses are often in place in the work environments where these levels are used. These levels are not selected to protect the most sensitive individuals. About half of the TLVs® are intended to protect against irritation. Published studies have shown that many of the TLVs® intended to protect against irritation actually represent levels where some or all of the study subjects did report irritation.[B-33, B-34]

The table is not inclusive of all contaminants in indoor air, and achieving the listed indoor concentrations for all of the listed substances does not ensure odor acceptability, avoidance of sensory irritation, or all adverse health effects for all occupants. In addition to indoor contaminant levels, the acceptability of indoor air also involves thermal conditions, indoor moisture levels as they impact microbial growth, and other indoor environmental factors. ASHRAE is not selecting or recommending default concentrations.

Users of this table should recognize that unlisted noxious contaminants can also cause unacceptable IAQ with regard to comfort (sensory irritation), odors, and health. When such contaminants are known or might reasonably be expected to be present, selection of an acceptable concentration and exposure may require reference to other guidelines or a review and evaluation of relevant toxicological and epidemiological literature.

## TABLE B-1 Comparison of Regulations and Guidelines Pertinent to Indoor Environments[a]

(The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

| | Enforceable and/or Regulatory Levels | | | Non-Enforced Guidelines and Reference Levels | | | |
|---|---|---|---|---|---|---|---|
| | **NAAQS/EPA (Ref. B-4)** | **OSHA (Ref. B-5)** | **MAK (Ref. B-2)** | **Canadian (Ref. B-8)** | **WHO/Europe (Ref. B-11)** | **NIOSH (Ref. B-13)** | **ACGIH (Ref. B-1)** |
| Carbon dioxide | | 5000 ppm | 5000 ppm<br>10,000 ppm [1 h] | 3500 ppm [L] | | 5000 ppm<br>30,000 ppm [15 min] | 5000 ppm<br>30,000 ppm [15 min] |
| Carbon monoxide[c] | 9 ppm [g]<br>35 ppm [1 h] [g] | 50 ppm | 30 ppm<br>60 ppm [30 min] | 11 ppm [8 h]<br>25 ppm [1 h] | 90 ppm [15 min]<br>50 ppm [30 min]<br>25 ppm [1 h]<br>10 ppm [8 h] | 35 ppm<br>200 ppm [C] | 25 ppm |
| Formaldehyde[h] | | 0.75 ppm<br>2 ppm [15 min] | 0.3 ppm<br>1 ppm[i] | 0.1 ppm [L]<br>0.05 ppm [L] [b] | 0.1 mg/m$^3$ (0.081 ppm) [30 min][p] | 0.016 ppm<br>0.1 ppm [15 min] | 0.3 ppm [C] |
| Lead | 1.5 µg/m$^3$ [3 months] | 0.05 mg/m$^3$ | 0.1 mg/m$^3$<br>1 mg/m$^3$ [30 min] | Minimize exposure | 0.5 µg/m$^3$ [1 yr] | 0.050 mg/m$^3$ | 0.05 mg/m$^3$ |
| Nitrogen dioxide | 0.05 ppm [1 yr] | 5 ppm [C] | 5 ppm<br>10 ppm [5 min] | 0.05 ppm<br>0.25 ppm [1 h] | 0.1 ppm[1 h]<br>0.02 ppm [1 yr] | 1 ppm [15 min] | 3 ppm<br>5 ppm [15 min] |
| Ozone | 0.12 ppm [1 h][g]<br>0.08 ppm | 0.1 ppm | j | 0.12 ppm [1 h] | 0.064 ppm<br>(120 µg/m$^3$) [8 h] | 0.1 ppm [C] | 0.05 ppm[k]<br>0.08 ppm[l]<br>0.1 ppm[m]<br>0.2 ppm[n] |
| Particles[e]<br><2.5 µm MMAD[d] | 15 µg/m$^3$[1 yr][o]<br>65 µg/m$^3$ [24 h][o] | 5 mg/m$^3$ | 1.5 mg/m$^3$ for <4 µm | 0.1 mg/m$^3$ [1 h]<br>0.040 mg/m$^3$ [L] | | | 3 mg/m$^3$ [C] |
| Particles[e]<br><10 µm MMAD[d] | 50 µg/m$^3$[1 yr][o]<br>150 µg/m$^3$ [24 h][o] | | 4 mg/m$^3$ | | | | 10 mg/m$^3$ [C] |
| Radon | | | | 800 Bq/m$^3$ [1 yr] | | | |
| Sulfur dioxide | 0.03 ppm [1 yr]<br>0.14 ppm [24 h] [g] | 5 ppm | 0.5 ppm<br>1 ppm [i] | 0.38 ppm [5 min]<br>0.019 ppm | 0.048 ppm [24 h]<br>0.012 ppm [1 yr] | 2 ppm<br>5 ppm [15 min] | 2 ppm<br>5 ppm [15 min] |
| Total Particles[e] | | 15 mg/m$^3$ | | | | | |

[a] Numbers in brackets [ ] refer to either a ceiling or to averaging times of less than or greater than eight hours (min = minutes; h = hours; y = year; C = ceiling, L = long-term). Where no time is specified, the averaging time is eight hours.

[b] Target level is 0.05 ppm because of its potential carcinogenic effects. Total aldehydes limited to 1 ppm. Although the epidemiological studies conducted to date provide little convincing evidence that formaldehyde is carcinogenic in human populations, because of this potential, indoor levels should be reduced as much as possible.

[c] As one example regarding the use of values in this table, readers should consider the applicability of carbon monoxide concentrations. The concentrations considered acceptable for nonindustrial, as opposed to industrial, exposure are substantially lower. These lower concentrations (in other words, the ambient air quality standards, which are required to consider populations at highest risk) are set to protect the most sensitive subpopulation, individuals with pre-existing heart conditions.

[d] MMAD = mass median aerodynamic diameter in microns (micrometers). Less than 3.0 µm is considered respirable; less than 10 µm is considered inhalable.

[e] Nuisance particles not otherwise classified (PNOC), not known to contain significant amounts of asbestos, lead, crystalline silica, known carcinogens, or other particles known to cause significant adverse health effects.

[f] See Table B-2 for the U.S. EPA guideline.

[g] Not to be exceeded more than once per year.

[h] The U.S. Department of Housing and Urban Development adopted regulations concerning formaldehyde emissions from plywood and particleboard intended to limit the airborne concentration of formaldehyde in manufactured homes to 0.4 ppm. (24 CFR Part 3280, HUD Manufactured Home Construction and Safety Standards).

[i] Never to be exceeded.

[j] Carcinogen, no maximum values established.

[k] TLV® for heavy work.

[l] TLV® for moderate work.

[m] TLV® for light work.

[n] TLV® for heavy, moderate, or light workloads (less than or equal to two hours).

[o] 62FR38652 - 38760, July 16, 1997.

[p] Epidemiological studies suggest a causal relationship between exposure to formaldehyde and nasopharyngeal cancer, although the conclusion is tempered by the small numbers of observed and expected cases. There are also epidemiological observations of an association between relatively high occupational exposures to formaldehyde and sinonasal cancer.

## Guide for Using TABLE B-2

The substances listed in Table B-2 are common air contaminants of concern in nonindustrial environments. The target concentrations that have been set or proposed by various national or international organizations concerned with health and comfort effects of outdoor and indoor air are listed for reference only. The table is not inclusive of all contaminants in indoor air, and achieving the target indoor concentrations for all of the listed substances does not ensure freedom from sensory irritation or from all adverse health effects for all occupants. In addition to indoor contaminant levels, the acceptability of indoor air also involves thermal conditions, indoor moisture levels as they impact microbial growth, and other indoor environmental factors. ASHRAE is not selecting or recommending default concentrations.

Health or comfort effects and exposure periods that are the basis for the guideline levels are listed in the "comments" column. For design, the goal should be to meet the guideline levels continuously during occupancy because people spend the great majority of their time indoors.

Users of this table should recognize that unlisted noxious contaminants can also cause unacceptable IAQ with regard to comfort (sensory irritation), odors, and health. When such contaminants are known or might reasonably be expected to be present, selection of an acceptable concentration and exposure may require reference to other guidelines or a review and evaluation of relevant toxicological and epidemiological literature. (Table B-2 summarizes some of this literature.)

## TABLE B-2 Concentration of Interest for Selected Contaminants

(Note: References numbers that are followed by [c] and [m] list the concentrations of interest [c] and measurement methods [m].)
(Note: The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

| Contaminant | Sources | Concentrations of Interest | Comments | References |
|---|---|---|---|---|
| Carbon Monoxide (CO) | Leaking vented combustion appliances<br>Unvented combustion appliances<br>Parking garages<br>Outdoor air | 9 ppm (8 h) | Based on effects on persons with coronary artery disease, average exposure for eight hours.<br>Sustained indoor concentrations exceeding outdoor concentrations may merit further investigation. Many carbon monoxide measuring instruments have limited accuracy at low levels.<br>Sources—burning of gasoline, natural gas, coal, oil, etc.<br>Health effects—reduces ability of blood to bring oxygen to body cells and tissues; cells and tissues need oxygen to work. Carbon monoxide may be particularly hazardous to people who have heart or circulatory problems and people who have damaged lungs or breathing passages. | B-4 [c]<br>B-9 [m] |
| Formaldehyde (HCHO) | Pressed-wood products<br>Furniture and furnishings | 0.1 mg/m$^3$ (0.081 ppm) (30 min) | Based on irritation of sensitive people, 30-minute exposure (WHO). | B-11 [c]<br>B-9, 26 [m] |
| | | 27 ppb (8 h) | Established as a never-to-exceed guideline to avoid irritant effects in sensitive individuals. Does not protect against formaldehyde's potential carcinogenicity (California Air Resources Board). | B-16 |
| | | 76 ppb (1 h)<br>27 ppb (8 h) | Based on the current acute one-hour reference exposure level (REL) of 76 ppb (94 μg/m$^3$), an exposure level of 27 ppb (33 μg/m$^3$) is derived for an 8-hour exposure period (Cal-EPA, OEHHA). | B-36, 41 |
| | | | Health effects—Acute and chronic inhalation exposure to formaldehyde in humans can result in eye, nose, and throat irritation, respiratory symptoms, exacerbation of asthma, and sensitization. Human studies have reported an association between formaldehyde exposure and lung and nasopharyngeal cancer. In 2004, the International Agency for Research on Cancer (IARC) concluded that "*formaldehyde is carcinogenic to humans (Group 1)*, on the basis of *sufficient evidence* in humans and *sufficient evidence* in experimental animals." | B-19, 20, 36, 42 |

**TABLE B-2 Concentration of Interest for Selected Contaminants *(continued)***

(Note: References numbers that are followed by [c] and [m] list the concentrations of interest [c] and measurement methods [m].)
(Note: The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

| Contaminant | Sources | Concentrations of Interest | Comments | References |
|---|---|---|---|---|
| Lead (Pb) | Paint dust<br>Outdoor air | 1.5 μg/m$^3$ | Based on adverse effects on neuropsychological functioning of children, average exposure for three months (WHO: 0.5-1 μg/m$^3$ for 1 year).<br>Sources—leaded gasoline (being phased out), paint (houses, cars), smelters (metal refineries), manufacture of lead storage batteries.<br>Health effects—brain and other nervous system damage; children are at special risk. Some lead-containing chemicals cause cancer in animals. Lead causes digestive and other health problems.<br>Environmental effects—Lead can harm wildlife. | B-4 [c]<br>B-4 [m]<br>B-18 |
| Nitrogen Dioxide ($NO_2$) | Leaking vented combustion appliances<br>Unvented combustion appliances<br>Outdoor air | 100 μg/m$^3$ | Based on providing protection against adverse respiratory effects, average exposure for one year.<br>Sources—burning of gasoline, natural gas, coal, oil, etc. Cars are an important source of $NO_2$ outdoors and cooking and water- and space-heating devices are important sources indoors.<br>Health effects—lung damage, illnesses of breathing passages and lungs (respiratory system).<br>Environmental effects—Nitrogen dioxide is a component of acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can reduce visibility.<br>Property damage—Acid aerosols can eat away stone used on buildings, statues, monuments, etc. | B-4 [c]<br>B-9 [m]<br>B-18 |
| | | 470 μg/m$^3$ | 24-hour average to prevent high exposures during use of combustion appliances such as space-heating devices and gas stoves. | B-43 |
| Odors | Occupants<br>VOC sources (including fungal sources such as mold)<br>Cooking, food processing, sewage, biowaste facilities, etc. | Predicted (or measured) acceptability to 80% or more of occupants or visitors | $CO_2$ concentration can be used as a surrogate for occupant odors (odorous bioeffluents). See Appendix C for a discussion of indoor $CO_2$ levels and ventilation rates. For sources other than people, source control is recommended. | B-12, 24, 29, 30 [c]<br>B-9 ($CO_2$), B-15 (odor) [m] |
| Ozone ($O_3$) | Electrostatic appliances<br>Office machines<br>Ozone generators<br>Outdoor air | 100 μg/m$^3$ (50 ppb) | Based on 25% increase in symptom exacerbations among adults or asthmatics (normal activity), eight-hour exposure (WHO); continuous exposure (FDA).<br>Ozone present at levels below the concentration of interest may contribute to the degradation of indoor air quality directly and by reacting with other contaminants in the indoor space.<br>Ground-level ozone is the principal component of smog.<br>Sources—outdoors, from chemical reaction of pollutants, VOCs, and $NO_x$; indoors, from photocopiers, laser printers, ozone generators, electrostatic precipitators, and some other air cleaners.<br>Health effects—breathing problems, reduced lung function, asthma, irritated eyes, stuffy nose, reduced resistance to colds and other infections. May speed up aging of lung tissue.<br>Environmental effects—Outdoors, ozone can damage plants and trees; smog can cause reduced visibility.<br>Property damage—Indoors and outdoors, ozone damages natural and synthetic rubbers, plastics, fabrics, etc. | B-6, 11 [c]<br>B-6 [m]<br>B-18 |
| Particles ($PM_{2.5}$) | Combustion products, cooking, candles, incense, resuspension, and outdoor air | 15 μg/m$^3$ | | B-4 |

## TABLE B-2 Concentration of Interest for Selected Contaminants *(continued)*

(Note: References numbers that are followed by [c] and [m] list the concentrations of interest [c] and measurement methods [m].)
(Note: The user of any value in this table should take into account the purpose for which it was adopted and the means by which it was developed.)

| Contaminant | Sources | Concentrations of Interest | Comments | References |
|---|---|---|---|---|
| Particles ($PM_{10}$) | Dust<br>Smoke<br>Deteriorating materials<br>Outdoor air | 50 μg/m$^3$ | Based on protecting against respiratory morbidity in the general population and avoiding exacerbation of asthma, average exposure for one year, no carcinogens. Indoor concentrations are normally lower; guideline level may lead to unacceptable deposition of "dust."<br>Sources—burning of wood, diesel, and other fuels; industrial plants; agriculture (plowing, burning off fields); unpaved roads.<br>Health effects—nose and throat irritation, lung damage, bronchitis, early death.<br>Environmental effects—Particulates are the main source of haze that reduces visibility.<br>Property damage—Ashes, soot, smoke, and dust can dirty and discolor structures and other property, including clothes and furniture. | B-4 [c]<br>B-4 [m]<br><br><br><br>B-18 |
| Radon (Rn) | Soil gas | 4 pCi/L[a] | Based on lung cancer, average exposure for one year. | B-7 [c,m]<br>B-10 [m] |
| Sulfur Dioxide ($SO_2$) | Unvented space heaters (kerosene)<br>Outdoor air | 80 μg/m$^3$ | Based on protecting against respiratory morbidity in the general population and avoiding exacerbation of asthma, average exposure for one year (WHO: 50 μg/m$^3$ if with PM).<br>Source—burning of coal and oil, especially high-sulfur coal from the eastern United States; industrial processes (paper, metals).<br>Health effects—breathing problems; may cause permanent damage to lungs.<br>Environmental effects—$SO_2$ is a component of acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can also reduce visibility.<br>Property damage—Acid aerosols can eat away stone used in buildings, statues, monuments, etc. | B-4 [c]<br>B-4 [m]<br>B-18 |
| Total Volatile Organic Compounds (TVOCs) | New building materials and furnishings<br>Consumable products<br>Maintenance materials<br>Outdoor air | Precise guidance on TVOC concentrations cannot be given | A variety of definitions of TVOC have been employed in the past. Reference B-27 contains a specific definition that reflects recent thinking on the subject.<br>There is insufficient evidence that TVOC measurements can be used to predict health or comfort effects. In addition, odor and irritation responses to organic compounds are highly variable. Furthermore, no single method currently in use measures all organic compounds that may be of interest. Therefore, some investigators have reported the total of all measured VOCs as the SumVOC in order to make explicit that the reported value does not represent the total of all VOCs present. Some of the references included here use this method for presenting VOC measurement results.<br>Setting target concentrations for TVOCs is not recommended. Setting target concentrations for specific VOCs of concern is preferred. | B-9 [m]<br>B-14, 26-28, 35, 38 |
| Volatile Organic Compounds (VOCs) | New building materials and furnishings<br>Consumable products<br>Maintenance materials<br>Outdoor air | Must be determined for each individual compound | Individual volatile organic compounds may be contaminants of concern in the application of the IAQ Procedure. Concentrations of concern range from less than 1 part per billion (ppb) for some very toxic compounds or for compounds having very low odor thresholds up to concentrations several orders of magnitude higher. Not all compounds can be identified, and toxicological data are incomplete for many compounds. | B-22-26, 28, 44, 45, 46 [c]<br>B-9, 10, 21 [m]<br>B-11, 15, 37, 39, 40 |

[a] The US EPA has promulgated a guideline value of 4 pCi/L indoor concentration. This is not a regulatory value but an action level where mitigation is recommended if the value is exceeded in long-term tests.

**Conversion Factors**[B-17]

Parts per million and mass per unit volume:

Measurements of indoor airborne concentrations of substances are generally converted to standard conditions of 77°F (25°C) and 29.92 in. Hg (101.325 kPa) pressure. Vapors or gases are often expressed in parts per million (ppm) by volume or in mass per unit volume. Concentrations in ppm by volume can be converted to mass per unit volume values as follows:

ppm × molecular weight/24,450 = mg/L
ppm × molecular weight/0.02445 = μg/m$^3$
ppm × molecular weight/24.45 = mg/m$^3$
ppm × molecular weight × 28.3/24,450 = mg/ft$^3$

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## INFORMATIVE APPENDIX C
## RATIONALE FOR MINIMUM PHYSIOLOGICAL REQUIREMENTS FOR RESPIRATION AIR BASED ON $CO_2$ CONCENTRATION

Oxygen is necessary for metabolism of food to sustain life. Carbon and hydrogen in foods are oxidized to $CO_2$ and $H_2O$, which are eliminated by the body as waste products. Foods can be classified as carbohydrates, fats, and proteins, and the ratio of carbon to hydrogen in each is somewhat different. The respiratory quotient (RQ) is the volumetric ratio of carbon dioxide produced to oxygen consumed. It varies from 0.71 for a diet of 100% fat to 0.8 for a diet of 100% protein and 1.00 for a diet of 100% carbohydrates (see Reference C-l). A value of RQ = 0.83 applies to a normal diet mix of fat, carbohydrate, and protein.

The rate at which oxygen is consumed and carbon dioxide is generated depends on physical activity. These relationships are shown in Figure C.2 (see Reference C-2). The breathing rate is shown also. A simple mass balance equation gives the outdoor airflow rate needed to maintain the steady-state $CO_2$ concentration below a given limit.

$$V_o = N/(C_s - C_o) \quad \text{(C-1)}$$

where

$V_o$ = outdoor airflow rate per person
$V_e$ = breathing rate
$N$ = $CO_2$ generation rate per person
$C_e$ = $CO_2$ concentration in exhaled breath
$C_s$ = $CO_2$ concentration in the space
$C_o$ = $CO_2$ concentration in outdoor air

For example, at an activity level of 1.2 met units (1.0 met = 18.4 Btu/h·ft$^2$), corresponding to sedentary persons, the $CO_2$ generation rate is 0.31 L/min. Laboratory and field studies have shown that with sedentary persons about 15 cfm (7.5 L/s) per person of outdoor air will dilute odors from human bioeffluents to levels that will satisfy a substantial majority (about 80%) of unadapted persons (visitors) to a space.[C-3,C-4,C-5,C-6,C-7] If the ventilation rate is to be held to 15 cfm (7.5 L/s) per person, the resulting steady-state $CO_2$ concentration relative to that in the outdoor air is

$$C_s - C_o = N/V_o$$
$$= 0.31/(7.5 \times 60 \text{ s/min})$$
$$= 0.000689 \text{ L of } CO_2 \text{ per L of air}$$
$$\approx 700 \text{ ppm}$$

Thus, maintaining a steady-state $CO_2$ concentration in a space no greater than about 700 ppm above outdoor air levels will indicate that a substantial majority of visitors entering a space will be satisfied with respect to human bioeffluents (body odor). A more detailed discussion of this relationship between $CO_2$ concentrations and the perception of bioeffluents, as well as the use of indoor $CO_2$ to estimate building ventilation rates, is contained in ASTM Standard D6245.[C-8]

$CO_2$ concentrations in acceptable outdoor air typically range from 300 to 500 ppm. High $CO_2$ concentrations in the outdoor air can be an indicator of combustion and/or other contaminant sources.

Figure C.3 shows the outdoor airflow rate required as a function of physical activity and steady-state room concentration. If the activity level is greater than 1.2 met, the required ventilation must be increased to maintain the same carbon dioxide level.

Also the decrease in oxygen content of the room air can be found from Equation C-l when oxygen concentration is substituted for carbon dioxide concentration.

$$C_o - C_s = N/V_o \quad \text{(C-2)}$$

The term $N$ now has a negative value with respect to its use in Equation C-1 since oxygen is consumed rather than generated.

$$C_s = C_o - N/V_o \quad \text{(C-3)}$$

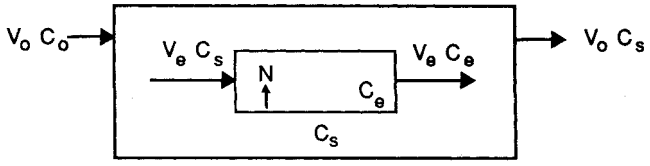


**Figure C.1 Two chamber model.**

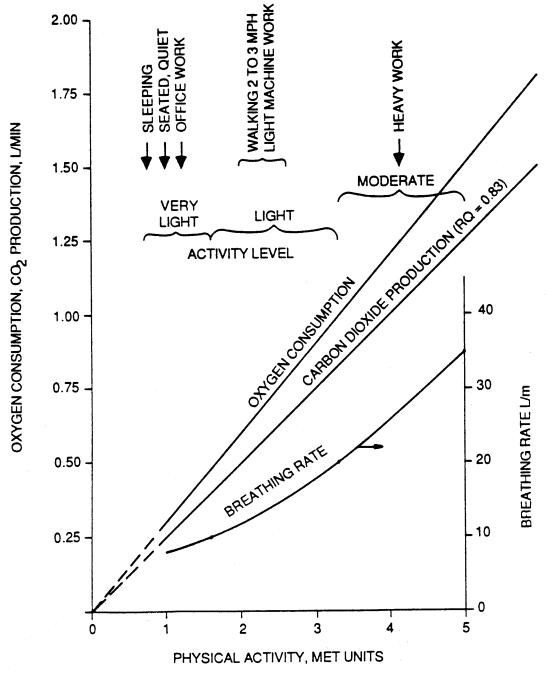


**Figure C.2 Metabolic data.**

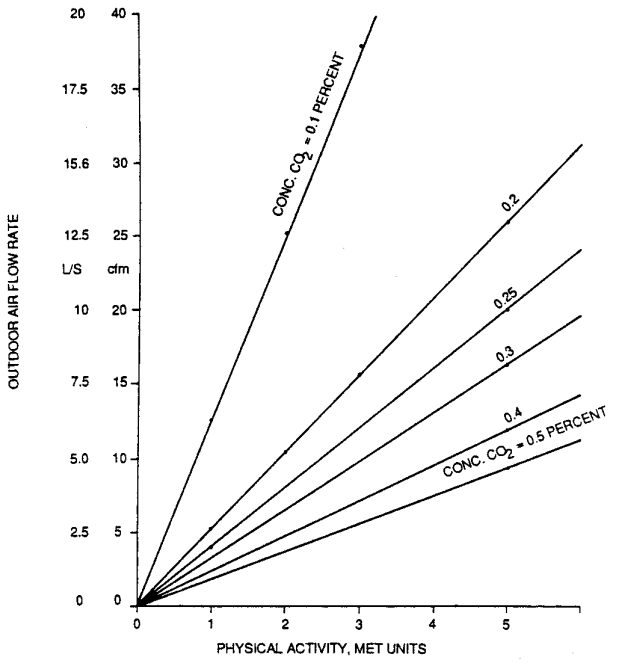


**Figure C.3 Ventilation requirements.**

The oxygen consumption rate is 0.36 L/min when the activity level is 1.2 met. For ventilation at a rate of 15 cfm (429 L/m) and an activity level of 1.2 met units, the room oxygen level will be reduced from an outdoor concentration to 20.9%. Thus, the oxygen content of the room is reduced from 21% to 20.9%, a change of only 0.5%. The carbon dioxide is raised from the background of 0.03% to 0.1%, a change of 230%. Thus, dilution of carbon dioxide is clearly more significant than replacing oxygen.

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## INFORMATIVE APPENDIX D
## ACCEPTABLE MASS BALANCE EQUATIONS FOR USE WITH THE IAQ PROCEDURE

When applying the IAQ Procedure from Section 6.3, mass balance analysis may be employed to determine outdoor air ventilation requirements to control indoor contaminant levels. The equations in Table D-1 are acceptable for performing such mass balance analysis in single-zone systems.

***Quantities***

$A, B$ = filter location
$V$ = volumetric flow
$C$ = contaminant concentration
$e$ = air change effectiveness
$E_f$ = filter efficiency
$F_r$ = flow reduction factor
$N$ = contaminant generation rate
$R$ = recirculation flow factor

***Subscripts***

$o$ = outdoor
$r$ = return
$s$ = space

Figure D.l shows a representative system. A filter may be located in the recirculated airstream (location A) or in the supply (mixed) airstream (location B).

Variable-air-volume (VAV) systems reduce the circulation rate when the thermal load is satisfied. This is accounted for by a flow reduction factor $F_r$.

A mass balance for the contaminant may be written to determine the required outdoor airflow or the space contaminant concentration for each of the system arrangements. The various permutations for the air-handling and distribution systems are described in Table D-l. There are eight variations. The mass balance equations for computing the required outdoor airflow and the space contaminant concentration at steady-state conditions for each system are presented in Table D-l.

If the allowable space contamination is specified, the equations in Table D-l may be solved for the outdoor flow rate $V_o$. When the outdoor airflow rate is specified, the equations may be solved for the resulting contaminant concentration as shown in Table D-l.

While the calculation methods in this appendix are based on single-zone systems and steady-state analysis, calculation methods exist that account for multizone and transient effects.[D-1]

## REFERENCE


D-1 Dols, W.S., and G.N. Walton. 2002. CONTAMW 2.0 User Manual. National Institute of Standards and Technology, NISTIR 6921.


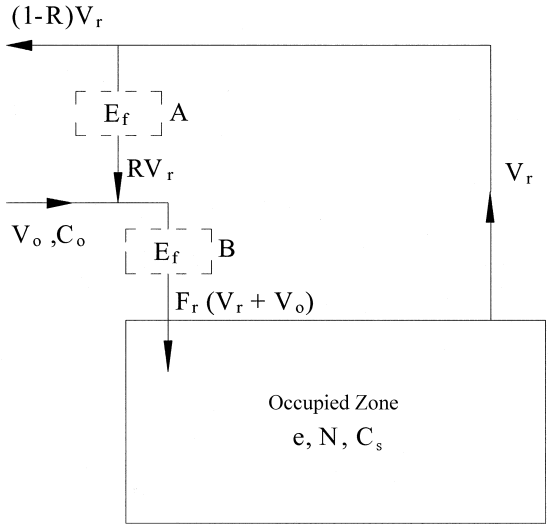


**Figure D.1 Ventilation system schematic.**

**TABLE D-1 Required Outdoor Air or Space Contaminant Concentration with Recirculation and Filtration**

| Filter Location | Required Recirculation Rate: Flow | Required Recirculation Rate: Outdoor Airflow | Required Outdoor Airflow | Space Contaminant Concentration |
|---|---|---|---|---|
| None | VAV | 100% | $V_o = \frac{N}{E_v F_r (C_s - C_o)}$ | $C_s = C_o + \frac{N}{E_v F_r V_o}$ |
| A | Constant | Constant | $V_o = \frac{N - E_v R V_r E_f C_s}{E_v (C_s - C_o)}$ | $C_s = \frac{N + E_v V_o C_o}{E_v (V_o + R V_r E_f)}$ |
| A | VAV | Constant | $V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v (C_s - C_o)}$ | $C_s = \frac{N + E_v V_o C_o}{E_v (V_o + F_r R V_r E_f)}$ |
| A | VAV | Proportional* | $V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v F_r (C_s - C_o)}$ | $C_s = \frac{N + E_v F_r V_o C_o}{F_r E_v (V_o + R V_r E_f)}$ |
| B | Constant | Constant | $V_o = \frac{N - E_v R V_r E_f C_s}{E_v [C_s - (1 - E_f) C_o]}$ | $C_s = \frac{N + E_v V_o (1 - E_f) C_o}{E_v (V_o + R V_r E_f)}$ |
| B | VAV | 100% | $V_o = \frac{N}{e F_r [C_s - (1 - E_f) C_o]}$ | $C_s = \frac{N + e F_r V_o (1 - E_f) C_o}{e F_r V_o}$ |
| B | VAV | Constant | $V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v [C_s - (1 - E_f) C_o]}$ | $C_s = \frac{N + E_v V_o (1 - E_f) C_o}{E_v (V_o + F_r R V_r E_f)}$ |
| B | VAV | Proportional | $V_o = \frac{N - E_v F_r R V_r E_f C_s}{E_v F_r [C_s - (1 - E_f)(C_o)]}$ | $C_s = \frac{N + E_v F_r V_o (1 - E_f) C_o}{E_v F_r (V_o + R V_r E_f)}$ |

* Proportional indicates that the outdoor airflow varies with the supply airflow, such that the outdoor airflow is equal to the design value times the flow reduction factor $F_r$.

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

## NORMATIVE APPENDIX E
## VENTILATION RATES FOR HEALTH CARE FACILITIES

**TABLE E-1 Outdoor Air Requirements for Ventilation of Health Care Facilities (Hospitals, Nursing and Convalescent Homes)***

| Application | Estimated Maximum** Occupancy P/1000 ft² or 100 m² | Outdoor Air Requirements: cfm/person | Outdoor Air Requirements: L/s · person | Outdoor Air Requirements: cfm/ft² | Outdoor Air Requirements: L/s · m² | Comments |
|---|---|---|---|---|---|---|
| Patient rooms | 10 | 25 | 13 | | | Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency. Procedures generating contaminants may require higher rates. |
| Medical procedure | 20 | 15 | 8 | | | |
| Operating rooms | 20 | 30 | 15 | | | |
| Recovery and ICU | 20 | 15 | 8 | | | |
| Autopsy rooms | 20 | | | 0.50 | 2.50 | Air shall not be recirculated into other spaces. |
| Physical therapy | 20 | 15 | 8 | | | |

* Table E-1 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to dilute human bioeffluents and other contaminants with an adequate margin of safety and to account for health variations among people and varied activity levels.
** Net occupiable space.

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## INFORMATIVE APPENDIX F
## SEPARATION OF EXHAUST OUTLETS AND OUTDOOR AIR INTAKES

### F1. GENERAL

Exhaust air and vent outlets as defined in Table 5-1 shall be located no closer to outdoor air intakes, and operable windows, skylights, and doors, both those on the subject property and those on adjacent properties, than the minimum separation distance *L* specified in this section. The distance *L* is defined as the shortest "stretched string" distance measured from the closest point of the outlet opening to the closest point of the outdoor air intake opening or operable window, skylight, or door opening, along a trajectory as if a string were stretched between them.

### F2. APPLICATION

Exhaust outlets and outdoor air intakes or other openings shall be separated in accordance with the following.

**Exception:** Laboratory fume hood exhaust air outlets shall be in compliance with NFPA 45-1991 and ANSI/AIHA Z9.5-1992.

**F2.1 Outdoor Air Intakes.** Minimum separation distance between exhaust air/vent outlets as defined in Table 5-1 and outdoor air intakes to mechanical ventilation systems or operable windows, skylights, and doors that are required as part of natural ventilation systems shall be equal to distance *L* determined in accordance with Section F3.

**Exception:** Separation distances do not apply when exhaust and outdoor air intake systems do not operate simultaneously.

**F2.2 Other Building Openings.** Minimum separation distance between building exhaust air/vent outlets as defined in Table 5-1 and operable openings to occupiable spaces shall be half of the distance *L* determined in accordance with Section F3. Minimum separation distance between high odor intensity or noxious or dangerous exhaust air/vent outlets and operable openings to occupiable spaces shall be equal to the distance *L* determined in accordance with Section F3.

**F2.3 Additional Limitations for Noxious or Dangerous Air.** Minimum separation distance between exhausts located less than 65 ft (20 m) vertically below outdoor air intakes or operable windows and doors shall be equal to a horizontal separation only as determined in accordance with Section F3; no credit may be taken for any vertical separation.

**F2.4 Equipment Wells.** Exhaust air outlets that terminate in an equipment well that also encloses an outdoor air intake shall meet the separation requirements of this section and, in addition, shall either

a. terminate at or above the highest enclosing wall and discharge air upward at a velocity exceeding 1000 fpm (5 m/s) or
b. terminate 3 ft (1 m) above the highest enclosing wall (with no minimum velocity).

**Exception:** Low contaminant or intensity air.

For the purpose of this section, an equipment well is an area (typically on the roof) enclosed on three or four sides by walls that are less than 75% free area, and the lesser of the length and width of the enclosure is less than three times the average height of the walls. The free area of the wall is the ratio of area of the openings through the wall, such as openings between louver blades and undercuts, divided by the gross area (length times height) of the wall.

**F2.5 Property Lines.** Minimum separation distance between exhaust air/vent outlets and property lines shall be half of the distance *L* determined in accordance with Section F3. For significant contaminant or odor intensity exhaust air, where the property line abuts a street or other public way, no minimum separation is required if exhaust termination is 10 ft (3 m) above grade.

### F3. DETERMINING DISTANCE *L*

Separation distance *L* shall be determined using any of the following approaches:

a. Use the values of *L* in Table F-1.
b. Calculate *L* in accordance with Equation F-1 (a or b).
c. Determine *L* using any calculation or test procedure approved by the authority having jurisdiction that shows that the proposed design will result in equivalent or greater dilution factors than those specified in Table F-2.

$$L = 0.09 \cdot \sqrt{Q} \cdot (\sqrt{DF} - U/400) \text{ in feet (I-P)} \qquad \text{(F-1a)}$$

$$L = 0.04 \cdot \sqrt{Q} \cdot (\sqrt{DF} - U/2) \text{ in meters (SI)} \qquad \text{(F-1b)}$$

where

$Q$ = exhaust air volume, cfm (L/s). For gravity vents, such as plumbing vents, use an exhaust rate of 150 cfm (75 L/s). For flue vents from fuel-burning appliances, assume a value of 250 cfm per million Btu/h (0.43 L/s per Kw) of combustion input (or obtain actual rates from the combustion appliance manufacturer.

$DF$ = dilution factor, which is the ratio of outside air to entrained exhaust air in the outside air intake. The minimum dilution factor shall be determined as a function of exhaust air class in Table F-2.

For exhaust air composed of more than one class of air, the dilution factor shall be determined by averaging the dilution factors by the volume fraction of each class:

$$DF = \frac{\sum(DF_i \cdot Q_i)}{\sum Q_i}$$

where

$DF_i$ = dilution factor from Table F-2 for class $i$ air and $Q_i$ is the volumetric flow rate of class $i$ air in the exhaust airstream.

$U$ = exhaust air discharge velocity, fpm (m/s). As shown in Figure F.1, $U$ shall have a positive value when the exhaust is directed away from the outside air intake at an angle that is greater than 45° from the direction of a line drawn from the closest exhaust point the edge of the intake; $U$ shall have a negative value when the exhaust is directed toward the intake bounded by lines drawn from the closest exhaust point the edge of the intake; and $U$ shall be set to zero for other exhaust air directions regardless of actual velocity. $U$ shall be set to 0 in Equation F-1 for vents from gravity (atmospheric) fuel-fired appliances, plumbing vents, and other nonpowered exhausts, or if the exhaust discharge is covered by a cap or other device that dissipates the exhaust airstream. For hot gas exhausts such as combustion products, an effective additional 500 fpm (2.5 m/s) upward velocity shall be added to the actual discharge velocity if the exhaust stream is aimed directly upward and unimpeded by devices such as flue caps or louvers.

**TABLE F-1 Minimum Separation Distance, *L*, in ft (m)**

| Significant Contaminant or Odor Intensity | Noxious or Dangerous Particles |
|---|---|
| 15 (5) | 30 (10) |

**TABLE F-2 Minimum Dilution Factors**

| Exhaust Air Class | Dilution Factor, *DF* |
|---|---|
| Significant contaminant or odor intensity | 15 |
| Noxious or dangerous particles | 50* |

*Does not apply to fume hood exhaust. See Section F2.

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## INFORMATIVE APPENDIX G APPLICATION AND COMPLIANCE

This appendix contains application and compliance suggestions that are intended to assist users and enforcement agencies in applying this standard.

For the most part, ANSI/ASHRAE Standard 62.1-2007 is specifically written for new buildings because some of its requirements assume that other requirements within the standard have been met. In the case of existing buildings, retroactive application and compliance with all the requirements of this standard may not be practical. However, the principles established in this standard may be applied to most existing commercial and institutional buildings. Some existing buildings may achieve acceptable IAQ despite not meeting the requirements of Standard 62.1-2007 due to, for example, good maintenance and capital improvement procedures, building materials that, by virtue of their age, have very low contaminant emission rates, and many other factors.

### G1. APPLICATION

**G1.1 New Buildings.** All sections and normative appendices should apply to new buildings falling within the scope of this standard.

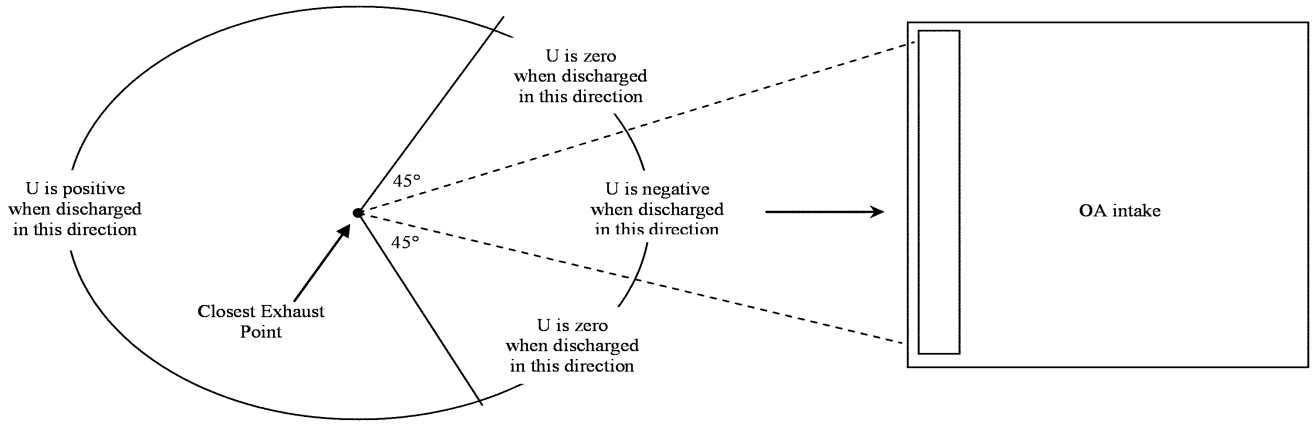


**Figure F.1 Exhaust air discharge velocity (U).**

**G1.2 Existing Buildings.** The standard should be applied to existing buildings at least in the following circumstances:

1. *Additions to Existing Buildings.* All additions to existing buildings should meet the requirements of this standard as if the addition were a new building. An exception may be made when an existing ventilation system is extended to serve the addition. In this case, the existing system components, such as fans and cooling and heating equipment, need not meet the requirements of this standard. However, the extended existing system should remain in compliance with ventilation codes and standards that were in effect at the time it was permitted for construction.

2. *Repairs.* Repairing (making operational) existing equipment or other building components does not require the building or any of its components to retroactively comply with this standard.

3. *Replacement.* Any component of a building that is removed and replaced should meet the applicable requirements of Section 5, Systems and Equipment, of this standard for that component. An exception may be made in cases when replacing a component of like size and kind, provided all requirements of codes and standards used at the time of original system design and installation are met. For example, replacement of an air-conditioning unit with one of similar capacity would not require retroactive compliance with ventilation rates and other requirements of this standard. Unaltered components do not need to be retroactively brought into compliance except when there are substantial alterations (as defined below).

4. *Substantial Alterations.* If a building is substantially altered, the requirements of this standard should be met as if the building were new. A building would be considered substantially altered if the cost of the revisions exceeds 50% of the building's fair market value, excluding the cost of compliance with this standard.

5. *Change in Use.* If the space application category as listed in Table 6-1 changes, such as from office to retail, the minimum ventilation rates required by Section 6, "Procedures," should be met for that space.

## G2. COMPLIANCE

Demonstrating that acceptable IAQ has been achieved, such as by measuring contaminant concentrations or surveying occupants, would not be required by this standard except where required by the IAQ Procedure.

***The following section is a suggested model code language.***

## *APPLICATION AND COMPLIANCE*

### *Application*

***New Buildings.*** *All sections and normative appendices apply to new buildings falling within the scope of this standard.*

### *Existing Buildings*

***Additions to Existing Buildings.*** *All additions to existing buildings within the scope of this standard shall meet the requirements of all sections and normative appendices.*

***Exception:*** *When an existing ventilation system is extended to serve an addition, the existing system components, such as fans and cooling and heating equipment, need not meet the requirements of this standard. However, the extended existing system must remain in compliance with ventilation codes and standards that were in effect at the time it was permitted for construction.*

***Repairs.*** *Repairing (making operational) existing equipment or other building components shall be allowed without requiring the building or any of its components to comply with this standard.*

***Replacement.*** *Any component of a building that is removed and replaced shall meet the applicable requirements of Section 5, "Systems and Equipment," of this standard for that component. Unaltered components are not required to be brought into compliance except as required due to a change in use.*

***Exception:*** *Replacement of a building component or individual piece of equipment with a component of like size and kind, provided that all requirements of codes effective at the time of original system design and installation are met. For example, replacement of an air-conditioning unit with one of similar capacity would not require that the ventilation rate requirements and other requirements of this standard be met.*

***Substantial Alterations.*** *If a building is substantially altered, all sections and normative appendices of this standard shall be met as if the building were new. A building shall be considered substantially altered if the cost of the revisions exceeds 50% of the building's fair market value, excluding the cost of compliance with all sections and normative appendices of this standard.*

***Change in Use.*** *If the space application category as listed in Table 2 changes, such as from office to retail, the minimum ventilation rates required by Section 6, "Procedures," shall be met for that space.*

### *Compliance*

*Demonstrating that acceptable IAQ has been achieved, such as by measuring contaminant concentrations or surveying occupants, is not required by this standard except where required by the IAQ Procedure.*

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## INFORMATIVE APPENDIX H
## DOCUMENTATION

This appendix summarizes the requirements for documentation contained in the body of the standard using a series of templates that summarizes the design criteria used and assumptions made to comply with this standard. One way to comply with the documentation requirements of the standard is to complete these templates as appropriate during the project design process.

### Outdoor Air Quality

Section 4.3 of this standard requires an investigation of the outdoor air quality in the vicinity of the project site. This template offers a means of documenting the results of both the regional and local investigations and the conclusions reached concerning the acceptability of the outdoor air quality for indoor ventilation.

**TABLE H-1**

| **Regional Outdoor Air Quality Pollutants** | **Attainment or Nonattainment According to the U.S. Environmental Protection Agency** |
|---|---|
| Particulates (PM 2.5) | (Yes/No) |
| Particulates (PM 10) | (Yes/No) |
| Carbon monoxide—1 hour/8 hours | (Yes/No) |
| Ozone | (Yes/No) |
| Nitrogen dioxide | (Yes/No) |
| Lead | (Yes/No) |
| Sulfur Dioxide | (Yes/No) |
| **Local Outdoor Air Quality Survey** | **Date: Time:** |
| a) Area surveyed | (Brief description of the site) |
| b) Nearby facilities | (Brief description type of facilities—industrial, commercial, hospitality, etc.) |
| c) Odors or irritants | (List and describe) |
| d) Visible plumes | (List and describe) |
| e) Nearby sources of vehicle exhaust | (List and describe) |
| f) Prevailing winds | (Direction) |
| g) Other observations | |
| Conclusions | (Remarks concerning the acceptability of the outdoor air quality) |

### Building Ventilation Design Criteria

This template provides a means of documenting significant design criteria for the overall building. Only the last column, in accordance with Section 5.2.3, is specifically required by the standard. The other columns are motivated by the general documentation requirement described in Section 6.4.

**TABLE H-2**

| Building Ventilation Design Criteria | | | | | | |
|---|---|---|---|---|---|---|
| **Total Building Outdoor Air Intake** | **Total Building Exhaust Air (see Section 5.10.2)** | **Outdoor Air Cleaning Required (See Section 6.2.1)** | | **Occupied Space Relative Humidity (Choose One Criterion per Section 5.10.1)** | | **Air Balancing (See Section 5.2.3)** |
| | | **Particulate Matter** | **Ozone** | **Peak Outdoor DP at Peak Indoor Latent Load** | **Lowest Space SHR at Concurrent Outdoor Condition** | |
| (cfm) | (cfm) | (Yes/No) | (Yes/No) | (% RH based on equipment selection) | (% RH based on equipment selection) | (NEBB, AABC, etc.) |

### Ventilation Rate Procedure

Section 6.2 permits the use of this prescription-based procedure to design ventilation systems. This template documents the assumptions made when using this procedure as required by Sections 5.17.4 and 6.4.

**TABLE H-3**

| Space Identification | Space Type | Occupant Density | Rate/Person | Rate/SF | Zone Air Distribution Effectiveness | System Ventilation Efficiency | Class of Air |
|---|---|---|---|---|---|---|---|
| (List number or name of each ventilation zone, such as office number or name, retail space name, classroom number) | (List occupancy category of the space from Table 6-1 such as office space, retail sales, classroom age 5–8, etc.) | (People/ $ft^2$ or $m^2$) | (cfm or L/s) | (cfm or L/s) | (Table 6-2) | (Table 6-3 or Appendix A) | (Tables 5-2 or 6-1; include justification for classification if not in these tables) |

## IAQ Procedure

Section 6.3 permits the use of this performance-based procedure to design ventilation systems. This template documents the design criteria and assumptions made when using this procedure and justification of the design approach, as required by Section 6.3.2.

**TABLE H-4**

| IAQ Procedure Assumptions | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | Contaminant Target Concentration | | | | |
| **Contaminant of Concern** | **Contaminant Source** | **Contaminant Strength** | **Limit** | **Exposure Period** | **Cognizant Authority Reference** | **Perceived IAQ** | **Design Approach** |
| (Identify and list) | (Identify and list) | (Determine and list) | (List) | (List) | (List) | (Percentage of satisfied building occupants) | (Select from Section 6.3.1.4 and include justification) |

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## INFORMATIVE APPENDIX I
## ADDENDA DESCRIPTION INFORMATION

ANSI/ASHRAE Standard 62.1-2007 incorporates ANSI/ASHRAE Standard 62.1-2004 and Addenda a, b, c, d, e, f, g, and h to ANSI/ASHRAE Standard 62.1-2004. Table I-1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE and ANSI approval dates for each addendum.

**TABLE I-1 Addenda to ANSI/ASHRAE Standard 62.1-2004***

| Addendum | Section(s) Affected | Description of Changes* | Approval Dates: • Standards Committee • ASHRAE BOD • ANSI |
|---|---|---|---|
| a | Section 5.10, Dehumidification Systems | Clarifies dehumidification analysis requirements. Also offers exceptions to the 65% RH limit and to the net positive intake airflow requirement. | January 21, 2006<br>January 26, 2006<br>April 10, 2006 |
| b | Table 5-2, Other Spaces; Table 6-1, Minimum Ventilation Rates in Breathing Zone; Table 6-4, Minimum Exhaust Rates; Sections 5.17.1, Classification, and 5.17.4, Documentation | Corrects inconsistencies in Tables 5-2, 6-1, and 6-4 and provides additional information for several occupancy categories. | January 21, 2006<br>January 26, 2006<br>April 10, 2006 |
| c | Informative Appendix B, Summary of Selected Air Quality Guidelines | Updates information in Informative Appendix B. | January 21, 2006<br>January 26, 2006<br>April 10, 2006 |
| d | Table 4-1, National Primary Ambient Air Quality Standards for Outdoor Air as Set by the U.S. Environmental Protection Agency | Updates information in Table 4-1 to be consistent with current US EPA NAAQS, adding PM 2.5 as a criteria pollutant. | January 21, 2006<br>January 26, 2006<br>April 10, 2006 |
| e | Informative Appendix H, Documentation | New informative appendix summarizes the documentation requirements in the body of the standard, thus providing a single point of reference for users. | June 24, 2006<br>June 29, 2006<br>March 3, 2007 |
| f | Sections 1, Purpose, and 2, Scope | Updates the purpose and scope of the standard to make them more consistent with changes that have already been incorporated into the body of the standard (removal of smoking rates, new/existing buildings distinctions, O&M and construction sections, and others). | June 24, 2006<br>June 29, 2006<br>July 27, 2006 |
| g | New Section 5.18, Requirements for Buildings Containing ETS Areas and ETS-Free Areas | Briefly, requires space classification based on expected presence of ETS, separation of ETS and ETS-free areas, and cautionary signage for ETS areas. | June 25, 2005<br>June 30, 2005<br>January 20, 2006 |
| h | Tables 6-1, Minimum Ventilation Rates in Breathing Zone, 6-4, Minimum Exhaust Rates, E-2, Outdoor Air Requirements for Ventilation of Residential Facilities (Private Dwellings, Single, Multiple), and E-3, Outdoor Air Requirements for Ventilation of Vehicles | Adds requirements for residential spaces into the ventilation rate table (Table 6-1) in the body of the standard. Also deletes Tables E-2 and E-3 from Normative Appendix E, which provided ventilation requirements for residences and vehicles. | January 27, 2007<br>March 2, 2007<br>March 3, 2007 |

* These descriptions may not be complete and are provided for information only.

**NOTE**

**When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.**

# NOTICE

## INSTRUCTIONS FOR SUBMITTING A PROPOSED CHANGE TO THIS STANDARD UNDER CONTINUOUS MAINTENANCE

This standard is maintained under continuous maintenance procedures 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. SSPC consideration will be given to proposed changes at the Annual Meeting (normally June) if proposed changes are received by the Manager of Standards (MOS) no later than December 31. Proposals received after December 31 shall be considered by the SSPC no later than at the Annual Meeting of the following year.

Proposed changes must be submitted to the MOS in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format if the MOS concludes that the differences are immaterial to the proposed change submittal. If the MOS concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

## ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either a recent version of Microsoft Word (preferred) or another commonly used word-processing program. Please save each change proposal file with a different name (for example, “prop01.doc,” “prop02.doc,” etc.). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as word-processed or scanned documents.

ASHRAE will accept the following as equivalent to the signature required on the change submittal form to convey non-exclusive copyright:

| | |
|---|---|
| Files attached to an e-mail: | Electronic signature on change submittal form (as a picture; *.tif, or *.wpg). |
| Files on a CD: | Electronic signature on change submittal form (as a picture; *.tif, or *.wpg) or a letter with submitter’s signature accompanying the CD or sent by facsimile (single letter may cover all of proponent’s proposed changes). |

Submit an e-mail or a CD containing the change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or fax to 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE’s Home Page, www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
Phone: 404-636-8400. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

# FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

**NOTE:** Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), submitted on a CD, or submitted in paper by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

**1. Submitter:**

Affiliation:

Address: City: State: Zip: Country:

Telephone: Fax: E-Mail:

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter's signature: _____ Date: _____

***All electronic submittals must have the following statement completed:***

I *(insert name)* _____, through this electronic signature, hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

**2. Number and year of standard:**

**3. Page number and clause (section), subclause, or paragraph number:**

**4. I propose to:** *(check one)*

[ ] Change to read as follows
[ ] Add new text as follows
[ ] Delete and substitute as follows
[ ] Delete without substitution

Use underscores to show material to be added (<u>added</u>) and strike through material to be deleted (~~deleted~~). Use additional pages if needed.

**5. Proposed change:**

**6. Reason and substantiation:**

**7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified.**

[ ] Check if additional pages are attached. Number of additional pages: _____

[ ] Check if attachments or referenced materials cited in this proposal accompany this proposed change. Please verify that all attachments and references are relevant, current, and clearly labeled to avoid processing and review delays. *Please list your attachments here:*

## 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.