

2. SCOPE

2.1 This standard applies to spaces intended for human occupancy within buildings except those within dwelling units in residential occupancies in which occupants are nontransient.

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
- 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, vapors, or any combination thereof.

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

air, primary: air supplied to the ventilation zone prior to mixing with any locally recirculated air.

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

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

air, supply: air delivered by mechanical or natural ventilation to a space and 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 with the potential to reduce acceptability of the air.

contaminant mixture: two or more contaminants that target the same organ system.

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

dwelling unit: a single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

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.

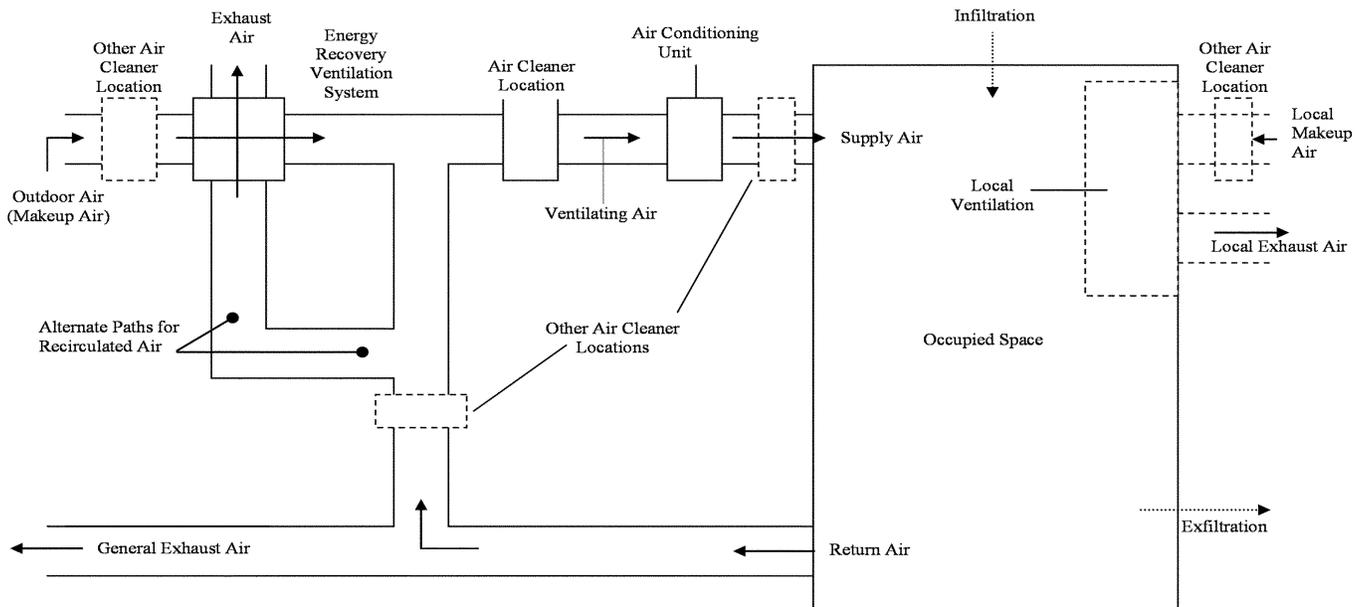


FIGURE 3.1 Ventilation system.

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*. This definition includes smoke produced from the combustion of cannabis and controlled substances and the emissions produced by electronic smoking devices.

equipment well: 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.

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

Informative 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 outdoor and exhaust airflow rates.

industrial space: an indoor environment where the primary activity is production or manufacturing 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 protozoan.

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

net occupiable area: the floor area of an occupiable space defined by the inside surfaces of its walls but excluding shafts, column enclosures, and other permanently enclosed, inaccessible, and unoccupiable areas. Obstructions in the space, such as furnishings, display or storage racks, and other obstructions, whether temporary or permanent, are considered to be part of the net occupiable area.

nontransient: occupancy of a dwelling unit or sleeping unit for more than 30 days.

occupant sensor: a device such as a motion detector or a captive key system that detects the presence of one or more persons within a space.

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

occupied mode: when a zone is scheduled to be occupied.

occupied-standby mode: when a zone is scheduled to be occupied and an occupant sensor indicates zero population within the zone.

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

readily accessible: capable of being reached quickly for operation without requiring personnel to climb over or remove obstacles or to resort to the use of unsafe climbing aids such as tables or chairs.

residential occupancies: occupancies that are not classified as institutional by the authority having jurisdiction and that contain permanent provisions for sleeping.

sleeping unit: a room or space in which people sleep that includes permanent provisions for living, eating, and either sanitation or kitchen facilities but not both. Such rooms and spaces that are also part of a dwelling unit are not sleeping units.

unoccupied mode: when a zone is not scheduled to be occupied.

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.

ventilation zone: any indoor area that requires ventilation and comprises one or more spaces with the same occupancy category (see Table 6.2.2.1), occupant density, zone air distribution effectiveness (see Section 6.2.2.2), and design zone primary airflow (see Section 6.2.5.1) per unit area.

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

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.

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.

4.1.1 In the United States, compliance status shall be either in “attainment” or “nonattainment” with the *National Ambient Air Quality Standards* (NAAQS)¹. In the United States, areas with no U.S. Environmental Protection Agency (USEPA) compliance status designation shall be considered “attainment” areas.

Informative Note: The NAAQS are shown in Table I-1 of Informative Appendix I.

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 will 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 as a minimum:

a. Regional air quality compliance status

Informative Note to 4.3(a): Regional outdoor air quality compliance status for the United States is available from USEPA located at www.epa.gov.

b. Local survey information

1. Date of observations

2. Time of observations

3. Site description

4. Description of facilities on site and on adjoining properties

5. Observation of odors or irritants

6. Observation of visible plumes or visible air contaminants

7. Description of sources of vehicle exhaust on site and on adjoining properties

8. Identification of potential contaminant sources on the site and from adjoining properties, including any that operate only seasonally

c. Conclusion regarding the acceptability of outdoor air quality and the information supporting the conclusion

5. SYSTEMS AND EQUIPMENT

5.1 Ventilation Air Distribution. Ventilating systems shall be designed in accordance with the requirements of the following subsections.

5.1.1 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.

5.1.2 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.

Informative Note: Systems with direct connection of ventilation air ducts to terminal units, for example, comply with this requirement.

5.1.3 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.

5.2 Exhaust Duct Location

5.2.1 Exhaust ducts that convey Class 4 air shall be negatively pressurized relative to ducts, plenums, or occupiable spaces through which the ducts pass.

5.2.2 Exhaust ducts under positive pressure that convey Class 2 or Class 3 air shall not extend through ducts, plenums,

TABLE 5.5.1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Class 2 air exhaust/relief outlet ^a	10 (3)
Class 3 air exhaust/relief outlet ^a	15 (5)
Class 4 air exhaust/relief outlet ^b	30 (10)
Plumbing vents terminating less than 3 ft (1 m) above the level of the outdoor air intake	10 (3)
Plumbing vents terminating at least 3 ft (1 m) above the level of the outdoor air intake	3 (1)
Vents, chimneys, and flues from combustion appliances and equipment ^c	15 (5)
Garage entry, automobile loading area, or drive-in queue ^d	15 (5)
Truck loading area or dock, bus parking/idling area ^d	25 (7.5)
Driveway, street, or parking place ^d	5 (1.5)
Thoroughfare with high traffic volume	25 (7.5)
Roof, landscaped grade, or other surface directly below intake ^{e,f}	1 (0.30)
Garbage storage/pick-up area, dumpsters	15 (5)
Cooling tower intake or basin	15 (5)
Cooling tower exhaust	25 (7.5)

- a. This requirement applies to the distance from the outdoor air intakes for one ventilation system to the exhaust outlets and relief outlets for any other ventilation system.
- b. Minimum distance listed does not apply to laboratory fume hood exhaust air outlets. Separation criteria for fume hood exhaust shall be in compliance with ANSI/AIHA Z9.5 ⁶. Informative Appendix J contains sources of additional information on separation criteria. These include the *ACGIH Industrial Ventilation Manual* ¹¹, *ASHRAE Handbook—HVAC Applications* ¹², *ASHRAE Laboratory Design Guide* ¹³, and NSF/ANSI 49 ¹⁴.
- c. The minimum distances relative to fuel-fired appliances shall be as required by ANSI Z223.1/NFPA 54 ⁷ for fuel gas burning appliances and equipment, NFPA 31 ⁸ for oil burning appliances and equipment, and NFPA 211 ⁹ for other combustion appliances and equipment.
- d. Distance measured to closest place that vehicle exhaust is likely to be located
- e. The minimum separation distance shall not apply where outdoor surfaces below the air intake are sloped more than 45 degrees from horizontal or where such surfaces are less than 1 in. (30 mm) in width.
- f. Where snow accumulation is expected, the surface of the snow at the expected average snow depth shall be considered to be a surface directly below an intake.

or occupiable spaces other than the space from which the exhaust air is drawn.

Exception: Exhaust ducts conveying Class 2 air and exhaust ducts conveying air from residential kitchen hoods that are sealed in accordance with SMACNA Seal Class A ².

5.3 Ventilation System Controls. Mechanical ventilation systems shall include controls in accordance with the following subsections.

5.3.1 All systems shall be provided with manual or automatic controls to maintain not less than the outdoor air intake flow (V_{ot}) required by Section 6 under all load conditions or dynamic reset conditions.

5.3.2 Systems with fans supplying variable primary air (V_{ps}), including single-zone VAV and multiple-zone recirculating VAV systems, shall be provided with one or more of the following:

- Outdoor air intake, return air dampers, or a combination of the two that modulates to maintain not less than the outdoor air intake flow (V_{ot})
- Outdoor air injection fans that modulate to maintain not less than the outdoor air intake flow (V_{ot})
- Other means of ensuring compliance with Section 5.3.1

5.4 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 requirements of the following subsections.

5.4.1 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 ³, ASTM C 1338 ⁴, or ASTM D3273 ⁵.

Exception: Sheet metal surfaces and metal fasteners.

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

5.4.2 Resistance to Erosion. Airstream surface materials shall be evaluated in accordance with the Erosion Test in UL 181 ³ 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.

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

5.5.1 Location. Outdoor air intakes (including openings 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 5.5.1 or the calculation method in Normative Appendix B.

Exception: Other separation distances shall be permitted, provided it can be shown analytically that an equivalent

or lesser rate of introduction of contaminants from outdoor sources will be attained.

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

- a. Limit water penetration through the intake to $0.07 \text{ oz/ft}^2\cdot\text{h}$ ($21.5 \text{ g/m}^2\cdot\text{h}$) of inlet area when tested using the rain test apparatus described in Section 58 of UL 1995¹⁰.
- 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-L¹¹ or equivalent. Manage the water that penetrates the louver by providing a drainage area or moisture removal devices.
- c. Select louvers that restrict wind-driven rain penetration to less than $2.36 \text{ oz/ft}^2\cdot\text{h}$ ($721 \text{ g/m}^2\cdot\text{h}$) 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.
Informative Note to 5.5.2(c): This performance corresponds to Class A (99% effectiveness) when rated according to AMCA 511¹⁵ and tested per AMCA 500-L¹⁶.
- 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 or moisture removal devices.

5.5.3 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 1995¹⁰.

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

- a. Access doors to permit cleaning of wetted surfaces shall be provided.
- b. Outdoor air ductwork or plenums shall pitch to drains designed in accordance with the requirements of Section 5.10.

5.5.5 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.

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

5.6 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.

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

5.8 Particulate Matter Removal. Particulate matter filters or air cleaners having a minimum efficiency reporting value (MERV) of not less than 8 when rated in accordance with ANSI/ASHRAE Standard 52.2¹² shall be provided upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to an occupiable space.

Exception: Cooling coils that are designed, controlled, and operated to provide sensible cooling only.

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

5.9.1 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.

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 spaces designed and constructed to manage moisture, such as shower rooms, pool rooms, and spa rooms.

Informative Note: System configuration, climatic conditions, or a combination of both might 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.

5.9.2 Building Exfiltration. Ventilation systems for a building shall be designed such that the total building outdoor air intake equals or exceeds the total building exhaust under all load and dynamic reset conditions.

Exceptions:

1. Where an imbalance is required by process considerations and approved by the authority having jurisdiction, such as in certain industrial facilities.
2. When outdoor air dry-bulb temperature is below the indoor space dew-point design temperature.

Informative Note: Although individual zones within a building may be neutral or negative with respect to outdoors