

## 1. PURPOSE

1.1 The purpose of this standard is to specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for 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 indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard. Release of moisture in residential kitchens and bathrooms, locker rooms, and swimming pools is included in the scope of this standard.

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

2.3 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.

2.4 This standard considers chemical, physical, and biological contaminants that can affect air quality. Thermal comfort requirements are not included in this standard.

2.5 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.

**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.

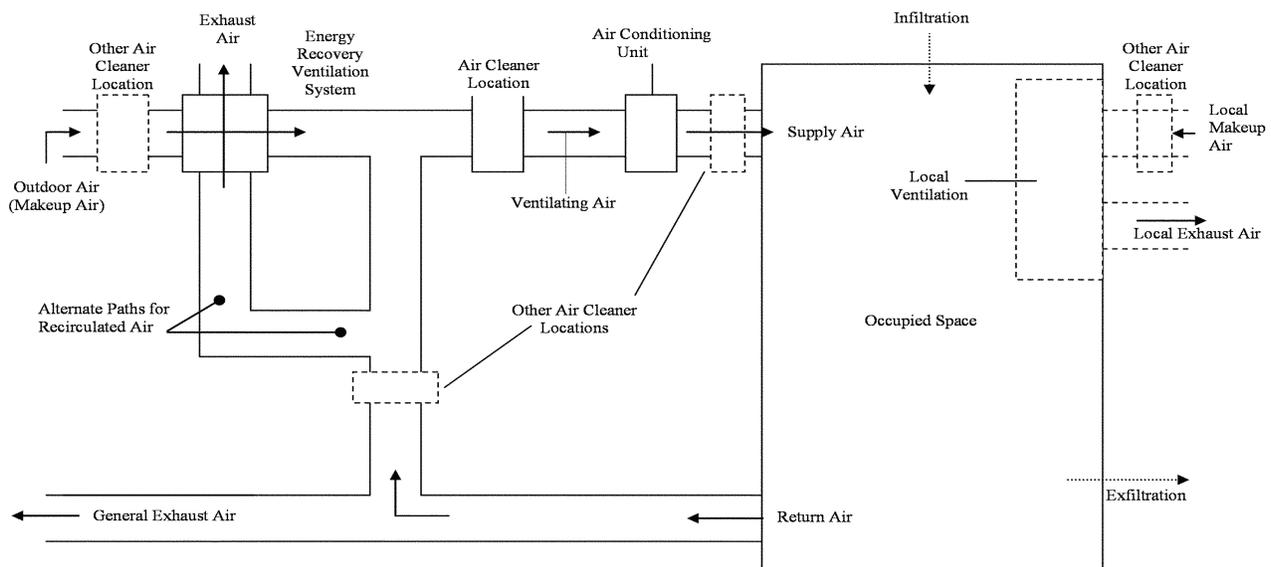


Figure 3.1 Ventilation system.

**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.

**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)<sup>1</sup> 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](http://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 to 5.1:** An engineered natural ventilation system when approved by the authority having jurisdiction need not meet the requirements of 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<sup>2</sup> (2.3 m<sup>2</sup>).

**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		ppm	Concentration Averaging		ppm
	μg/m <sup>3</sup>	ppm		μg/m <sup>3</sup>	ppm	
Sulfur dioxide	80	0.03	1 year	365 <sup>a</sup>	0.14 <sup>a</sup>	24 hours
Particles (PM 10)	50 <sup>b</sup>	—	1 year	150 <sup>a</sup>	—	24 hours
Carbon monoxide				40,000 <sup>a</sup>	35 <sup>a</sup>	1 hour
Carbon monoxide				10,000 <sup>a</sup>	9 <sup>a</sup>	8 hours
Oxidants (ozone)				235 <sup>c</sup>	0.12 <sup>c</sup>	1 hour
Nitrogen dioxide	100	0.055	1 year			
Lead	1.5	—	3 months <sup>d</sup>			

a Not to be exceeded more than once per year.

b Arithmetic mean.

c Standard is attained when expected number of days per calendar year with maximal hourly average concentrations above 0.12 ppm (235 μg/m<sup>3</sup>) is equal to or less than 1, as determined by Appendix H to subchapter C, 40 CFR 50.

d Three-month period is a calendar quarter.

**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.

**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.<sup>2</sup>

**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

**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<sup>3</sup> and ANSI/AIHA Z9.5-1992.<sup>4</sup>  
 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<sup>5</sup> and in the *ASHRAE Handbook—HVAC Applications*.<sup>6</sup>  
 Note 4: Shorter separation distances are permitted when determined in accordance with (a) Chapter 7 of ANSI Z223.1/NFPA 54-2002<sup>7</sup> for fuel gas burning appliances and equipment; (b) Chapter 6 of NFPA 31-2001<sup>8</sup> for oil burning appliances and equipment, or (c) Chapter 7 of NFPA 211-2003<sup>9</sup> 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.

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,<sup>10</sup> ASTM C 1338,<sup>11</sup> or comparable test methods.

**Exception to 5.5.1:** 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<sup>10</sup> and shall not break away, crack, peel, flake off, or show evidence of delamination or continued erosion under test conditions.

**Exception to 5.5.2:** 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. **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<sup>2</sup>·h (21.5 g/m<sup>2</sup>·h) of inlet area when tested using the rain test apparatus described in Section 58 of UL 1995.<sup>12</sup>
- (b) Select louvers that limit water penetration to a maximum of 0.01 oz/ft<sup>2</sup> (3 g/m<sup>2</sup>) 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<sup>13</sup> or equivalent. Manage the water that penetrates the louver by providing a drainage area and/or moisture removal devices.