STANDARD

ANSI/ASHRAE Standard 62.1-2022
(Supersedes ANSI/ASHRAE Standard 62.1-2019)
Includes ANSI/ASHRAE addenda listed in Appendix Q

Ventilation and Acceptable Indoor Air Quality

See Appendix Q for approval dates by ASHRAE and the American National Standards Institute.

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 ISSN 1041-2336

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Approved American National Standard
ANSI
www.ansi.org

ASHRAE Standing Standard Project Committee 62.1
Cognizant TC: 4.3, Ventilation Requirements and Infiltration
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ASHRAE STANDARDS COMMITTEE 2022–2023

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Ventilation and Acceptable Indoor Air Quality

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NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

(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

ASHRAE Standard 62.1 specifies minimum ventilation rates and other measures intended to provide indoor air quality (IAQ) that is acceptable to human occupants and that minimizes adverse health effects. Since its original publication, Standard 62.1 has been revised and enhanced in ways that make it more than an air treatment and ventilation standard. To signify that indoor air quality goes beyond minimum ventilation requirements—and in recognition of those aspects of building systems (equipment, filtration, controls, and more) that contribute to acceptable IAQ—the title of the standard has been updated to "Ventilation ***and*** *Acceptable Indoor Air Quality."*

Standard 62.1 is uniquely qualified to address ventilation and acceptable IAQ in the built environment and will enable stakeholders to make a conscientious effort to improve the indoor environment while maintaining a minimum standard for ventilation. The addenda that make up the 2022 edition of the standard represent years of research, statistical evidence, and improved building systems and technologies inherent to acceptable IAQ. Notable changes are as follows (for a full list, refer to Informative Appendix Q):

- *Reorganized Section 5, "Systems and Equipment," to reflect the path of airflow and better illustrate how buildings, systems, and equipment are related—essentially the tertiary purpose of the standard*
- *Continued focus on IAQ, including improvements to the IAQ Procedure, setting maximum dew-point temperatures in mechanically cooled buildings and required exhaust air separation distances*
- *Owner acknowledgment of ANSI/ASHRAE Standard 188*
- *Relocated outpatient/ambulatory surgery and support care spaces in the scope of ASHRAE/ASHE Standard 170 to a new normative appendix and will continue to provide requirements for ventilation for these occupancies when appropriate and approved by an authority having jurisdiction*
- *Updates to definitions; clarification for air density adjustments; and removal of some items related to transient occupancies that are now under the scope of Standard 62.2*

Standard 62.1 continues to provide procedures and methods for the minimum requirements of ventilation, indoor air quality, and operation to engineers, design professionals, owners, and jurisdictional authorities where model codes have been adopted. Additionally, local jurisdictions have the opportunity to evaluate and adopt the entire standard for the benefit of commercial building occupants.

This standard is updated on a regular basis using ASHRAE's continuous maintenance procedures. Addenda are publicly reviewed, approved by ASHRAE and ANSI, and posted on the ASHRAE website. Change proposals can be submitted online at www.ashrae.org/continuous-maintenance. The project committee for Standard 62.1 takes 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 (IAQ) 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 IAQ in existing buildings.

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 operations and maintenance.

2.3 In addition to ventilation, this standard contains requirements related to certain contaminants and contaminant sources, including outdoor air, construction processes, moisture, and biological growth.

2.4 This standard does not prescribe specific ventilation rate requirements for the following:

a. Spaces that contain smoking or that do not meet the requirements in the standard for separation from spaces that contain smoking

b. Patient care areas not listed in this standard
c. Laboratories with hazardous materials

3. DEFINITIONS

3.1 Terminology (See Figure 3-1)

acceptable indoor air quality (IAQ): 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:

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

cool air: air whose temperature is less than the average space temperature.

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

indoor air: air in an enclosed occupiable space.

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

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

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

recirculated air: air removed from a space, or treated within the space, that is reused as supply air.

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

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

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

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

warm air: air whose temperature is greater than the average space temperature.

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

breathing zone: 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.

ceiling return: air removed from the space more than 4.5 ft (1.4 m) above the floor.

ceiling supply: air supplied to the space more than 4.5 ft (1.4 m) above the floor.

classroom: a space for instruction in which the instructor regularly occupies and stores supplies in the space.

lecture classroom: a space for instruction in which all occupants are interim and no supplies are stored in the space.

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: 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.

design compounds (DCs): chemical compounds found in the indoor environment that have the potential to reduce acceptability of the air and are considered in designing to the IAQ Procedure (IAQP).

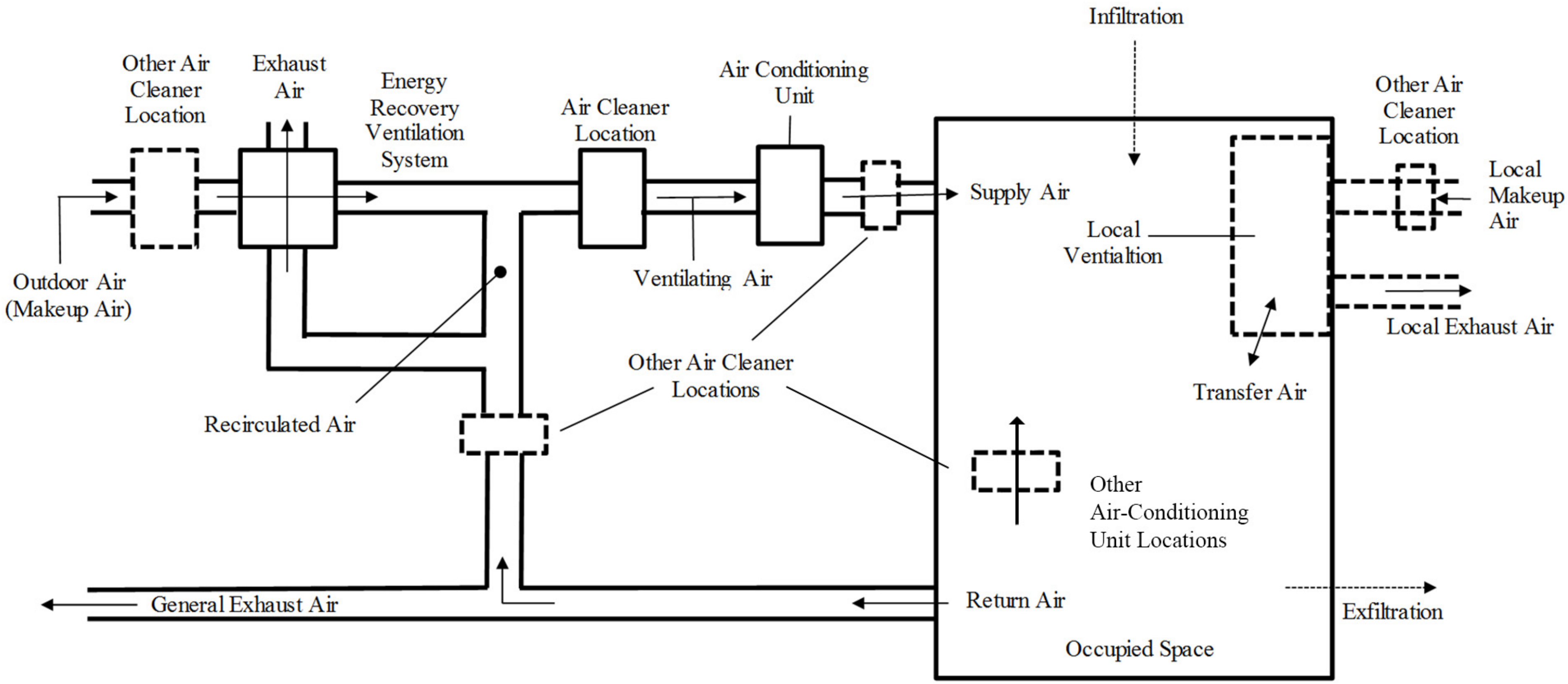

Figure 3-1 Ventilation system.

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 device: a device or combination of devices or system to transfer heat and/or water vapor between separate outdoor and exhaust airstreams.

environmental tobacco smoke (ETS): "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 area: spaces where smoking is permitted, as well as those spaces not separated from spaces where smoking is permitted in accordance with the requirements of Section 5 in this standard.

ETS-free area: an area where no smoking occurs and 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.)

evaporative heat rejection equipment: heat rejection devices, including open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers, with an open water circuit that reject heat through the evaporation of water.

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.

floor return: air removed from the space less than 4.5 ft (1.4 m) above the floor.

floor supply: air supplied to the space less than 4.5 ft (1.4m) above the floor.

hazardous materials: any biological, chemical, radiological, or physical item or agent that has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. Hazardous chemicals are any chemicals that are classified as a health hazard or simple asphyxiant, in accordance with the Hazard Communication Standard (29 CFR1910.1200), and any other particularly hazardous substances, including select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity. Hazardous biological agents are any pathogenic, allergenic, or toxigenic microorganisms, including BSL2-4 agents as defined in the National Institute for Health's *Biosafety in Microbiological and Biomedical Laboratories*.

imaging room, Class 1: imaging rooms that meet the criterion of Class 1 as per the Facility Guidelines Institute (FGI) *Guidelines for Design and Construction of Outpatient Facilities*, Table 2.1-5.6.2.5.1.3.

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: 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 spaces that are intended to be occupied occasionally and for short periods of time, such as storage rooms, equipment rooms, and emergency exitways.

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.

openable area: net free area of an opening.

patient care area: an area used primarily for the provision of clinical care to patients. Such care includes monitoring, evaluation, and treatment services.

particulate matter 2.5 (PM2.5): aerosol particles with an aerodynamic diameter less than or equal to a nominal 2.5 µm.

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 (AHJ) 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.

stratified air distribution system: a device or combination of devices applied to provide a stratified thermal and pollutant distribution within a zone.

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

unusual source: an item or activity not usually expected within an occupancy category and that has the potential to create contaminants. (***Informative Note:*** Informative Appendix J contains information on sources and contaminants expected in certain occupancy categories.)

ventilation: 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), occupant density, zone air distribution effectiveness (see Section 6.2.1.2), and design zone primary airflow (see Section 6.2.4.3.2 and Normative Appendix A) 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: 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 air distribution effectiveness: ratio of the change of contaminant concentration between the air supply and air exhaust to the change of contaminant concentration between the air supply and the breathing zone.

3.2 Initialisms, Abbreviations, and Acronyms

AHJ	authority having jurisdiction
ACGIH	American Conference of Governmental Industrial Hygienists
AgBB	Committee for Health Related Evaluation of Building Products (German)
AHRI	Air Conditioning, Heating, and Refrigeration Institute
AIHA	American Industrial Hygiene Association
AMCA	Air Movement and Control Association
ANSI	American National Standards Institute
ASHE	American Society for Health Care Engineering
BSL	biological safety level
Cal	California

CFR	Code of Federal Regulations
CIBSE	Chartered Institution of Building Services Engineers
CREL	chronic reference exposure levels
DC	design compound
DCV	demand controlled ventilation
DL	design limit
EHS	environmental health and safety
EPA	Environmental Protection Agency
ETS	environmental tobacco smoke
HVAC	heating, ventilation, and air conditioning
IAQ	indoor air quality
IAQP	Indoor Air Quality Procedure
I-P	inch-pound
ISO	International Organization for Standardization
LCI	lowest concentration of interest
MERV	minimum efficiency reporting value
NAAQS	National Ambient Air Quality Standards
NFPA	National Fire Protection Association
NSF	National Sanitation Foundation
O&M	operations and maintenance
OS	occupied standby
PM	particulate matter
SI	International System of Units
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UL	Underwriters Laboratories
VAV	variable air volume
VRP	Ventilation Rate Procedure

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 the National Ambient Air Quality Standards (NAAQS) 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 NAAQS. In the United States, areas with no U.S. Environmental Protection Agency (U.S. EPA) compliance status designation shall be considered "attainment" areas.

Informative Notes:

1. The NAAQS are shown in Informative Appendix E, Table E-1.
2. The U.S. EPA list of nonattainment areas can be found at www.epa.gov/green-book.
3. Air quality data collected at outdoor monitors across the U.S. can be found at www.epa.gov/outdoor-air-quality-data.
4. Internet links to detailed information on the NAAQS and contaminant levels for other select counties and regions can be found in Informative Appendix E.

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

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

a. A weather barrier or other means shall be provided to prevent liquid-water penetration into the envelope.
   Exception to 5.1.1(a): When the envelope is engineered to allow incidental water penetration to occur without resulting in damage to the envelope construction.
b. 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 to 5.1.1(b): When the envelope is engineered to manage incidental condensation without resulting in damage to the envelope construction.
c. Exterior joints, seams, or penetrations in the building envelope that are pathways for air leakage shall be caulked, gasketed, weather stripped, provided with a continuous air barrier, or otherwise sealed to limit infiltration through the envelope to reduce uncontrolled entry of outdoor air moisture and pollutants.

Informative Note: In localities where soils contain high concentrations of radon or other soil-gas contaminants, the AHJ might impose additional measures such as subslab depressurization.

5.1.2 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 prevent condensate from forming on the exposed surface and within the insulating material.

Exception to 5.1.2: Where condensate will wet only surfaces that will be managed to prevent or control mold growth. A management plan must be submitted along with the design specifying design assumptions and limits of the plan. The plan must be provided to the owner.

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

a. maintain the garage pressure at or below the pressure of the adjacent occupiable spaces,
b. use a vestibule to provide an airlock between the garage and the adjacent occupiable spaces, or
c. otherwise limit migration of air from the attached parking garage into the adjacent occupiable spaces of the building in a manner acceptable to the authority having jurisdiction (AHJ).

5.3 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 5.3.1 through 5.3.8. This section does not purport to achieve acceptable IAQ in ETS areas.

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

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

Exceptions to 5.3.2:

1. 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
   a. the separation walls are constructed as smoke barriers in accordance with the requirements of applicable standards;

b. 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
c. 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).
2. 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.

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

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

Exception to 5.3.3: 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.

Informative 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.

5.3.4 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 5.3.2.

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

5.3.6 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.

5.3.7 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.

Exception to 5.3.7: Instead of the specified sign, equivalent notification means acceptable to the AHJ may be used.

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

5.3.8 Reclassification. An area that was previously an ETS area but now meets the requirements of an ETS-free area shall be permitted to be classified as such where smoke exposure has stopped and odor and irritation from residual ETS contaminants are not apparent.

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

5.4.1 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 listed in Table 5-1 shall be equal to or greater than

a. the separation distance in Table 5-1 or
b. the calculation methods in Normative Appendix B

and shall comply with all other requirements of this section.

5.4.1.1 Exhaust/Relief Outlets. Separation criteria for Class 2 and Class 3 exhaust/relief outlets apply to the distance from the outdoor air intakes for one ventilation system to the exhaust outlets and relief outlets for any other ventilation system.

5.4.1.2 Fuel-Burning Equipment. The minimum distances relative to fuel-fired appliances shall be as required by ANSI Z223.1/NFPA 54 for fuel-gas-burning appliances and equipment, NFPA 31 for oil-burning appliances and equipment, and NFPA 211 for other combustion appliances and equipment.

Table 5-1 Air Intake Minimum Separation Distance

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

5.4.1.3 Roof, Landscaped Grade, or Another Surface Directly Below Intake. 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.

Exception to 5.4.1.3: The minimum separation distance in Table 5-1 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.

5.4.1.4 Laboratory Exhaust. Separation criteria for fume hood exhaust shall be in compliance with ANSI/AIHA Z9.5.

5.4.2 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 oz/ft^2·h (21.5 g/m^2·h) of inlet area when tested using the rain test apparatus described in UL 1995, Section 58.
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 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 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. (***Informative Note:*** This performance corresponds to Class A (99% effectiveness) when rated according to AMCA 511 and tested per AMCA 500-L.)
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.

5.4.3 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 UL 1995, Section 58.

5.4.4 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 5.7.

5.4.5 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.

5.5 Particulate Matter Removal. Particulate matter filters or air cleaners having either

a. a MERV of not less than 8 where rated in accordance with ASHRAE Standard 52.2 or
b. the minimum efficiency within ISO ePM10 where rated in accordance with ISO 16890

shall be provided upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to an occupiable space.

Exception to 5.5: Cooling coils that are designed, controlled, and operated to provide sensible cooling only.

5.6 Finned-Tube Coils and Heat Exchangers

5.6.1 Drain Pans. A drain pan, in accordance with Section 5.7, shall be provided beneath all dehumidifying cooling-coil assemblies and all condensate-producing heat exchangers.

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

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

5.7.1 Drain Pan Slope. Pans intended to collect and drain liquid water shall be sloped at least 0.125 in./ft (10 mm/m) from the horizontal toward the drain outlet or shall be otherwise designed such that water drains freely from the pan whether the fan is ON or OFF.

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

5.7.3 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.

5.7.4 Pan Size. The drain pan shall be located under the water-producing device. Drain pan width shall be sized 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/ft^2 (1.5 mL/m^2) of face area per hour under peak sensible and peak dew-point design conditions, accounting for both latent load and coil face velocity.

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

5.8.1 Water Quality. Water purity shall meet or exceed potable water standards at the point where it enters the ventilation system, space, or water vapor generator. Water vapor generated shall contain no chemical additives other than those chemicals in a potable water system.

Exceptions to 5.8.1:

1. Water spray systems that use chemical additives that meet NSF/ANSI Standard 60.
2. Boiler water additives that meet the requirements of 21 CFR 173.310 and include automated dosing devices.

5.8.2 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 5.8.2: Equipment such as eliminators, coils, or evaporative media shall be permitted to be located within the absorption distance recommended by the manufacturer, provided a drain pan complying with the requirements of Section 5.7 is used to capture and remove any water that drops out of the airstream due to impingement on these obstructions.

5.9 Ozone-Generating Devices. The use of ozone-generating devices shall comply with the following sections.

Exception to 5.9: Electronic devices used exclusively for the operation of HVAC equipment and controls.

Informative Note: Ozone generation is expected from ozone generators, corona discharge technology, some ultraviolet lights, electronic devices that create chemical reactions within the system, and some devices using a high voltage (>480 V). Motors and relays are examples of electronic devices that would be exempt.

5.9.1 Air-Cleaning Devices. Air-cleaning devices shall be listed and labeled in accordance with UL 2998.

Informative Note: The use of devices not intended for air cleaning with the potential to generate ozone should be avoided.

5.9.2 Ultraviolet Devices. Ultraviolet-generating devices in supply air or spaces shall not transmit 185 nm wavelengths.

Informative Note: Ultraviolet devices used in treatment of closed water systems may produce 185 nm wavelengths, which may generate ozone.

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

5.10.1 Designing for Air Balancing. Ventilation air distribution systems shall be provided that allow field verification of outdoor air intake flow (V_{ot}) during operation.

5.10.1.1 Designing for Varying Loads and Operating Conditions. The ventilation air distribution system for variable-air-volume (VAV) and multispeed constant-air-volume applications 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 or dynamic reset condition.

5.10.2 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.

5.10.3 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.

5.11 Airstream Surfaces. All airstream surfaces in equipment and ducts in the HVAC system shall be designed and constructed in accordance with the requirements of the following subsections.

5.11.1 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, ASTM C1338, or ASTM D3273.

Exception to 5.11.1: 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.

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

Exception to 5.11.2: Sheet metal surfaces and metal fasteners.

5.12 Mechanically or Indirectly Evaporatively Cooled Buildings. Systems that cool by mechanical means or indirect evaporation shall be designed to limit the indoor humidity to a maximum dew point of 60°F (15°C) during both occupied and unoccupied hours whenever the outdoor air dew point is above 60°F (15°C). The dew-point limit shall not be exceeded 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.

Exceptions to 5.12:

1. Spaces equipped with materials, assemblies, coatings, and furnishings that resist microbial growth and that are not damaged by continuously high indoor air humidity.
2. During overnight unoccupied periods not exceeding 12 hours, the 60°F (15°C) dew-point limit shall not apply, provided that indoor relative humidity does not exceed 65% at any time during those hours.

Informative Notes:

1. Examples of spaces that are potentially exempted by Exception 1 are shower rooms, swimming pool enclosures, kitchens, spa rooms, or semicooled warehouse spaces that contain stored contents that are not damaged by continuously high indoor air humidity or microbial growth.
2. This requirement reduces the risk of microbial growth in buildings and their interstitial spaces, because it limits the mass of indoor water vapor that can condense or be absorbed into mechanically cooled surfaces. The dew-point limit is explicitly extended to unoccupied hours because of the extensive public record of mold growth in schools, apartments, dormitories, and public buildings that are intermittently cooled during unoccupied hours when the outdoor air dew point is above 60°F (15°C).

5.13 Air Classification and Recirculation. Air shall be classified, and its recirculation shall be limited in accordance with the following subsections.

5.13.1 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 Table 6-1, 6-2, or 6-3 or as approved by the AHJ. Air leaving spaces or locations that are not listed in Table 6-1, 6-2, or 6-3 shall be designated with the same classification as air from the most similar space or location listed in terms of occupant activities and building construction.

Exception to 5.13.1: Air from spaces where ETS is present. (Classification of air from spaces where ETS is present is not addressed. Spaces that are expected to include ETS do not have a classification listed in Table 6-1.)

Informative Note: Classifications in Table 6-1, 6-2, or 6-3 are based on relative contaminant concentration using the following subjective criteria:

1. Class 1: Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.
2. 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.)
3. Class 3: Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
4. Class 4: Air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered as harmful.

5.13.2 Redesignation

5.13.2.1 Air Cleaning. If air leaving a space or location passes through an air-cleaning system, redesignation of the cleaned air to a cleaner classification shall be permitted per the following requirements:

a. Class 2 air where based on the subjective criteria in the informative note for Section 5.13.1 and where approved by the AHJ.
b. Class 3 and Class 4 air when all requirements of Sections 6.3.1 through 6.3.5 are followed.

5.13.2.2 Transfer. A mixture of air that has been transferred through or returned from spaces or locations with different air classes shall be redesignated with the highest classification among the air classes mixed.

Informative Note: For example, mixed return air to a common system serving both a Class 1 space and a Class 2 space is designated as Class 2 air.

5.13.2.3 Ancillary Spaces. Redesignation of Class 1 air to Class 2 air shall be permitted for Class 1 spaces that are ancillary to Class 2 spaces.

Informative Note: For example, an office within a restaurant might be designated as a space ancillary to a Class 2 space, thus enabling the office to receive Class 2 air.

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

5.13.3.1 Class 1 Air. Recirculation or transfer of Class 1 air to any space shall be permitted.

5.13.3.2 Class 2 Air

5.13.3.2.1 Recirculation of Class 2 air within the space of origin shall be permitted.

5.13.3.2.2 Recirculation or transfer of Class 2 air to other Class 2 or Class 3 spaces shall be permitted, provided that the other spaces are used for the same or similar purpose or task and involve the same or similar pollutant sources as the Class 2 space.

5.13.3.2.3 Transfer of Class 2 air to toilet rooms shall be permitted.

5.13.3.2.4 Recirculation or transfer of Class 2 air to Class 4 spaces shall be permitted.

5.13.3.2.5 Class 2 air shall not be recirculated or transferred to Class 1 spaces.

Exception to 5.13.3.2.5: When using any energy recovery device, recirculation from leakage, carryover, or transfer from the exhaust side of the energy recovery device is permitted but shall not be counted as outdoor air. Exhaust air transfer ratio of Class 2 air shall not exceed 10% of the outdoor air intake flow at the design static pressure differential as defined in AHRI 1060.

5.13.3.3 Class 3 Air

5.13.3.3.1 Recirculation of Class 3 air within the space of origin shall be permitted.

5.13.3.3.2 Class 3 air shall not be recirculated or transferred to any other space.

Exception to 5.13.3.3.2: When using any energy recovery device, recirculation from leakage, carryover, or transfer from the exhaust side of the energy recovery device is permitted but shall not be counted as outdoor air. Exhaust air transfer ratio of Class 3 air shall not exceed 5% of the outdoor air intake flow at the design static pressure differential as defined in AHRI 1060.

5.13.3.4 Class 4 Air. Class 4 air shall not be recirculated or transferred to any space or recirculated within the space of origin.

5.13.4 Documentation. Design documentation shall indicate the justification for classification of air from any occupancy category, airstream, or location not listed in Table 6-1, 6-2, or 6-3.

5.14 Exhaust Duct Location

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

5.14.2 Exhaust ducts under positive pressure that convey Class 2 or Class 3 air shall not extend through ducts, plenums, or occupiable spaces other than the space from which the exhaust air is drawn.

Exception to 5.14.2: 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.

5.15 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's instructions. Products of combustion from vented appliances shall be vented directly outdoors.

5.16 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 to 5.16: Equipment specifically designed for discharge indoors in accordance with the manufacturer's recommendations.

5.17 Building Exfiltration. Ventilation systems for a building equipped with or served by mechanical cooling equipment 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 to 5.17:

1. Where an imbalance is required by process considerations and approved by the AHJ, 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 or to other zones, net positive mechanical intake airflow for the building as a whole reduces infiltration of untreated outdoor air.

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

5.18.1 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.

5.18.2 Systems with fans supplying variable primary air (V_{ps}) shall be provided with any combination of control equipment, methods, or devices to maintain no less than the outdoor air intake flow (V_{ot}) required for compliance with Section 5.18.1.

5.19 Access for Inspection, Cleaning, and Maintenance

5.19.1 Equipment Clearance. Ventilation equipment shall be installed with working space that will allow for inspection and routine maintenance, including filter replacement and fan belt adjustment and replacement.

5.19.2 Ventilation Equipment Access. Access doors, panels, or other means shall be provided and sized to allow unobstructed access for inspection, maintenance, and calibration of all ventilation system components for which routine inspection, maintenance, or calibration is necessary. Ventilation system components include air-handling units, fan-coil units, water-source heat pumps, other terminal units, controllers, and sensors.

5.19.3 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 fewer
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

5.20 Legionella Risk. The building owner shall be provided with written documentation of the design information for all of the HVAC-related water systems and elements that are required to be addressed by ANSI/ASHRAE Standard 188.

Informative Note: Typical elements of the HVAC system addressed by Standard 188 include open- and closed-circuit cooling towers and evaporative condensers that provide cooling or refrigeration for the HVAC system and humidification systems. This requirement is related to HVAC's influence on Legionnaires' Disease risk, but it is important to note that there are multiple sources of potential water-to-people transmission inside buildings that are potable-water-based, such as shower heads, some humidifiers, and ice machines, as well as nonpotable sources that are not associated with HVAC, such as decorative water features.

6. PROCEDURES

6.1 General. The Ventilation Rate Procedure (VRP), the Indoor Air Quality Procedure (IAQP), the Natural Ventilation Procedure, or a combination thereof shall be used to meet the requirements of this section. In addition, the requirements for exhaust ventilation in Section 6.5 shall be met regardless of the method used to determine minimum outdoor airflow rates.

Informative Note: Although the intake airflow determined using each of these approaches may differ significantly because of assumptions about the design, any of these approaches is a valid basis for design.

6.1.1 Ventilation Rate Procedure. The prescriptive design procedure presented in Section 6.2, in which outdoor air intake rates are determined based on space type/application, occupancy level, and floor area, shall be permitted to be used for any zone or system.

6.1.2 Indoor Air Quality Procedure. The IAQP is an alternative to the VRP used to determine the design rate of outdoor airflow to maintain concentrations of design compounds (DCs) and PM2.5 in the indoor environment to be less than design limits (DLs), based on indoor and outdoor sources, air cleaning, and other variables. These outdoor air requirements shall be calculated with mass-balance equations. Verification of occupant satisfaction and indoor DC concentrations shall be performed after the building is completed.

6.1.3 Natural Ventilation Procedure. The prescriptive or engineered system design procedure presented in Section 6.4, in which outdoor air is provided through openings to the outdoors, shall be permitted to be used for any zone or portion of a zone in conjunction with mechanical ventilation systems in accordance with Section 6.4.

6.1.4 Outdoor Air Treatment. Each ventilation system that provides outdoor air shall comply with Sections 6.1.4.1 through 6.1.4.4.

Exception to 6.1.4: Systems supplying air for enclosed parking garages, warehouses, storage rooms, janitor's closets, trash rooms, recycling areas, shipping/receiving/distribution areas.

Informative 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.

6.1.4.1 Particulate Matter Smaller than 10 Micrometers (PM10). In buildings located in an area where the national standard or guideline for PM10 is exceeded, particle filters or air-cleaning devices shall be provided to clean the outdoor air at any location prior to its introduction to occupied spaces. Particulate matter filters or air cleaners shall have either

a. a MERV of not less than 8 where rated in accordance with ASHRAE Standard 52.2 or
b. the minimum efficiency within ISO ePM10 where rated in accordance with ISO 16890.

Informative Note: See Informative Appendix E for resources regarding selected PM10 national standards and guidelines.

6.1.4.2 Particulate Matter Smaller than 2.5 Micrometers (PM2.5). In buildings located in an area where the national standard or guideline for PM2.5 is exceeded, particle filters or air-cleaning devices shall be provided to clean the outdoor air at any location prior to its introduction to occupied spaces. Particulate matter filters or air cleaners shall have either

a. a MERV of not less than 11 where rated in accordance with ASHRAE Standard 52.2 or
b. the minimum efficiency within ISO ePM2.5 where rated in accordance with ISO 16890.

Informative Note: See Informative Appendix E for resources regarding selected PM2.5 national standards and guidelines.

6.1.4.3 Ozone. Air-cleaning devices for ozone shall be provided when the most recent three-year average annual fourth-highest daily maximum eight-hour average ozone concentration exceeds 0.100 ppm (195 $\mu g/m^3$).

Such air-cleaning devices shall have a volumetric ozone removal efficiency of not less than 40% where installed, operated, and maintained in accordance with the manufacturer's recommendations and shall be approved by the AHJ. Such devices shall be operated where the outdoor ozone levels are expected to exceed 0.100 ppm (195 $\mu g/m^3$).

Exceptions to 6.1.4.3: Air cleaning for ozone shall not be required where

1. the system design outdoor air intake flow is 1.5 ach or less,
2. controls are provided that sense outdoor ozone level and reduce intake airflow to 1.5 ach or less while complying with the outdoor airflow requirements of Section 6, or
3. outdoor air is brought into the building and heated by direct-fired makeup air units.

Informative Note: In the U.S., a most recent three-year average annual fourth-highest daily maximum eight-hour average ozone concentration exceeding 0.100 ppm (195 $\mu g/m^3$) equates to a U.S. EPA eight-hour ozone classification of "Serious" or higher (Severe 15, Severe 17, or Extreme).

6.1.4.4 Other Outdoor Contaminants. In buildings located in an area where the national standard for one or more contaminants not addressed in Section 6.1.4 is exceeded, any design assumptions and calculations related to the impact on IAQ shall be included in the design documents.

6.2 Ventilation Rate Procedure. The outdoor air intake flow (V_{ot}) for a ventilation system shall be determined in accordance with Section 6.1.4 and Sections 6.2.1 through 6.2.6.

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

6.2.1 Zone Calculations. Ventilation zone parameters shall be determined in accordance with Sections 6.2.1.1 through Section 6.2.1.3 for ventilation zones served by the ventilation system, except that the ventilation rates from ASHRAE/ASHE Standard 170 shall be used for the occupancy categories within the scope of ASHRAE/ASHE Standard 170. For outpatient facilities outside the scope of ASHRAE/ASHE Standard 170, refer to Normative Appendix D.

Informative Note: The ventilation rates in ASHRAE/ASHE Standard 170 are intended to achieve asepsis and control odor migration and might not be adequate to achieve acceptable IAQ as defined in Standard 62.1.

6.2.1.1 Breathing Zone Outdoor Airflow. The outdoor airflow required in the breathing zone (V_{bz}) of the occupiable space or spaces in a ventilation zone shall be not less than the value determined in accordance with Equation 6-1.

$$V_{bz} = R_p \times P_z + R_a \times A_z \tag{6-1}$$

where

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

P_z = zone population, the number of people in the ventilation zone during use

Table 6-1 Minimum Ventilation Rates in Breathing Zone

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density	Air Class	OS (6.2.6.1.4)
	cfm/person	L/s·person	cfm/ft^2	L/s·m^2	#/1000 ft^2 or #/100 m^2		
Animal Facilities							
Animal exam room (veterinary office)	10	5	0.12	0.6	20	2	
Animal imaging (MRI/CT/PET)	10	5	0.18	0.9	20	3	
Animal operating rooms	10	5	0.18	0.9	20	3	
Animal postoperative recovery room	10	5	0.18	0.9	20	3	
Animal preparation rooms	10	5	0.18	0.9	20	3	
Animal procedure room	10	5	0.18	0.9	20	3	
Animal surgery scrub	10	5	0.18	0.9	20	3	
Large-animal holding room	10	5	0.18	0.9	20	3	
Necropsy	10	5	0.18	0.9	20	3	
Small-animal-cage room (static cages)	10	5	0.18	0.9	20	3	
Small-animal-cage room (ventilated cages)	10	5	0.18	0.9	20	3	
Correctional Facilities							
Booking/waiting	7.5	3.8	0.06	0.3	50	2	
Cell	5	2.5	0.12	0.6	25	2	
Dayroom	5	2.5	0.06	0.3	30	1	
Guard stations	5	2.5	0.06	0.3	15	1	
Educational Facilities							
Art classroom	10	5	0.18	0.9	20	2	
Classrooms (ages 5 to 8)	10	5	0.12	0.6	25	1	
Classrooms (age 9 plus)	10	5	0.12	0.6	35	1	
Computer lab	10	5	0.12	0.6	25	1	
Daycare sickroom	10	5	0.18	0.9	25	3	
Daycare (through age 4)	10	5	0.18	0.9	25	2	
Lecture classroom	7.5	3.8	0.06	0.3	65	1	✓
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3	150	1	✓
Libraries	5	2.5	0.12	0.6	10		
Media center	10	5	0.12	0.6	25	1	
Multiuse assembly	7.5	3.8	0.06	0.3	100	1	✓
Music/theater/dance	10	5	0.06	0.3	35	1	✓
Science laboratories	10	5	0.18	0.9	25	2	
University/college laboratories	10	5	0.18	0.9	25	2	
Wood/metal shop	10	5	0.18	0.9	20	2	
Food and Beverage Service							
Bars, cocktail lounges	7.5	3.8	0.18	0.9	100	2	

Table 6-1 Minimum Ventilation Rates in Breathing Zone *(Continued)*

	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Default Values Occupant Density		
Occupancy Category	**cfm/person**	**L/s·person**	**cfm/ft²**	**L/s·m²**	**#/1000 ft² or #/100 m²**	**Air Class**	**OS (6.2.6.1.4)**
Cafeteria/fast-food dining	7.5	3.8	0.18	0.9	100	2	
Kitchen (cooking)	7.5	3.8	0.12	0.6	20	2	
Restaurant dining rooms	7.5	3.8	0.18	0.9	70	2	
General							
Break rooms	5	2.5	0.06	0.3	25	1	✓
Coffee stations	5	2.5	0.06	0.3	20	1	✓
Conference/meeting	5	2.5	0.06	0.3	50	1	✓
Corridors	—	—	0.06	0.3	—	1	✓
Occupiable storage rooms for liquids or gels	5	2.5	0.12	0.6	2	2	
Hotels, Motels, Resorts, Dormitories							
Barracks sleeping areas	5	2.5	0.06	0.3	20	1	✓
Bedroom/living room	5	2.5	0.06	0.3	10	1	✓
Laundry rooms, central	5	2.5	0.12	0.6	10	2	
Laundry rooms within dwelling units	5	2.5	0.12	0.6	10	1	
Lobbies/prefunction	7.5	3.8	0.06	0.3	30	1	✓
Multipurpose assembly	5	2.5	0.06	0.3	120	1	✓
Miscellaneous Spaces							
Banks or bank lobbies	7.5	3.8	0.06	0.3	15	1	✓
Bank vaults/safe deposit	5	2.5	0.06	0.3	5	2	✓
Computer (not printing)	5	2.5	0.06	0.3	4	1	✓
Freezer and refrigerated spaces (<50°F [10°C])	10	5	0	0	0	2	
Manufacturing where hazardous materials are not used	10	5.0	0.18	0.9	7	2	
Manufacturing where hazardous materials are used (excludes heavy industrial and chemical processes)	10	5.0	0.18	0.9	7	3	
Pharmacy (prep. area)	5	2.5	0.18	0.9	10	2	
Photo studios	5	2.5	0.12	0.6	10	1	
Shipping/receiving	10	5	0.12	0.6	2	2	
Sorting, packing, light assembly	7.5	3.8	0.12	0.6	7	2	
Telephone closets	—	—	0.00	0.0	—	1	
Transportation waiting	7.5	3.8	0.06	0.3	100	1	✓
Warehouses	10	5	0.06	0.3	—	2	
Office Buildings							
Breakrooms	5	2.5	0.12	0.6	50	1	
Main entry lobbies	5	2.5	0.06	0.3	10	1	✓

Table 6-1 Minimum Ventilation Rates in Breathing Zone *(Continued)*

Occupancy Category	People Outdoor Air Rate R_p cfm/person	People Outdoor Air Rate R_p L/s·person	Area Outdoor Air Rate R_a cfm/ft^2	Area Outdoor Air Rate R_a L/s·m^2	Default Values: Occupant Density #/1000 ft^2 or #/100 m^2	Air Class	OS (6.2.6.1.4)
Occupiable storage rooms for dry materials	5	2.5	0.06	0.3	2	1	
Office space	5	2.5	0.06	0.3	5	1	✓
Reception areas	5	2.5	0.06	0.3	30	1	✓
Telephone/data entry	5	2.5	0.06	0.3	60	1	✓
Public Assembly Spaces							
Auditorium seating area	5	2.5	0.06	0.3	150	1	✓
Courtrooms	5	2.5	0.06	0.3	70	1	✓
Legislative chambers	5	2.5	0.06	0.3	50	1	✓
Libraries	5	2.5	0.12	0.6	10	1	
Lobbies	5	2.5	0.06	0.3	150	1	✓
Museums (children's)	7.5	3.8	0.12	0.6	40	1	
Museums/galleries	7.5	3.8	0.06	0.3	40	1	✓
Places of religious worship	5	2.5	0.06	0.3	120	1	✓
Residential							
Common corridors	—	—	0.06	0.3		1	✓
Retail							
Sales (except as below)	7.5	3.8	0.12	0.6	15	2	
Barbershop	7.5	3.8	0.06	0.3	25	2	✓
Beauty and nail salons	20	10	0.12	0.6	25	2	
Coin-operated laundries	7.5	3.8	0.12	0.6	20	2	
Mall common areas	7.5	3.8	0.06	0.3	40	1	✓
Pet shops (animal areas)	7.5	3.8	0.18	0.9	10	2	
Supermarket	7.5	3.8	0.06	0.3	8	1	✓
Sports and Entertainment							
Bowling alley (seating)	10	5	0.12	0.6	40	1	
Disco/dance floors	20	10	0.06	0.3	100	2	✓
Gambling casinos	7.5	3.8	0.18	0.9	120	1	
Game arcades	7.5	3.8	0.18	0.9	20	1	
Gym, sports arena (play area)	20	10	0.18	0.9	7	2	
Health club/aerobics room	20	10	0.06	0.3	40	2	
Health club/weight rooms	20	10	0.06	0.3	10	2	
Spectator areas	7.5	3.8	0.06	0.3	150	1	✓
Stages, studios	10	5	0.06	0.3	70	1	✓
Swimming (pool and deck)	—	—	0.48	2.4	—	2	

Table 6-2 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
Animal Facilities						
Animal imaging (MRI/CT/PET)	—	0.90		—	4.5	3
Animal operating rooms	—	3.00		—	15	3
Animal postoperative recovery room	—	1.50		—	7.5	3
Animal preparation rooms	—	1.50		—	7.5	3
Animal procedure room	—	2.25		—	11.3	3
Animal surgery scrub	—	1.50		—	7.5	3
Large-animal holding room	—	2.25		—	11.3	3
Necropsy	—	2.25		—	11.3	3
Small-animal-cage room (static cages)	—	2.25		—	11.3	3
Small-animal-cage room (ventilated cages)	—	1.50		—	7.5	3
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 rooms for athletic, industrial, and health care facilities	—	0.50		—	2.5	2
All other locker rooms	—	0.25	—	—	1.25	2
Shower rooms	20/50		G,I	10/25		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, H	12.5/25	—	2
Toilets—public	50/70	—	D, H	25/35	—	2
Woodwork shop/classrooms	—	0.50	—	—	2.5	2

NOTES:
A Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.
B Where combustion equipment is intended to be used on the playing surface, additional dilution ventilation, source control, or both shall be provided.
C Exhaust shall not be required where two or more sides compose walls that are at least 50% open to the outside.
D Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur. The lower rate shall be permitted to 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 hours of use, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
F See other applicable standards for exhaust rate.
G For continuous system operation, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
H Exhaust air that has been cleaned to meet Class 1 criteria from Section 5.13.1 shall be permitted to be recirculated.
I Rate is per showerhead.

Table 6-3 Airstreams or Sources

Description	Air Class
Kitchen grease hoods	4
Kitchen hoods other than grease hoods	3
Diazo printing equipment discharge	4
Hydraulic elevator machine room	2
Laboratory hoods	4
Paint spray booths	4
Refrigerating machinery rooms	3

R_p = outdoor airflow rate required per person as determined from Table 6-1 (***Informative Note:*** These values are based on adapted occupants.)

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

Informative Notes:

1. Equation 6-1 accounts for people-related sources and area-related sources independently in the determination of the outdoor air rate required at the breathing zone. The use of Equation 6-1 in the context of this standard does not necessarily imply that simple addition of outdoor airflow rates for different sources can be applied to any other aspect of IAQ.
2. The rates in Table 6-1 are based on all other applicable requirements of this standard being met. If other requirements of the standard are not met, then the rates do not apply.

6.2.1.1.1 Unlisted Occupancy. Where 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.

6.2.1.1.2 Source Strengths. The VRP minimum rates are based on contaminant sources and source strengths that are typical for the listed occupancy categories. Where unusual sources are expected, the additional ventilation or air cleaning required shall be calculated using Section 6.3 or criteria established by the environmental health and safety (EHS) professional responsible to the owner.

Informative Notes:

1. Zones where emissions are expected from stored hazardous materials are not typical for any listed occupancy category.
2. Dry ice, theatrical smoke, and smoke-producing activities are not typical for any listed occupancy categories.

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

6.2.1.1.4 Dwelling and Sleeping Units. Air from one dwelling unit with transient occupancy, or air from one sleeping unit, shall not be recirculated or transferred to any other unit.

6.2.1.1.5 Laboratories. Laboratory spaces that comply with all requirements of ANSI/AIHA Z9.5 are not required to comply with the rates in Table 6-1.

6.2.1.1.6 Animal Facilities. Animal facilities that have completed a risk evaluation performed by the EHS professional responsible to the owner or to the owner's designee are not required to comply with the rates in Table 6-1.

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

Exceptions to 6.2.1.1.7:

1. Where the number of people expected to occupy the ventilation zone fluctuates, zone population equal to the average number of people shall be permitted, provided such average is determined in accordance with Section 6.2.5.2.
2. Where the largest or average number of people expected to occupy the ventilation zone cannot be established for a specific design, an estimated value for zone population shall be permitted,

Table 6-4 Zone Air Distribution Effectiveness (E_z)

Air Distribution Configuration	E_z
Well-Mixed-Air Distribution Systems	
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 average space temperature where the supply air-jet velocity is less than 150 fpm (0.8 m/s) within 4.5 ft (1.4 m) of the floor and ceiling return	0.8
Ceiling supply of warm air less than 15°F (8°C) above average space temperature where the supply air-jet velocity is equal to or greater than 150 fpm (0.8 m/s) within 4.5 ft (1.4 m) of the floor and ceiling return	1.0
Floor supply of warm air and floor return	1.0
Floor supply of warm air and ceiling return	0.7
Makeup supply outlet located more than half the length of the space from the exhaust, return, or both	0.8
Makeup supply outlet located less than half the length of the space from the exhaust, return, or both	0.5
Stratified-Air Distribution Systems (Section 6.2.1.2.1)	
Floor supply of cool air where the vertical throw is greater than or equal to 60 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor and ceiling return at a height less than or equal to 18 ft (5.5 m) above the floor	1.05
Floor supply of cool air where the vertical throw is less than 60 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor and ceiling return at a height less than or equal to 18 ft (5.5 m) above the floor	1.2
Floor supply of cool air where the vertical throw is less than 60 fpm (0.25 m/s) at a height of 4.5 ft (1.4 m) above the floor and ceiling return at a height greater than 18 ft (5.5 m) above the floor	1.5
Personalized Ventilation Systems (Section 6.2.1.2.2)	
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with ceiling supply of cool air and ceiling return	1.40
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with ceiling supply of warm air and ceiling return	1.40
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with a stratified air distribution system with nonaspirating floor supply devices and ceiling return	1.20
Personalized air at a height of 4.5 ft (1.4 m) above the floor combined with a stratified air distribution system with aspirating floor supply devices and ceiling return	1.50

provided such value is the product of the net occupiable area of the ventilation zone and the default occupant density listed in Table 6-1.

6.2.1.2 Zone Air Distribution Effectiveness. The zone air distribution effectiveness (E_z) shall be determined in accordance with Table 6-4 or Normative Appendix C.

Informative Notes:

1. For some configurations, the default value depends on space and supply air temperature.
2. Calculation of E_z using the procedures in Normative Appendix C may result in values greater than those listed in Table 6-4 for systems with the same description.

6.2.1.2.1 Stratified Air Distribution Systems. A stratified air distribution system shall be designed in accordance with the following subsections, or the zone air distribution effectiveness (E_z) shall be determined in accordance with Normative Appendix C.

6.2.1.2.1.1 Supply Air. Cool air shall be at least 4°F (2°C) less than the average room air temperature.

6.2.1.2.1.2 Return Air. The return air openings or pathways shall be located more than 9 ft (2.8 m) above the floor.

6.2.1.2.1.3 Stratification. The zone shall not contain any devices that mechanically mix the air, and shall be protected from impinging airstreams from adjacent ventilation zones.

Informative Note: Ceiling fans, blowers, air curtains, aspirating diffusers without adequate draft separation, or other devices that disrupt the stratification cause the zone air distribution effectiveness to be similar to a well-mixed system.

6.2.1.2.2 Personalized Ventilation Systems. A personalized ventilation system shall be designed in accordance with the following subsections, or the zone air distribution effectiveness (E_z) shall be determined in accordance with Normative Appendix C.

Informative Note: A personalized ventilation system is primarily for exposure control and dilution of contaminants in the breathing zone and may provide some spot cooling. Personalized ventilation is used when the occupant spends most of their time in one occupied space. The ventilation outlet is usually incorporated into or mounted on the furniture. It is used in conjunction with another air distribution system that handles the area ventilation requirements and thermal loads in the space.

6.2.1.2.2.1 Personalized Air. The personalized air shall be distributed in the breathing zone and designed such that the velocity is equal to or less than 50 fpm (0.25 m/s) at the head/facial region of the occupant.

6.2.1.2.2.2 Return Air. The return air openings or pathways shall be located more than 9 ft (2.8 m) above the floor.

6.2.1.3 Zone Outdoor Airflow. The zone outdoor airflow (V_{oz}) provided to the ventilation zone by the supply air distribution system shall be determined in accordance with Equation 6-2.

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

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

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

6.2.3 100% Outdoor Air Systems. For ventilation systems wherein one or more air handler supplies only outdoor air to one or more ventilation zone, the outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-4.

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

6.2.4 Multiple-Zone Recirculating Systems. For ventilation systems wherein one or more air handler supplies a mixture of outdoor air and recirculated air to more than one ventilation zone, the outdoor air intake flow (V_{ot}) shall be determined in accordance with Sections 6.2.4.1 through 6.2.4.4.

6.2.4.1 Uncorrected Outdoor Air Intake. The uncorrected outdoor air intake (V_{ou}) flow shall be determined in accordance with Equation 6-5.

$$V_{ou} = D\Sigma_{all\ zones}(R_p \times P_z) + \Sigma_{all\ zones}(R_a \times A_z) \tag{6-5}$$

6.2.4.1.1 Occupant Diversity. The occupant diversity ratio (D) shall be determined in accordance with Equation 6-6 to account for variations in population within the ventilation zones served by the system.

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

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

Exception to 6.2.4.1.1: Alternative methods to account for occupant diversity shall be permitted, provided the resulting V_{ou} value is not less than that determined using Equation 6-5.

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

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

6.2.4.1.3 Other Ventilation Requirements. When a zone ventilation rate is obtained from criteria other than this standard, the ventilation rate shall be converted to cubic feet per minute (cfm) or litres per second (L/s) and the value added to V_{ou} for use in system design calculations.

6.2.4.2 System Ventilation Efficiency. The system ventilation efficiency (E_v) shall be determined in accordance with Section 6.2.4.3 for the Simplified Procedure or Normative Appendix A for the Alternative Procedure.

Informative Note: These procedures also establish zone minimum primary airflow rates for VAV systems.

6.2.4.3 Simplified Procedure

6.2.4.3.1 System Ventilation Efficiency. System ventilation efficiency (E_v) shall be determined in accordance with Equation 6-7 or 6-8.

$$E_v = 0.88 \times D + 0.22 \text{ for } D < 0.60 \tag{6-7}$$

$$E_v = 0.75 \text{ for } D \geq 0.60 \tag{6-8}$$

6.2.4.3.2 Zone Minimum Primary Airflow. For each zone, the minimum primary airflow ($V_{pz\text{-}min}$) shall be determined in accordance with Equation 6-9.

$$V_{pz\text{-}min} = V_{oz} \times 1.5 \tag{6-9}$$

6.2.4.4 Outdoor Air Intake. The design outdoor air intake flow (V_{ot}) shall be determined in accordance with Equation 6-10.

$$V_{ot} = V_{ou}/E_v \tag{6-10}$$

6.2.5 Design for Varying Operating Conditions

6.2.5.1 Variable Load Conditions. Ventilation systems shall be designed to be capable of providing not less than the minimum ventilation rates required in the breathing zone where the zones served by the system are occupied, including all full- and part-load conditions.

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

6.2.5.2 Short-Term Conditions. Where it is known that peak occupancy will be of short duration, ventilation will be varied or interrupted for a short period of time, or both, the design shall be permitted to be based on the average conditions over a time period (T) determined by Equation 6-11a (I-P) or 6-11b (SI).

$$T = 3v/V_{bz} \tag{6-11a}$$

$$T = 50v/V_{bz} \tag{6-11b}$$

where

T = averaging time period, min

v = the volume of the ventilation zone where 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:

a. Zones with fluctuating occupancy: The zone population (P_z) shall be permitted to be averaged over time (T).
b. Zones with intermittent interruption of supply air: The average outdoor airflow supplied to the breathing zone over time (T) shall be not less than the breathing zone outdoor airflow (V_{bz}) calculated using Equation 6-1.
c. Systems with intermittent closure of the outdoor air intake: The average outdoor air intake over time (T) shall be not less than the minimum outdoor air intake (V_{ot}) calculated using Equation 6-3, 6-4, or 6-5 as appropriate.

6.2.6 Dynamic Reset. The system shall be permitted to be designed to reset the outdoor air intake flow (V_{ot}), the space or ventilation zone airflow (V_{oz}) as operating conditions change, or both.

6.2.6.1 Demand Controlled Ventilation. DCV shall be permitted as an optional means of dynamic reset.

Exception to 6.2.6.1: CO_2-based DCV shall not be applied in zones with indoor sources of CO_2 other than occupants, or with CO_2 removal mechanisms such as gaseous air cleaners.

6.2.6.1.1 For DCV zones in the occupied mode, breathing zone outdoor airflow (V_{bz}) shall be reset in response to current population. Current population estimates used in DCV control calculations shall not result in ventilation rates that are less than those required by the actual population during any one-hour time period.

6.2.6.1.2 For DCV zones in the occupied mode, breathing zone outdoor airflow (V_{bz}) shall be not less than the building component ($R_a \times A_z$) for the zone.

6.2.6.1.3 Where CO_2 sensors are used for DCV, the CO_2 sensors shall be certified by the manufacturer to be accurate within ±75 ppm at concentrations of both 600 and 1000 ppm when measured at sea level at 77°F (25°C). Sensors shall be factory calibrated and certified by the manufacturer to require calibration not more frequently than once every five years. Upon detection of sensor failure, the system shall provide a signal that resets the ventilation system to supply the required minimum quantity of outdoor air (V_{bz}) to the breathing zone for the design zone population (P_z).

6.2.6.1.4 For DCV zones in the occupied standby mode, breathing zone outdoor airflow shall be permitted to be reduced to zero for the occupancy categories indicated "OS" in Table 6-1, provided that airflow is restored to V_{bz} whenever occupancy is detected.

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

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

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

6.3 Indoor Air Quality Procedure. Breathing zone outdoor airflow (V_{bz}) shall be determined in accordance with Sections 6.3.1 through 6.3.5.

6.3.1 Design Compounds and PM2.5 Sources. The system design shall be based on the DCs and PM2.5 specified in Table 6-5. If there are additional outdoor sources identified from completing the process in Section 4.3, or if there are unusual sources, the compounds associated with those sources shall be determined and documented. The compounds from those additional sources shall be added to the DC list if a DL from a cognizant authority exists. For each DC and PM2.5, the emission rates from indoor sources from occupants, building materials, furnishings, equipment, and other sources and the outdoor concentrations shall be determined.

Informative Notes:

1. Indoor emission rate information for some compounds is provided in Informative Appendix N.
2. Outdoor concentrations can be determined from Section 4.

6.3.2 Design Compounds and PM2.5 Concentration. The concentration limits, referred to as *design limits*, shall be as specified in Table 6-5. Design ventilation shall be such that the calculated concentration of each DC, mixture of DCs, and PM2.5 does not exceed its limit. For any compounds added to the DC list in Table 6-5, data from cognizant authorities shall be used to determine if the compound causes the effects listed in Table 6-6, and compounds having one or more of the mixture effects shall be added to the mixture list for that effect. For each mixture, the mixed exposure sum (E_m), as determined by Equation 6-12, shall be less than 1.0:

$$E_m = \frac{C_1}{\mathrm{DL}} + \frac{C_2}{\mathrm{DL}_2} + \frac{C_i}{\mathrm{DL}_i} \tag{6-12}$$

where

E_m = mixed exposure sum

C_i = mass-balance model calculated airborne peak concentration for the *i*-th DC

DL_i = design limit for the *i*-th DC

Exceptions to 6.3.2:

1. Benzene, phenol, and tetrachloroethylene shall not be included in the mixture calculation for upper respiratory tract irritation, eye irritation, and central nervous system depression. Outside the U.S., if the outdoor concentrations of carbon monoxide, PM2.5, or ozone exceed the DL, the DL shall be the applicable ambient air standards where the project is located or as accepted by the AHJ.
2. Ammonia shall be included only for spaces that include nonhuman animals.

6.3.3 Design Approach. Zone and system outdoor airflow rates shall be the larger of those determined in accordance with Sections 6.3.3.1 and 6.3.3.2, based on emission rates, concentration limits, and other relevant design parameters.

6.3.3.1 Mass-Balance Analysis. Using a steady-state or dynamic mass-balance analysis, the minimum outdoor airflow rates required to achieve the concentration limits specified in Section 6.3.2 shall be determined for each DC, mixture of DCs, and PM2.5 within each zone served by the system.

Informative Note: In the completed building, measurement of the concentration of contaminants or contaminant mixtures of concern may be useful as a means of checking the accuracy of the design mass-balance analysis, but such measurement is not required for compliance.

Table 6-5 Design Compounds, PM2.5, and Their Design Limits

Compound or PM2.5	Cognizant Authority	Design Limit
Acetaldehyde	Cal EPA CREL (June 2016)	140 $\mu g/m^3$
Acetone	AgBB LCI	1,200 $\mu g/m^3$
Benzene	Cal EPA CREL (June 2016)	3 $\mu g/m^3$
Dichloromethane	Cal EPA CREL (June 2016)	400 $\mu g/m^3$
Formaldehyde	Cal EPA 8-hour CREL (2004)	33 $\mu g/m^3$
Naphthalene	Cal EPA CREL (June 2016)	9 $\mu g/m^3$
Phenol	AgBB LCI	10 $\mu g/m^3$
Tetrachloroethylene	Cal EPA CREL (June 2016)	35 $\mu g/m^3$
Toluene	Cal EPA CREL (June 2016)	300 $\mu g/m^3$
1,1,1-trichloroethane	Cal EPA CREL (June 2016)	1000 $\mu g/m^3$
Xylene, total	AgBB LCI	500 $\mu g/m^3$
Carbon monoxide	U.S. EPA NAAQS	9 ppm
PM2.5	U.S. EPA NAAQS (annual mean)	12 $\mu g/m^3$
Ozone	U.S. EPA NAAQS	70 ppb
Ammonia	Cal EPA CREL (June 2016)	200 $\mu g/m^3$

Table 6-6 Mixtures of Compounds

Upper Respiratory Tract Irritation	Eye Irritation	Central Nervous System
Acetaldehyde	Acetaldehyde	Acetone
Acetone	Acetone	Dichloromethane
Xylene, total	Formaldehyde	Xylene, total
Ozone	Xylene,total	1,1,1-trichloroethane
	Ozone	Toluene

Source: ACGIH (2017) (See Informative Appendix P, "Informative References").

6.3.3.2 Perceived Indoor Air Quality. Zone outdoor airflow rates shall be sufficient to ensure that 80% or more of the people exposed do not express dissatisfaction with the quality of the air when tested as required in Section 7.3.2.

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

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

6.3.5 Documentation. Design documentation shall include the list of PM2.5, DCs, and DLs and mixtures thereof; outdoor source data; emission rates, including citations; cognizant authorities for any additional DCs; mass-balance calculations for each zone; and specifications for verification required by Section 7.3.

6.4 Natural Ventilation Procedure. Natural ventilation systems shall comply with the requirements of either Section 6.4.1 or 6.4.2. Designers shall provide interior air barriers, insulation, or other means that separate naturally ventilated spaces from mechanically cooled spaces to prevent high-dew-point outdoor air from coming into contact with mechanically cooled surfaces.

6.4.1 Prescriptive Compliance Path. Any zone designed for natural ventilation shall include a mechanical ventilation system designed in accordance with Section 6.2, Section 6.3, or both.

Exceptions to 6.4.1:

1. Zones in buildings that have all of the following:
   a. Natural ventilation openings that comply with the requirements of Section 6.4.1.
   b. Controls that prevent the natural ventilation openings from being closed during periods of expected occupancy, or natural ventilation openings that are permanently open.
2. Zones that are not served by heating or cooling equipment.

6.4.1.1 Ceiling Height. For ceilings that are parallel to the floor, the ceiling height (H) to be used in Sections 6.4.1.3 through 6.4.1.5 shall be the minimum ceiling height in the zone.

For zones wherein ceiling height increases as distance from the ventilation increases, the ceiling height shall be the average height of the ceiling determined over a distance not greater than 6 m (20 ft) from the openings.

6.4.1.2 Floor Area to Be Ventilated. The naturally ventilated area in zones or portions of zones shall extend from the openings to a distance determined by Sections 6.4.1.3, 6.4.1.4, or 6.4.1.5. Openings shall meet the requirements of Section 6.4.1.6. For zones where ceilings are not parallel to the floor, the ceiling height shall be determined in accordance with Section 6.4.1.1.

6.4.1.3 Single Side Opening. For zones with openings on only one side of the zone, the naturally ventilated area shall extend to a distance not greater that two times the height of the ceiling from the openings.

6.4.1.4 Double Side Opening. For zones with openings on two opposite sides of the zone, the naturally ventilated area shall extend between the openings separated by a distance not greater than five times the height of the ceiling.

6.4.1.5 Corner Openings. For zones with openings on two adjacent sides of a zone, the naturally ventilated area shall extend to a distance not greater than five times the height of the ceiling along a line drawn between the outside edges of the two openings that are the farthest apart. Floor area outside that line shall comply with Section 6.4.1.3 as a zone having openings on only one side of the zone.

Informative Note: "Floor area outside that line" refers to the remaining area of the zone that is not bounded by the walls that have the openings and the line drawn between the openings.

6.4.1.6 Location and Size of Openings. Zones or portions of zones to be naturally ventilated shall have a permanently open airflow path to openings directly connected to the outdoors. The minimum flow rate to the zone shall be determined in accordance with Section 6.2.1.1. This flow rate shall be used to determine the required openable area of openings, accounting only for buoyancy-driven flow. Wind-driven flow shall be used only where it can be demonstrated that the minimum flow rate is provided during all occupied hours. Openings shall be sized in accordance with Section 6.4.1.6.1 (Path A) or Section 6.4.1.6.2 (Path B).

Informative Note: *Permanently open airflow path* refers to pathways that would allow airflow unimpeded by partitions, walls, furnishings, etc.

6.4.1.6.1 Sizing Openings—Path A. Where the zone is ventilated using a single opening or multiple single openings located at the same elevation, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6-7. Where the zone is ventilated using two openings located at different elevations or multiple pairs of such openings, the openable area as a percent of the net occupiable floor area shall be greater than or equal to the value indicated in Table 6-8.

Where openings are obstructed by louvers or screens, the openable area shall be based on the net free area of the opening. Where interior zones, or portions of zones, without direct openings to the outdoors are ventilated through adjoining zones, the opening between zones shall be permanently unobstructed and have a free area of not less than twice the percent of occupiable floor area used to determine the opening size of adjacent exterior zones, or 25 ft^2 (2.3 m^2), whichever is greater.

Informative Note: Tables 6-7 and 6-8 are based solely on buoyancy-driven flow and have not been created to address thermal comfort.

6.4.1.6.2 Sizing Openings—Path B. The required openable area for a single zone shall be calculated using CIBSE AM10, Section 4.3.

6.4.2 Engineered System Compliance Path. For an engineered natural ventilation system, the designer shall

a. determine hourly environmental conditions, including outdoor air dry-bulb temperature; dew-point temperature; outdoor concentration of contaminants, including PM2.5, PM10, and ozone where data are available; wind speed and direction; and internal heat gains during expected hours of natural ventilation operation.

Table 6-7 Minimum Openable Areas: Single Openings [a]

$V_{bz}/A_z \le$, (L/s)/m²	$V_{bz}/A_z \le$, cfm/ft²	Total Openable Areas in Zone as a Percentage of A_z		
		$H_S/W_S \le 0.1$	$0.1 < H_S/W_S \le 1$	$H_S/W_S > 1$
1.0	0.2	4.0	2.9	2.5
2.0	0.4	6.9	5.0	4.4
3.0	0.6	9.5	6.9	6.0
4.0	0.8	12.0	8.7	7.6
5.5	1.1	15.5	11.2	9.8

where
V_{bz} = breathing zone outdoor airflow, per Table 6-1.
A_z = zone floor area, the net occupiable floor area of the ventilation zone.
W_S = aggregated width of all single outdoor openings located at the same elevation.
H_S = vertical dimension of the single opening or the least vertical dimension of the openings where there are multiple openings.

a. Volumetric airflow rates used to estimate required openable area are based on the following:
- Dry-air density of 0.075 lbda/ft³ (1.2 kgda/m³) at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C)
- Temperature difference between indoors and outdoors of 1.8°F (1°C)
- Gravity constant of 32.2 ft/s² (9.81 m/s²)
- Window discharge coefficient of 0.6

Table 6-8 Minimum Openable Areas: Two Vertically Spaced Openings [a]

$V_{bz}/A_z \le$, (L/s)/m²	$V_{bz}/A_z \le$, cfm/ft²	Total Openable Areas in Zone as a Percentage of A_z					
		$H_{vs} \le$ 8.2 ft (2.5 m)		8.2 ft (2.5m) < $H_{vs} \le$ 16.4 ft (5 m)		16.4 ft (5 m) < H_{vs}	
		$A_s/A_l \le 0.5$	$A_s/A_l > 0.5$	$A_s/A_l \le 0.5$	$A_s/A_l > 0.5$	$A_s/A_l \le 0.5$	$A_s/A_l > 0.5$
1.0	0.2	2.0	1.3	1.3	0.8	0.9	0.6
2.0	0.4	4.0	2.6	2.5	1.6	1.8	1.2
3.0	0.6	6.0	3.9	3.8	2.5	2.7	1.7
4.0	0.8	8.0	5.2	5.0	3.3	3.6	2.3
5.5	1.1	11.0	7.1	6.9	4.5	4.9	3.2

where
V_{bz} = breathing zone outdoor airflow, per Table 6-1.
A_z = zone floor area, the net occupiable floor area of the ventilation zone.
H_{vs} = vertical separation between the center of the top and bottom openings' free operable area; in case of multiple horizontally spaced pairs of openings, use shortest distance encountered.
A_s = openable area of smallest opening (top or bottom); in case of multiple horizontally spaced pairs of top-and-bottom openings, use aggregated areas.
A_l = openable area of largest opening (top or bottom); in case of multiple horizontally spaced pairs of top-and-bottom openings, use aggregated areas.

a. Volumetric airflow rates used to estimate required operable area are based on the following:
- Dry-air density of 0.075 lbda/ft³ (1.2 kgda/m³) at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C)
- Temperature difference between indoors and outdoors of 1.8°F (1°C)
- Gravity constant of 32.2 ft/s² (9.81 m/s²)
- Window discharge coefficient of 0.6

b. determine the effect of pressure losses along natural ventilation airflow paths on the resulting flow rates, including inlet openings, air transfer grills, ventilation stacks, and outlet openings during representative conditions of expected natural ventilation system use.

c. quantify natural ventilation airflow rates of identified airflow paths accounting for wind induced and thermally induced driving pressures during representative conditions of expected natural ventilation system use.

d. design to provide outdoor air in quantities sufficient to result in acceptable IAQ as established under Section 6.2.1.1 or 6.3 during representative conditions of expected natural ventilation system use.

6.4.3 Control and Accessibility. The means to open required openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems.

6.4.4 Documentation. Where the Natural Ventilation Procedure is used, the designer shall document the values and calculations that demonstrate conformance with the compliance path and the controls systems and sequences required for operation of the natural ventilation system, including coordination with mechanical ventilation systems. Where the Prescriptive Compliance Path is used for buildings located in an area where the national standard for one or more contaminants is exceeded, any design assumptions and calculations related to the impact on IAQ shall be included in the design documents.

6.5 Exhaust Ventilation. The Prescriptive Compliance Path or the Performance Compliance Path shall be used to meet the requirements of this section. Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air, or transfer air.

6.5.1 Prescriptive Compliance Path. The design exhaust airflow shall be determined in accordance with the requirements in Tables 6-2 and 6-3.

Exception to 6.5.1: Laboratory spaces that comply with all requirements of ANSI/AIHA Z9.5.

6.5.1.1 Laboratory Hoods. Exhaust from laboratory hoods shall be Air Class 4 unless determined otherwise by the EHS professional responsible to the owner or to the owner's designee.

6.5.1.2 Pressure Requirements. While the required exhaust systems are operating, the exhaust airflow of zones listed in Table 6-2 shall be larger than their respective supply airflow. If zones listed in Table 6-2 are adjacent, the difference between the exhaust and the supply airflow shall be larger for the zone with the higher number class of air.

Exception to 6.5.1.2: Where airflow offset requirements are established by the EHS professional responsible to the owner or owner's designee.

Informative Notes:

1. Exhaust systems are required for any occupancy category listed in Table 6-2.
2. Where intermittent operation is allowed in Table 6-2, exhaust equipment is intended to be operated when the space is in use.

6.5.2 Performance Compliance Path. The exhaust airflow shall be determined in accordance with the following subsections.

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

6.5.2.2 Contaminant Concentration. For each contaminant of concern, a concentration limit and its corresponding exposure period and an appropriate reference to a cognizant authority shall be specified.

6.5.2.3 Monitoring and control systems shall be provided to automatically detect contaminant levels of concern and modulate exhaust airflow such that contaminant levels are maintained at not greater than the specified contaminant concentration limits.

6.6 Design Documentation Procedures. Design criteria and assumptions shall be documented and made available for operation of the system after installation. See Sections 4.3, 5.10.3, 5.13.4, 6.2.6.1.5, 6.3.5, and 6.4.4 regarding assumptions to be detailed in the documentation.

7. CONSTRUCTION AND SYSTEM START-UP

Compliance with Sections 7.1 and 7.2 is required for all buildings. Section 7.3 is required for buildings designed under the Indoor Air Quality Procedure in Section 6.3.

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.

Informative Note: Examples of acceptable measures include, but are not limited to, sealing the construction area using temporary walls or plastic sheathing, exhausting the construction area, 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 ANSI/SMACNA 006, *HVAC Duct Construction Standards—Metal and Flexible*:
   - Section S1.9 of Section 1.3.1, "Duct Construction and Installation Standards"
   - Section 7.4, "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 9.1, "Casing and Plenum Construction Standards"

b. All sections of SMACNA's *Fibrous Glass Duct Construction Standards*
c. NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*
d. NFPA 90B, *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 and Verification of Outdoor Air Performance. Ventilation systems shall be balanced in accordance with ASHRAE Standard 111 or another applicable national standard so as to verify conformance with the total outdoor airflow requirements of this standard (V_{ot}).

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 operating conditions that are the most restrictive to condensate flow to demonstrate proper drainage.

Exception to 7.2.3: 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.

Informative Note: Above conditions usually occur at full fan airflow for draw-through fans and minimum fan airflow for blow-through fans.

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 demonstrate that outdoor air dampers operate 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 operations and maintenance (O&M) manual describing basic data relating to the O&M 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

7.3 Indoor Air Quality Procedure Verification

7.3.1 Objective Evaluation. Perform design compound (DC) and PM2.5 measurement in the completed building to verify that design limits (DLs) are met. The peak concentration over an 8-hour occupied period shall not exceed the DL for carbon monoxide.

For ozone and PM2.5, the average concentration measured over an 8-hour occupied period shall not exceed the DL.

Table 7-1 Allowed Laboratory Test Methods

Compound	Allowed Test Methods
VOCs except formaldehyde, acetaldehyde and acetone	ISO 16000-6; EPA IP-1, EPA TO-17; ISO 16017-1; ISO 16017-2; ASTM D6345-10
Formaldehyde, acetaldehyde and acetone	ISO 16000-3; EPA TO-11; EPA IP-6; ASTM D5197
Carbon monoxide	ISO 4224; EPA IP-3

Table 7-2 Direct Reading Instruments Minimum Specifications

	Ozone	PM2.5	Carbon Monoxide
Accuracy (±)	5 ppb	Greater of 5 μg /m^3 or 20% of reading	Greater of 3 ppm or 20% of reading
Resolution (±)	1 ppb	5 μg/m^3	1 ppm

Table 7-3 Number of Measurements Points

Total Occupied Floor Area, ft^2 (m^2)	Number of Measurements
≤25,000 (2500)	1
>25,000 (2500) and ≤50,000 (5000)	2
>50,000 (5000) and ≤100,000 (10,000)	4
>100,000 (10,000)	6

For all other compounds, the concentration measured over the maximum period allowed by the test method up to 8 hours shall not exceed the DL for each DC. For DC mixtures, the mixture calculation shall be less than 1.0. The concentrations shall be measured using the relevant laboratory methods specified in Table 7-1. Inorganic compounds and PM2.5 may be measured instead using direct-read instruments that are calibrated in accordance with the device manufacturer's recommendations, are capable of measuring below the DL, and that follow the performance requirements specified in Table 7-2.

7.3.1.1 Design Compounds and PM2.5 Measurement Test. The measurement equipment shall be positioned in the breathing zone. The measurement shall be conducted with the HVAC system in normal operation and lowest outdoor air intake setting expected during the year. The number of measurement points shall be specified according to Table 7-3.

7.3.2 Subjective Evaluation. Using a subjective occupant evaluation conducted in the completed building, the survey test results shall demonstrate occupant level of acceptability of 80% or more within each zone served by the system.

Informative Note: Informative Appendix N presents one approach to subjective occupant evaluation.

Exception to 7.3.1 and 7.3.2: Objective and subjective evaluation are not required for every substantially similar zone. The minimum outdoor airflow rates shall be not less than those found in accordance with Sections 7.3.1 and 7.3.2 for a substantially similar zone.

Informative Note: For example, in a building with 100 single-person private offices of the same area, it is not necessary to perform an objective and subjective evaluation in each office as long as the minimum outdoor airflow for each office is greater than or equal to the airflow in the office that is tested according to Section 7.3.2. A ventilation zone is similar by definition if it has the same occupancy category (see Table 6-1), occupant density, zone air distribution effectiveness (see Section 6.2.1.2), and design zone primary airflow (see Section 6.2.4.3.2 and Normative Appendix A) per unit area.

7.3.3 Documentation. Documentation shall include methodology of testing, test results and any adjustments to design outdoor air from the values determined in Section 6.3, if applicable.

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 Building Alterations or Change of Use. When buildings are altered or when changes in building use, occupant category, significant change in occupant density, or other changes inconsistent with system design assumptions are made, the ventilation system design, operation, and maintenance shall be reevaluated and the O&M manual updated as necessary.

8.2 O&M Manual. An 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 the O&M procedures, ventilation system operating schedules and any changes made thereto, final design drawings, maintenance schedules based on manufacturer's instructions, and the maintenance requirements and frequencies provided in Table 8-1.

8.3 Ventilation System Operation. Mechanical and natural ventilation systems shall be operated in a manner consistent with the O&M manual. Systems shall be operated such that spaces are ventilated in accordance with Section 6 during periods of expected occupancy.

8.4 Ventilation System Maintenance. The building ventilation system components shall be maintained in accordance with the O&M manual.

Table 8-1 Minimum Maintenance Activity and Frequency for Ventilation System Equipment and Associated Components

Inspection/Maintenance Task	Frequency [a]
a. Investigate system for water intrusion or accumulation. Rectify as necessary.	As necessary
b. Verify that the space provided for routine maintenance and inspection of open cooling tower water systems, closed cooling tower water systems, and evaporative condensers is unobstructed.	Monthly
c. Open cooling tower water systems, closed cooling tower water systems, and evaporative condensers shall be treated to limit the growth of microbiological contaminants, including *legionella sp.*	Monthly
d. Verify that the space provided for routine maintenance and inspection of equipment and components is unobstructed.	Quarterly
e. Check pressure drop and scheduled replacement date of filters and air-cleaning devices. Clean or replace as necessary to ensure proper operation.	Quarterly
f. Check ultraviolet lamp. Clean or replace as needed to ensure proper operation.	Quarterly
g. Visually inspect dehumidification and humidification devices. Clean and maintain to limit fouling and microbial growth. Measure relative humidity and adjust system controls as necessary.	Quarterly
h. Maintain floor drains and trap primer located in air plenums or rooms that serve as air plenums to prevent transport of contaminants from the floor drain to the plenum.	Semiannually
i. Check ventilation and IAQ related control systems and devices for proper operation. Clean, lubricate, repair, adjust, or replace as needed to ensure proper operation.	Semiannually
j. Check P-traps in floor drains located in plenums or rooms that serve as air plenums. Prime as needed to ensure proper operation.	Semiannually
k. Check fan belt tension. Check for belt wear and replace if necessary to ensure proper operation. Check sheaves for evidence of improper alignment or evidence of wear and correct as needed.	Semiannually
l. Check variable-frequency drive for proper operation. Correct as needed.	Semiannually
m. Check for proper operation of cooling or heating coil for damage or evidence of leaks. Clean, restore, or replace as required.	Semiannually
n. Visually inspect outdoor air intake louvers, bird screens, mist eliminators, and adjacent areas for cleanliness and integrity; clean as needed; remove all visible debris or visible biological material observed and repair physical damage to louvers, screens, or mist eliminators if such damage impairs the item from providing the required outdoor air entry.	Semiannually
o. Visually inspect natural ventilation openings and adjacent areas for cleanliness and integrity; clean as needed. Remove all visible debris or visible biological material observed and repair physical damage to louvers, and screens if such damage impairs the item from providing the required outdoor air entry. Manual and/or automatic opening apparatus shall be physically tested for proper operation and repaired or replaced as necessary.	Semiannually

a. Minimum frequencies may be increased or decreased if indicated in the O&M manual.

Table 8-1 Minimum Maintenance Activity and Frequency for Ventilation System Equipment and Associated Components *(Continued)*

Inspection/Maintenance Task	Frequency [a]
p. Verify the operation of the outdoor air ventilation system and any dynamic minimum outdoor air controls.	Annually
q. Check air filter fit and housing seal integrity. Correct as needed.	Annually
r. Check control box for dirt, debris, and/or loose terminations. Clean and tighten as needed.	Annually
s. Check motor contactor for pitting or other signs of damage. Repair or replace as needed.	Annually
t. Check fan blades and fan housing. Clean, repair, or replace as needed to ensure proper operation.	Annually
u. Check integrity of all panels on equipment. Replace fasteners as needed to ensure proper integrity and fit/finish of equipment.	Annually
v. Assess field serviceable bearings. Lubricate if necessary.	Annually
w. Check drain pans, drain lines, and coils for biological growth. Check adjacent areas for evidence of unintended wetting. Repair and clean as needed.	Annually
x. Check for evidence of buildup or fouling on heat exchange surfaces. Restore as needed to ensure proper operation.	Annually
y. Inspect unit for evidence of moisture carryover from cooling coils beyond the drain pan. Make corrections or repairs as necessary.	Annually
z. Check for proper damper operation. Clean, lubricate, repair, replace, or adjust as needed to ensure proper operation.	Annually
aa. Visually inspect areas of moisture accumulation for biological growth. If present, clean or disinfect as needed.	Annually
ab. Check condensate pump. Clean or replace as needed.	Annually
ac. Visually inspect exposed ductwork and external piping for insulation and vapor barrier for integrity. Correct as needed.	Annually
ad. Verify the accuracy of permanently mounted sensors whose primary function is outdoor air delivery monitoring, outdoor air delivery verification, or dynamic minimum outdoor air control, such as flow stations at an air handler and those used for demand controlled ventilation, including CO_2 sensors. A sensor failing to meet the accuracy specified in the O&M manual shall be recalibrated or replaced. Performance verification shall include output comparison to a measurement reference standard consistent with those specified for similar devices in ASHRAE Standard 41.2 or ASHRAE Standard 111.	5 years
ae. Verify the total quantity of outdoor air delivered by air handlers set to minimum outdoor air mode. If measured minimum airflow rates are less than the design minimum rate documented in the O&M manual, ± a 10% balancing tolerance, (1) confirm the measured rate does not conform with the provisions of this standard and (2) adjust or modify the air-handler components to correct the airflow deficiency. Ventilation systems shall be balanced in accordance with ASHRAE Standard 111 or its equivalent, at least to the extent necessary to verify conformance with the total outdoor airflow and space supply airflow requirements of this standard. **Exception:** Units under 2000 cfm (1000 L/s) of supply air are exempt from this requirement.	5 years

a. Minimum frequencies may be increased or decreased if indicated in the O&M manual.

9. NORMATIVE REFERENCES

		Section
Air Conditioning, Heating and Refrigeration Institute (AHRI) **2311 Wilson Blvd., Arlington, VA 22201** **(+1) 703-524-8800; www.ahrinet.org**		
AHRI 1060 (2018)	Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment	5.13.3.2.5, 5.13.3.3.2
Air Movement and Control Association International, Inc. (AMCA) **30 West University Drive** **Arlington Heights, IL 60004-1893, United States** **1-847-394-0150; www.amca.org**		
AMCA 500-L-15	Laboratory Methods of Testing Louvers for Rating	5.4.2
American Industrial Hygiene Association (AIHA) **3141 Fairview Park Drive, Suite 777** **Falls Church, VA 22042, United States** **(703) 849-8888; www.aiha.org**		
ANSI/AIHA Z9.5-2012	Standard for Laboratory Ventilation	5.4.1.4, 6.2.1.1.5, 6.5.1, B1.1
ASHRAE **1791 Tullie Circle NE** **Atlanta, GA 30329, United States** **1-404-636-8400; www.ashrae.org**		
ANSI/ASHRAE Standard 41.2 (2018)	Standard Methods for Air Velocity and Airflow Measurement	Table 8-1
ANSI/ASHRAE Standard 52.2 (2017)	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size	5.5, 6.1.4.1, 6.1.4.2
ANSI/ASHRAE Standard 111-2008 (RA 2017)	Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems	7.2.2, Table 8-1
ANSI/ASHRAE/ASHE Standard 170 (2017)	Ventilation for Health Care Facilities	6.2.1
ANSI/ASHRAE Standard 188 (2018)	Legionellosis: Risk Management for Building Water Systems	5.20
ASTM International **100 Barr Harbor Dr.** **West Conshohocken, PA 19428-2959, United States** **1-610-832-9585; www.astm.org**		
ASTM C1338 (2014)	Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings	5.11.1
ASTM D3273 (2016)	Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber	5.11.1
ASTM D6345 (2010)	Standard Guide for Selection of Methods for Active, Integrative Sampling of Volatile Organic Compounds in Air	Table 7-1
ASTM D5197 (2016)	Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology)	Table 7-1
Chartered Institution of Building Services Engineers (CIBSE) **222 Balham High Road** **London** **SW12 9BS** **United Kingdom** **+44 (0)20 8675 5211; www.cibse.org**		
CIBSE AM10 (2005)	Natural Ventilation in Non-Domestic Buildings	6.4.1.6.2
Facility Guidelines Institute (FGI) **https://fgiguidelines.org**		
2018	Guidelines for Design and Construction of Outpatient Facilities	3.1

		Section
International Organization for Standardization (ISO) **ISO Central Secretariat, 1 rue de Varembee, Case postale 56** **CH-1211 Geneva 20, Switzerland** **+41-22-749-01-11; www.iso.org**		
ISO 4224 (2000)	Ambient air—Determination of carbon monoxide—Non-dispersive infrared spectrometric method	Table 7-1
ISO 16000-3 (2011)	Indoor air—Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air—Active sampling method	Table 7-1
ISO 16000-6 (2011)	Indoor air—Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID	Table 7-1
ISO 16017-1 (2000)	Indoor, ambient and workplace air—Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography—Part 1: Pumped sampling	Table 7-1
ISO 16017-2 (2003)	Indoor, ambient and workplace air—Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography—Part 2: Diffusive sampling	Table 7-1
ISO 16890 (2016)	Air Filters for General Ventilation	5.5, 6.1.4.1, 6.1.4.2
National Fire Protection Association (NFPA) **1 Battery March Park** **Quincy, MA 02169-7471** **United States** **1-617-770-0700; www.nfpa.org**		
ANSI Z223.1/NFPA 54 (2018)	National Fuel Gas Code	5.4.1.2
NFPA 31 (2016)	Standard for the Installation of Oil-Burning Equipment	5.4.1.2
NFPA 45 (2015)	Standard on Fire Protection for Laboratories Using Chemicals	B1.1
NFPA 90A (2018)	Standard for the Installation of Air-Conditioning and Ventilating Systems	7.1.5
NFPA 90B (2018)	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems	7.1.5
NFPA 211 (2019)	Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances	5.4.1.2
National Institutes of Health (NIH) **9000 Rockville Pike, Bethesda, Maryland 20892** **(301) 496-4000; www.nih.gov**		
2020	Biosafety in Microbiological and Biomedical Laboratories	3.1
NSF International **789 Dixboro Road** **Ann Arbor, MI 48105, United States** **734-769-8010; www.nsf.org; info@nsf.org**		
NSF/ANSI Standard 60 (2016)	Drinking Water Treatment Chemicals—Health Effects	5.8.1
Sheet Metal and Air Conditioning Contractors National Association (SMACNA) **4201 Lafayette Center Drive** **Chantilly, VA 20151, Unites States** **1-703-803-2980**		
	Fibrous Glass Duct Construction Standards, 7th Edition (2003)	7.1.5
ANSI/SMACNA 006 (2006)	HVAC Duct Construction Standards—Metal and Flexible, 3rd Edition	7.1.5
ANSI/SMACNA 016 (2012)	HVAC Air Duct Leakage Test Manual, 2nd Edition	5.14.2

		Section
Underwriters Laboratories, LLC. (UL) **333 Pfingsten Road** **Northbrook, IL 60062, United States** **847-272-8800; www.ul.com; cec.us@us.ul.com**		
UL 181 (2013)	Factory-Made Air Ducts and Air Connectors, 11th Edition	5.11.1, 5.11.2
UL 1995 (2015)	Heating and Cooling Equipment, 5th Edition	5.4.2, 5.4.3
UL 2998 (2016)	Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions from Air Cleaners	5.9.1
United States Environmental Protection Agency (EPA) **Ariel Rios Building** **1200 Pennsylvania Avenue, NW** **Washington, DC 20460, United States** **1-919-541-0800; www.epa.gov** **ENERGY STAR ® 1-888-782-7937** **WaterSense 1-866-987-7367 and 1-202-564-2660**		
EPA IP-1 (1990)	Determination of Volatile Organic Compounds (VOCs) in Indoor Air in Compendium of Methods for the Determination of Air Pollutants in Indoor Air	Table 7-1
EPA IP-3 (1990)	Determination of Carbon Monoxide (CO) or Carbon Dioxide (CO2) in Indoor Air in Compendium of Methods for the Determination of Air Pollutants in Indoor Air	Table 7-1
EPA IP-6 (1990)	Determination of Formaldehyde or other Aldehydes in Indoor Air in Compendium of Methods for the Determination of Air Pollutants in Indoor Air	Table 7-1
EPA TO-11 (1999)	Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance Liquid Chromatography (HPLC) [Active Sampling Methodology] in Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (Second Edition)	Table 7-1
EPA TO-17 (1999)	Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes in Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (Second Ed.)	Table 7-1
U.S. Government Printing Office (USGPO) **732 North Capitol St. NW** **Washington, DC 20401** **202-512-1800; www.gpo.gov**		
21 CFR 173.310 (2018)	Secondary Direct Food Additives Permitted in Food for Human Consumption—Boiler Water Additives	5.8.1
29 CFR 1910.1200	Hazard Communication Standard	3.1
40 CFR 50 (2018)	National Primary and Secondary Ambient Air Quality Standards	4.1.1, Table 6-5, Table 6-6, 6.1.4.1, 6.1.4.2

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

NORMATIVE APPENDIX A
MULTIPLE-ZONE SYSTEM VENTILATION EFFICIENCY: ALTERNATIVE PROCEDURE

This appendix presents an alternative procedure for calculating the system ventilation efficiency (E_v) for multiple-zone recirculating systems that must be used when Section 6.2.4.3 is 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-2). Figure A-1 contains a ventilation system schematic depicting most of the quantities used in this appendix.

A1. SYSTEM VENTILATION EFFICIENCY

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

A1.1 Average Outdoor Air Fraction. The average outdoor air fraction (X_s) for the ventilation system shall be determined in accordance with Equation A-1.

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

where the uncorrected outdoor air intake (V_{ou}) is found in accordance with Section 6.2.4.1, and the system primary airflow (V_{ps}) is found at the condition analyzed.

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

A1.2 Zone Ventilation Efficiency. The zone ventilation efficiency (E_{vz}) shall be determined in accordance with Sections A1.2.1 or A1.2.2.

A1.2.1 Single Supply Systems. For single supply systems, wherein all of the air supplied to each ventilation zone is a mixture of outdoor air and system-level recirculated air, zone ventilation efficiency (E_{vz}) shall be determined in accordance with Equation A-2. Examples of single supply systems include constant-air-volume reheat, single-duct VAV, single-fan dual-duct, and multiple-zone systems.

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

where the average outdoor air fraction for the system (X_s) is determined in accordance with Equation A-1, and the primary outdoor air fraction for the zone (Z_{pz}) is determined in accordance with Equation A-3.

$$Z_{pz} = V_{oz}/V_{pz} \qquad \text{(A-3)}$$

For VAV systems, V_{pz} is the lowest zone primary airflow value expected at the design condition analyzed.

A1.2.2 Secondary Recirculation Systems. For secondary recirculation systems wherein all or part of the supply air to each ventilation zone is recirculated air (air that has not been directly mixed with outdoor air) from other zones, zone ventilation efficiency (E_{vz}) shall be determined in accordance with Equation A-4. Examples of secondary recirculation systems include dual-fan dual-duct and fan-powered mixing-box systems and systems that include transfer fans for conference rooms.

$$E_{vz} = (F_a + X_s \times F_b - Z_{pz} \times E_p \times F_c)/F_a \qquad \text{(A-4)}$$

where system air fractions F_a, F_b, and F_c are determined in accordance with Equations A-5, A-6, and A-7, respectively.

$$F_a = E_p + (1 - E_p) \times E_r \qquad \text{(A-5)}$$

$$F_b = E_p \qquad \text{(A-6)}$$

$$F_c = 1 - (1 - E_z) \times (1 - E_r) \times (1 - E_p) \qquad \text{(A-7)}$$

Where the zone primary air fraction (E_p) is determined in accordance with Equation A-8, zone secondary recirculation fraction (E_r) is determined by the designer based on system configuration, and zone air distribution effectiveness (E_z) is determined in accordance with Section 6.2.1.2.

$$E_p = V_{pz}/V_{dz} \qquad \text{(A-8)}$$

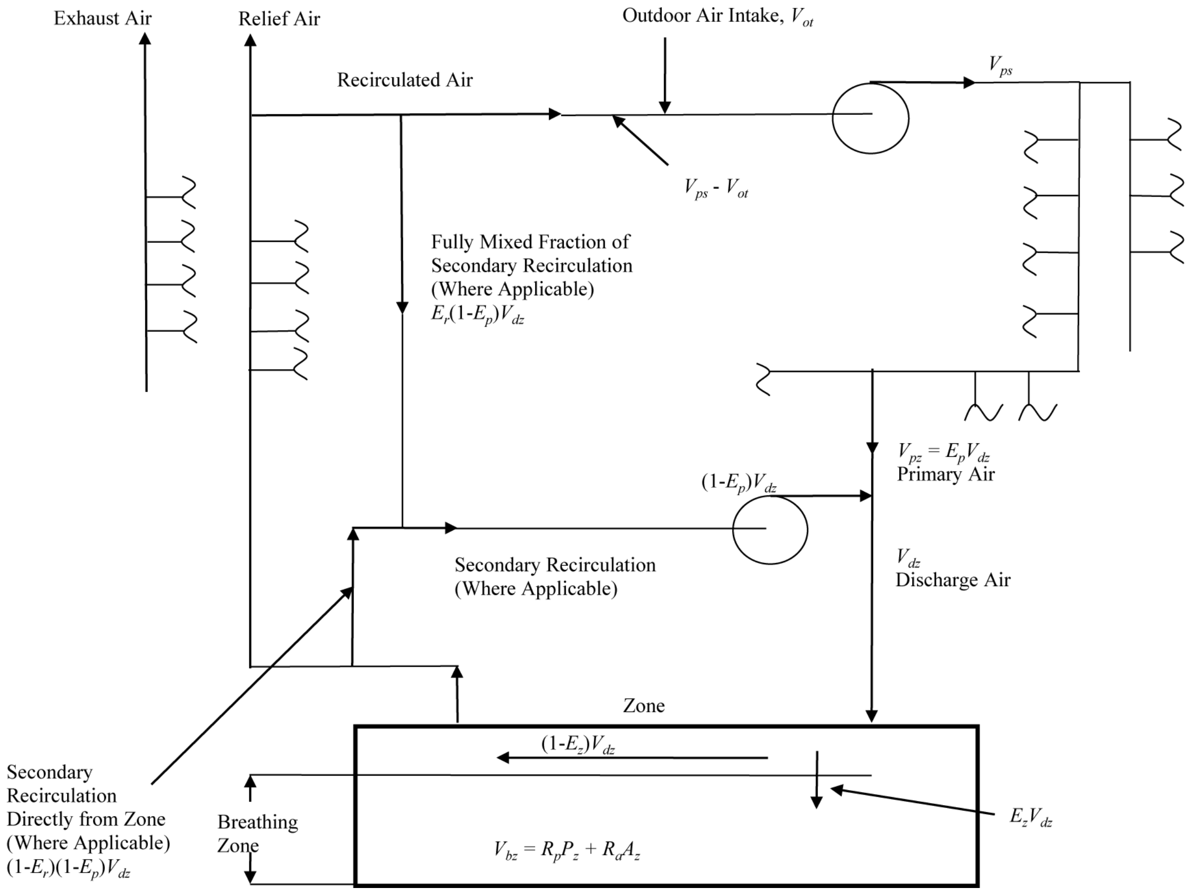

Figure A-1 Ventilation system schematic.

where V_{dz} is zone discharge airflow.

Informative Notes:

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

A1.3 System Ventilation Efficiency. The system ventilation efficiency shall equal the lowest zone ventilation efficiency among all ventilation zones served by the air handler in accordance with Equation A-9.

$$E_v = \text{minimum } (E_{vz}) \tag{A-9}$$

A2. DESIGN PROCESS

The system ventilation efficiency and therefore the outdoor air intake flow for the system (V_{ot}) determined as part of the design process are based on the design and minimum expected supply airflows to individual ventilation zones as well as the design outdoor air requirements to the zones. For VAV system design purposes, zone ventilation efficiency (E_{vz}) for each ventilation zone shall be found using the minimum expected zone primary airflow (V_{pz}) and using the highest expected system primary airflow (V_{ps}) at the design condition analyzed.

Informative Note: Increasing the zone supply airflow values during the design process, particularly to the critical zones requiring the highest fraction of outdoor air, reduces the system outdoor air intake flow requirement determined in the calculation.

A2.1 Selecting Zones for Calculation. Zone ventilation efficiency (E_{vz}) shall be calculated for all ventilation zones.

Exception to A2.1: Because system ventilation efficiency (E_v) is determined by the minimum value of the zone ventilation efficiency (E_{vz}) in accordance with Equation A-9, calculation of E_{vz} is not required for any ventilation zone that has an E_{vz} value that is equal to or larger than that of the ventilation zone for which a calculation has been made.

Informative Note: The value of E_{vz} for a ventilation zone will be equal to or larger than that for another ventilation zone if all of the following are true relative to the other ventilation zone:

a. Floor area per occupant (A_z/P_z) is no lower.
b. Minimum zone discharge airflow rate per unit area (V_{dz}/A_z) is no lower.
c. Primary air fraction (E_p) is no lower.
d. Zone air distribution effectiveness (E_z) is no lower.
e. Area outdoor air rate (R_a) is no higher.
f. People outdoor air rate (R_p) is no higher.

A3. SYMBOLS

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

D ***occupant diversity:*** ratio of the system population to the sum of the zone populations.

E_p ***primary air fraction:*** fraction of primary air in the discharge air to the ventilation zone.

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

E_v ***system ventilation efficiency:*** 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 airstream.

E_{vz} ***zone ventilation efficiency:*** efficiency with which the system distributes air from the outdoor air intake to the breathing zone in any particular ventilation zone.

E_z ***zone air distribution effectiveness:*** a measure of the effectiveness of supply air distribution to the breathing zone. E_z is determined in accordance with Section 6.2.1.2 or Normative Appendix C.

F_a ***supply air fraction:*** fraction of supply air to the ventilation zone that includes sources of air from outside the zone.

F_b ***mixed-air fraction:*** fraction of supply air to the ventilation zone from fully mixed primary air.

F_c ***outdoor air fraction:*** fraction of outdoor air to the ventilation zone that includes sources of air from outside the zone.

P_s ***system population:*** simultaneous number of occupants in the area served by the ventilation system.

P_z ***zone population:*** see Section 6.2.1.1.

R_a ***area outdoor air rate:*** see Section 6.2.1.1.

R_p ***people outdoor air rate:*** see Section 6.2.1.1.

V_{bz} ***breathing zone outdoor airflow:*** see Section 6.2.1.1.

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

V_{ot} ***outdoor air intake flow:*** see Sections 6.2.2, 6.2.3, and 6.2.4.4.

V_{ou} ***uncorrected outdoor air intake:*** see Section 6.2.4.1.

V_{oz} ***zone outdoor airflow:*** see Section 6.2.1.3.

V_{ps} ***system primary airflow:*** 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_{pz} ***zone primary airflow:*** zone primary airflow to the ventilation zone, including outdoor air and recirculated air.

X_s ***average outdoor air fraction:*** at the primary air handler, the fraction of outdoor air intake flow in the system primary airflow.

Z_{pz} ***primary outdoor air fraction:*** outdoor air fraction required in the primary air supplied to the ventilation zone prior to the introduction of any secondary recirculation air.

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

NORMATIVE APPENDIX B
SEPARATION OF EXHAUST OUTLETS AND OUTDOOR AIR INTAKES

B1. GENERAL

This appendix presents an alternative procedure for determining separation distance between outdoor air intakes and exhaust air and vent outlets. This analytical method can be used instead of Table 5-1.

Exhaust air and vent outlets, as defined in Table 5-1, shall be located no closer to outdoor air intakes, or to 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 to the operable window, skylight, or door opening, along a trajectory as if a string were stretched between them.

B1.1 Application. Laboratory fume hood exhaust air outlets shall be in compliance with NFPA 45 and ANSI/AIHA Z9.5. Nonlaboratory exhaust outlets and outdoor air intakes or other openings shall be separated in accordance with the following.

B1.2 Outdoor Air Intakes. The minimum separation distance between exhaust air/vent outlets, as defined in Table 5-1, and outdoor air intakes to mechanical ventilation systems, or to 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 B2.

Exception to B1.2: Separation distances do not apply when exhaust and outdoor air intake systems are controlled such that they cannot operate simultaneously.

B1.3 Other Building Openings. The 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 B2. The minimum separation distance between either Class 3, Class 4, cooling tower, or combustion appliance/equipment exhaust air/vent outlets and operable openings to occupiable spaces shall be equal to the distance (*L*) determined in accordance with Section B2.

B1.4 Additional Limitations for Noxious or Dangerous Air. The 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 B2; no credit may be taken for any vertical separation.

B1.5 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 to B1.5: Exhaust air designated as Class 1 or Class 2.

B1.6 Property Lines. The minimum separation distance between exhaust air/vent outlets and property lines shall be half of the distance (*L*) determined in accordance with Section B2.

Exception to B1.6: For Class 3, Class 4, or combustion appliance/equipment exhaust air, where the property line abuts a street or other public way, no minimum separation is required if exhaust termination is at least 10 ft (3 m) above grade.

B2. DETERMINING DISTANCE *L*

The minimum separation distance (*L*) shall be determined using one of the following three approaches.

B2.1 Simple Method. A value of *L* in Table B-1 shall be used.

B2.2 Velocity Method. The value of *L* shall be determined using Equation B-1 (I-P) or B-2 (SI).

$$L = 0.09 \times \sqrt{Q} \times (\sqrt{\mathrm{DF}} - U/400)\ [\mathrm{ft}] \tag{B-1}$$

$$L = 0.04 \times \sqrt{Q} \times (\sqrt{\mathrm{DF}} - U/2)\ [\mathrm{m}] \tag{B-2}$$

where

Q = exhaust airflow rate, 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

Table B-1 Minimum Separation Distance

Exhaust Air Class (See Section 5.13)	Separation Distance (*L*), ft (m)
Significant contaminant or odor intensity (Class 3)	15 (5)
Noxious or dangerous particles (Class 4)	30 (10)

Table B-2 Exhaust Air Discharge Velocity

Exhaust Direction/Configuration	Exhaust Air Discharge Velocity (*U*) Modifier
Exhaust is directed away from the outdoor air intake at an angle that is greater than 45 degrees from the direction of a line drawn from the closest exhaust point to the edge of the intake.	*U* given a positive value.
Exhaust is directed toward the intake bounded by lines drawn from the closest exhaust point to the edge of the intake.	*U* given a negative value.
Exhaust is directed at an angle between the two above cases.	*U* is zero.
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.	*U* is zero.
Hot-gas exhausts such as combustion products if the exhaust stream is aimed directly upward and unimpeded by devices such as flue caps or louvers.	Add 500 fpm (2.5 m/s) upward velocity to *U*.

Table B-3 Minimum Dilution Factors

Exhaust Air Class (See Section 5.13)	Dilution Factor
Significant contaminant or odor intensity (Class 3)	15
Noxious or dangerous particles (Class 4)	50 [a]

a. Does not apply to fume hood exhaust. See Section B1.1.

million Btu/h (0.43 L/s per kW) of combustion input (or obtain actual rates from the combustion appliance manufacturer).

U = exhaust air discharge velocity, fpm (m/s). As shown in Figure B-1, U shall be determined using Table B-2.

DF = dilution factor, which is the ratio of outdoor airflow to entrained exhaust airflow in the outdoor air intake. The minimum dilution factor shall be determined as a function of exhaust air class in Table B-3.

For exhaust air comprising more than one class of air, the dilution factor shall be determined by averaging the dilution factors by the volume fraction of each class using Table B-3:

$$\mathrm{DF} = \sum (\mathrm{DF}_i \times Q_i)/\sum Q_i \qquad \text{(B-3)}$$

where

DF_i = dilution factor from Table B-3 for class i air

Q_i = volumetric flow rate of class i air in the exhaust airstream

B2.3 Concentration Method. Determine the acceptable concentration for health (C_{health}) and odor (C_{odor}) for each emitted chemical, compound, or mixture.

Design the exhaust and intake systems such that the maximum concentration at the intake (C_{max}) is less than the acceptable concentrations of all evaluated compounds and mixtures.

$$C_{max} < C_{health} \qquad \text{(B-4)}$$

$$C_{max} < C_{odor} \qquad \text{(B-5)}$$

At a minimum, determination of C_{max} shall consider wind speed, wind direction, exhaust exit velocity and momentum, geometry of building and adjacent structures, and architectural screens. Wind tunnel modeling is an acceptable design method.

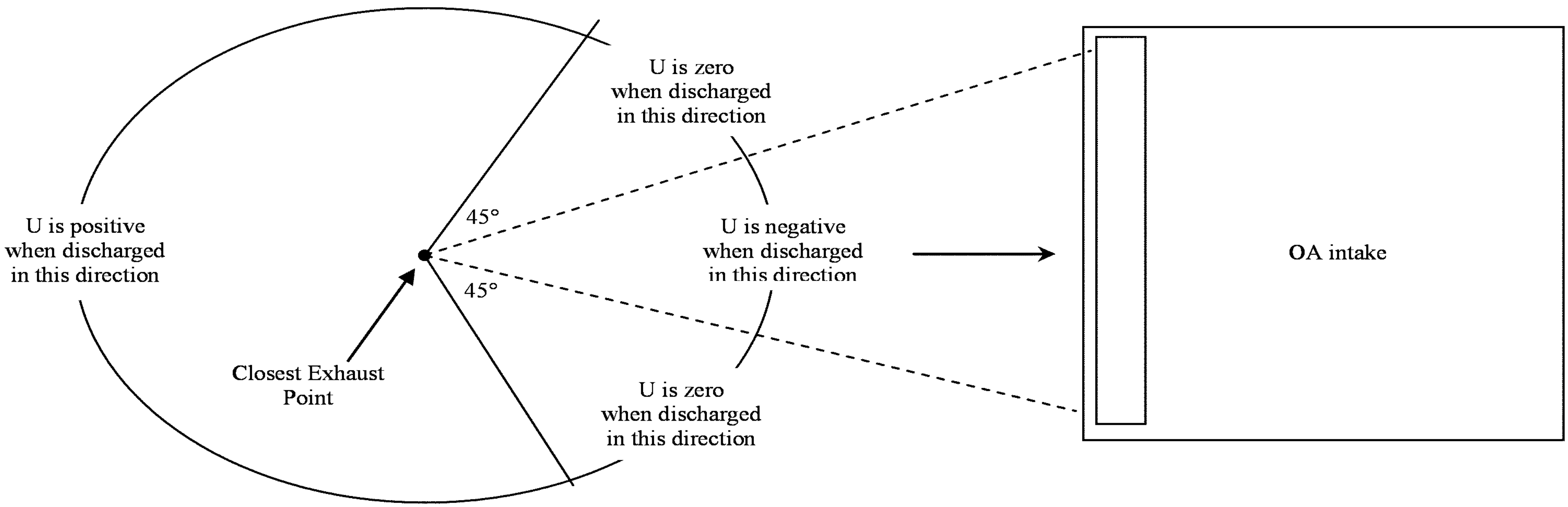

Figure B-1 Exhaust air discharge velocity (*U*).

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

NORMATIVE APPENDIX C
ZONE AIR DISTRIBUTION EFFECTIVENESS: ALTERNATIVE PROCEDURES

This appendix provides a procedure for determining zone air distribution effectiveness (E_z) for all system types.

Informative Note: Table 6-4 provides default values of E_z that are permitted to be used for the air distribution configurations described in the table. The reference E_z value of 1 is typical of ideal mixing in the zone. The strategy of removing contaminants or displacing contaminants from the breathing zone may result in an effective E_z value greater than unity, which is typical of stratified systems.

C1. ZONE AIR DISTRIBUTION EFFECTIVENESS

Zone air distribution effectiveness shall be calculated in accordance with Equation C-1:

$$E_z = (C_e - C_s)/(C - C_s) \tag{C-1}$$

where

E_z = zone air distribution effectiveness

C = average contaminant concentration at the breathing zone

C_e = average contaminant concentration at the exhaust

C_s = average contaminant concentration at the supply

C1.1 Personalized Ventilation Systems. For the purpose of calculating zone air distribution effectiveness for personalized ventilation systems, the breathing zone shall be 9 ft^2 (0.8 m^2) centered on each occupant with a height of 4.5 ft (1.4 m) from the floor.

C2. MODELED AIR DISTRIBUTION SYSTEM

C2.1 Computational Model. The computational fluid dynamics model for calculating zone air distribution effectiveness shall be in accordance with the following subsections.

C2.1.1 Computational Domain. The computational domain shall comprise all sensible heat sources, all major obstructions to airflow, and all air distribution devices. The calculation domain shall include all boundary walls.

C2.1.2 Solution Variables. Analysis shall include the solutions for fluid flow, heat transfer, and chemical species transport. The buoyancy (gravitational) effects shall be included in the calculation procedure.

C2.1.3 Boundary Conditions. Sensible heat sources shall be permitted to be modeled as volumetric heat sources to allow the air to pass through the source or as hollow blocks (no mesh inside) specified with either heat flux or constant temperature on the surfaces of the blocks. Boundary walls shall be modeled as adiabatic (zero heat flux), specified heat flux, or specified temperature boundary.

C2.1.4 Species Transport. The sources shall be modeled as volumetric source or a boundary flux with known generation rate with zero release velocity. The analysis shall be performed with a uniformly distributed source at the breathing zone level of the occupants. All the boundary walls shall be modeled as impermeable to the chemical species.

Informative Note: The species modeled should be a tracer gas, such as CO_2. Discretion is left to the modeler to determine the appropriate model depending on the design compounds in the zone.

C2.1.5 Turbulence Model. Reynolds (ensemble) averaging turbulence models shall be used.

Informative Note: Renormalization group and realizable k-ε models meet the requirements of this section.

C2.1.6 Computational Mesh. A fine mesh shall be generated near the sensible heat sources, such as occupants and computers, to resolve the thermal plume surrounding these sources. The fine mesh shall be generated on all supply air and return air locations.

C2.1.7 Solution Convergence. The solution convergence levels shall include the monitoring of relevant physical quantities, such as temperature or species concentration, at strategic locations. The globally scaled residuals shall be decreased to10^{-3} for all equations except the energy and species equations, for which the residuals shall be decreased to 10^{-7}. The mass and energy balance shall be calculated up to at least four (4) decimal places.

Informative Note: Review of the thermal comfort of occupants in the computational model may be desirable.

C2.2 Zone Air Distribution Effectiveness. Zone air distribution effectiveness (E_z) shall be computed in accordance with Equation C-1 for each computational cell in the breathing zone. The zone air distribution effectiveness (E_z) of the system shall be the average value of the zone air distribution effectiveness of each computational cell within the breathing zone. The analysis shall be performed for both summer cooling conditions and winter heating conditions.

Informative Note: Validation of the computational model with physical measurements during design can improve the accuracy of the computational model and the zone air distribution effectiveness of the system. Field measurements could also be performed post building occupancy to verify zone air distribution effectiveness.

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

NORMATIVE APPENDIX D
VENTILATION RATES FOR OUTPATIENT FACILITIES NOT COVERED BY ASHRAE/ASHE STANDARD 170

D1. GENERAL

This appendix presents minimum ventilation rates in breathing zones for spaces in outpatient facilities to which the AHJ deemed ASHRAE/ASHE Standard 170 not applicable.

D2. VENTILATION RATES

For zones in outpatient facilities not covered bay ASHRAE/ASHE Standard 170, ventilation zone parameters shall be determined in accordance with Sections 6.2.1.1 through 6.2.1.3 using the rates in Table D-1.

Table D-1 Minimum Ventilation Rates in Breathing Zone *(Continued)*

	People Outdoor Air Rate (R_p)		Area Outdoor Air Rate (R_a)		Default Values		
					Occupant Density		
Occupancy Category	cfm/ person	L/s· person	cfm/ft^2	L/s·m^2	#/1000 ft^2 or #/100 m^2	Air Class	OS (6.2.6.1.4)
Outpatient Health Care Facilities [a,b]							
Birthing room	10	5	0.18	0.9	15	2	
Class 1 imaging rooms	7.5	3.8	0.12	0.6	5	1	
Dental operatory	10	5	0.18	0.9	20	1	
General examination room	7.5	3.8	0.12	0.6	20	1	
Other dental treatment areas	5	2.5	0.06	0.3	5	1	
Physical therapy exercise area	20	10	0.18	0.9	7	2	
Physical therapy individual room	10	5	0.12	0.6	20	2	
Physical therapeutic pool area	—	—	0.48	2.4	—	3	
Prosthetics and orthotics room	10	5	0.18	0.9	20	2	
Psychiatric consultation room	5	2.5	0.06	0.3	20	1	
Psychiatric examination room	5	2.5	0.06	0.3	20	1	
Psychiatric group room	5	2.5	0.06	0.3	50	1	
Psychiatric seclusion room	10	5	0.12	0.6	5	1	
Speech therapy room	5	2.5	0.06	0.3	20	1	
Urgent care examination room	7.5	3.8	0.12	0.6	20	2	
Urgent care observation room	5	2.5	0.06	0.3	20	2	
Urgent care treatment room	7.5	3.8	0.12	0.6	20	2	
Urgent care triage room	10	5	0.18	0.9	20	3	

a. The requirements of this table provide for acceptable IAQ. The requirements of this table do not address the airborne transmission of viruses, bacteria, and other infectious contagions.

b. These rates are intended only for outpatient dental clinics where the amount of nitrous oxide is limited. They are not intended for dental operatories in institutional buildings where nitrous oxide is piped.

(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 E
INFORMATION ON SELECTED NATIONAL STANDARDS AND GUIDELINES FOR PM10, PM2.5, AND OZONE

Section 4 requires that the status of compliance with National Ambient Air Quality Standards (NAAQS) be determined for the geographical area of the building site. Table E-1 is a representative table presenting the NAAQS information for the United States. Links to detailed information on the ambient air quality standards and contaminant levels for other select counties and regions are as follows:

- U.S. NAAQS: www.epa.gov/green-book and www.epa.gov/criteria-air-pollutants/naaqs-table
- Canadian Ambient Air Quality Standards: www.ccme.ca/en/air-quality-report#slide-7
- Hong Kong Air Quality Objectives: www.epd.gov.hk/epd/english/environmentinhk/air/air_quality_objectives/air_quality_objectives.html
- Singapore Air quality Targets: www.nea.gov.sg/our-services/pollution-control/air-pollution/air-quality
- European Commission Air Quality Standards: ec.europa.eu/environment/air/quality/standards.htm
- Brazil Air Quality Standards: www.transportpolicy.net/index.php?title=Brazil:_Air_Quality_Standards
- World Health Organization (WHO) Air Quality Guideline Values: www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

The Clean Air Act (www.epa.gov/clean-air-act-overview), which was last amended in 1990, requires the United States Environmental Protection Agency (U.S. EPA) to set NAAQS (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act identifies two types of NAAQS. *Primary standards* provide public health protection, including protecting the health of “sensitive” populations, such as asthmatics, children, and the elderly. *Secondary standards* provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

U.S. EPA has set NAAQS for six principal pollutants, which are called “criteria” air pollutants (www.epa.gov/criteria-air-pollutants). Periodically, the standards are reviewed and may be revised. The current standards are listed in Table E-1. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic metre of air ($\mu g/m^3$).

Table E-1 NAAQS for the Unites States
(www.epa.gov/criteria-air-pollutants/naaqs-table)

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO) www.epa.gov/co-pollution/table-historical-carbon-monoxide-co-national-ambient-air-quality-standards-naaqs		Primary	Eight (8) hours	9 ppm	Not to be exceeded more than once per year
			One (1) hour	35 ppm	
Lead (Pb) www.epa.gov/lead-air-pollution/table-historical-lead-pb-national-ambient-air-quality-standards-naaqs		Primary and secondary	Rolling three (3) month average	0.15 μg/m^3 (Note 1)	Not to be exceeded
Nitrogen Dioxide (NO_2) www.epa.gov/no2-pollution/table-historical-nitrogen-dioxide-national-ambient-air-quality-standards-naaqs		Primary	One (1) hour	100 ppb	Ninety-eighth (98th) percentile of one-hour daily maximum concentrations, averaged over three years
		Primary and secondary	One (1) year	53 ppb (Note 2)	Annual mean
Ozone (O_3) www.epa.gov/ozone-pollution/table-historical-ozone-national-ambient-air-quality-standards-naaqs		Primary and secondary	Eight (8) hours	0.070 ppm (Note 3)	Annual fourth-highest daily maximum eight-hour concentration, averaged over three years
Particulate Matter (PM) www.epa.gov/pm-pollution/table-historical-particulate-matter-pm-national-ambient-air-quality-standards-naaqs	PM2.5	Primary	One (1) year	12.0 μg/m^3	Annual mean, averaged over three years
		Secondary	One (1) year	15.0 μg/m^3	Annual mean, averaged over three years
		Primary and secondary	Twenty-four (24) hours	35 μg/m^3	Ninety-eight (98th) percentile, averaged over three years
	PM10	Primary and secondary	Twenty-four (24) hours	150 μg/m^3	Not to be exceeded more than once per year on average over three years
Sulfur Dioxide (SO_2) www.epa.gov/so2-pollution/table-historical-sulfur-dioxide-national-ambient-air-quality-standards-naaqs		Primary	One (1) hour	75 ppb (Note 4)	Ninety-ninth (99th) percentile of one-hour daily maximum concentrations, averaged over three years
		Secondary	Three (3) hours	0.5 ppm	Not to be exceeded more than once per year

Note 1: In areas designated "nonattainment" for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 μg/m^3 as a calendar quarter average) also remain in effect.

Note 2: The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purpose of clearer comparison to the one-hour standard level.

Note 3: Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

Note 4: The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (a) any area for which it is not yet one year since the effective date of designation under the current (2010) standards, and (b) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and that is designated "nonattainment" under the previous SO_2 standards or is not meeting the requirements of an SIP call under the previous SO_2 standards (40 CFR 50.4[3]). An SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

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INFORMATIVE APPENDIX F ACCEPTABLE MASS-BALANCE EQUATIONS FOR USE WITH THE IAQ PROCEDURE

When applying the Indoor Air Quality Procedure from Section 6.3, mass-balance analysis may be employed to determine outdoor air ventilation requirements to control concentrations to meet design targets.

Table F-1 presents mass-balance equations for analysis of single-zone systems. Figures F-1 and F-2 show representative single-zone systems. A filter may be located in the recirculated airstream (location A) or in the supply (mixed) airstream (location B). The equations do not account for sources within the HVAC system that may occur, such as filter off-gassing, energy recovery carryover of specific gases, or generation of particles or compounds.

VAV single-zone systems reduce the circulation rate when the thermal load is lower than the design load. This is accounted for by a flow reduction fraction (F_r).

A mass-balance equation for each design compound or PM2.5 may be written and used to determine the required outdoor airflow or the breathing zone resultant concentration for the various system arrangements. Six permutations for air-handling and single-zone air distribution systems are described in Table F-1. The mass-balance equations for computing the required outdoor airflow and the breathing-zone contaminant concentration at steady-state conditions for each single-zone system are presented in Table F-1.

If the allowable breathing zone design target is specified, the equations in Table F-1 may be solved for the zone outdoor airflow rate (V_{oz}). When the zone outdoor airflow rate is specified, the equations may be solved for the resulting breathing zone design compound or PM2.5 concentration.

While the calculation methods in this appendix are based on single-zone systems and steady-state analysis, calculation methods that account for multiple-zone and transient effects are also available (see Dols and Walton [2002] in Informative Appendix P).

Table F-1 Required Zone Outdoor Airflow or Space Breathing Zone Contaminant Concentration with Recirculation and Filtration for Single-Zone Systems

Required Recirculation Rate				
Filter Location	**Flow**	**Outdoor Airflow**	**Required Zone Outdoor Airflow (V_{oz} in Section 6)**	**Space Breathing Zone Contaminant Concentration**
None	VAV	100%	$V_{oz} = \dfrac{N}{E_z F_r (C_{bz} - C_o)}$	$C_{bz} = C_o + \dfrac{N}{E_z F_r V_{oz}}$
A	Constant	Constant	$V_{oz} = \dfrac{N - E_z R V_r E_f C_{bz}}{E_z (C_{bz} - C_o)}$	$C_{bz} = \dfrac{N + E_z V_{oz} C_o}{E_z (V_{oz} + R V_r E_f)}$
A	VAV	Constant	$V_{oz} = \dfrac{N - E_z F_r R V_r E_f C_{bz}}{E_z (C_{bz} - C_o)}$	$C_{bz} = \dfrac{N + E_z V_{oz} C_o}{E_z (V_{oz} + F_r R V_r E_f)}$
B	Constant	Constant	$V_{oz} = \dfrac{N - E_z R V_r E_f C_{bz}}{E_z [C_{bz} - (1 - E_f)(C_o)]}$	$C_{bz} = \dfrac{N + E_z V_{oz} (1 - E_f) C_o}{E_z (V_{oz} + R V_r E_f)}$
B	VAV	100%	$V_{oz} = \dfrac{N}{E_z F_r [C_{bz} - (1 - E_f)(C_o)]}$	$C_{bz} = \dfrac{N + E_z F_r V_{oz} (1 - E_f) C_o}{E_z F_r V_{oz}}$
B	VAV	Constant	$V_{oz} = \dfrac{N - E_z F_r R V_r E_f C_{bz}}{E_z [C_{bz} - (1 - E_f)(C_o)]}$	$C_{bz} = \dfrac{N + E_z V_{oz} (1 - E_f) C_o}{E_z (V_{oz} + F_r R V_r E_f)}$

Table F-1 Required Zone Outdoor Airflow or Space Breathing Zone Contaminant Concentration with Recirculation and Filtration for Single-Zone Systems *(Continued)*

Symbol or Subscript	Definition
A, B	filter location
V	volumetric flow
C	contaminant concentration
E_z	zone air distribution effectiveness
E_f	filter efficiency
F_r	design flow reduction fraction factor
N	contaminant generation rate
R	recirculation flow factor
Subscript: o	outdoor
Subscript: r	return
Subscript: b	breathing
Subscript: z	zone

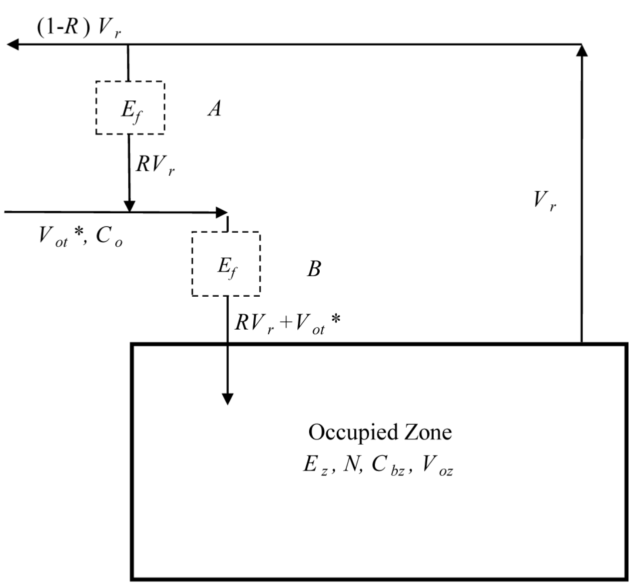

Figure F-1 Ventilation system schematic—constant-volume system with no infiltration/exfiltration. (*V_{ot} = V_{oz} for single-zone systems.)

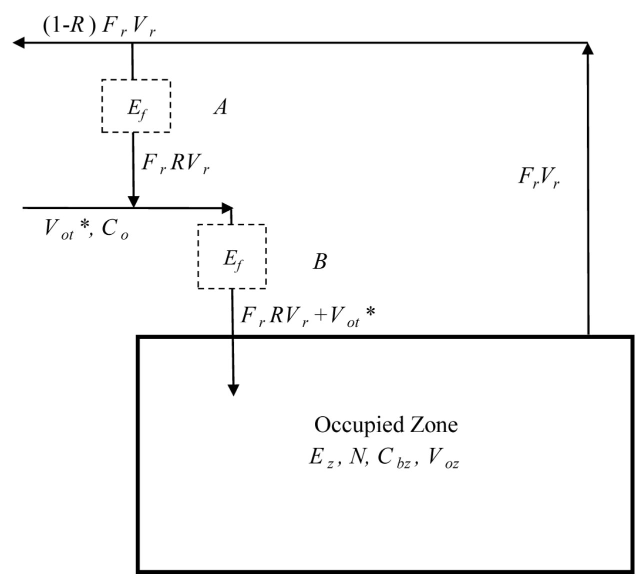

Figure F-2 Ventilation system schematic—variable-air-volume system with no infiltration/exfiltration. (*V_{ot} = V_{oz} for single-zone systems).

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INFORMATIVE APPENDIX G
SIMPLIFIED VENTILATION RATE CALCULATION FOR MULTIPLE-ZONE RECIRCULATING SYSTEMS SERVING ONLY SPECIFIED OCCUPANCY CATEGORIES IN EXISTING BUILDINGS

G1. USE OF THIS APPENDIX

This appendix is intended to be used to assess ventilation rates in existing buildings for third-party building evaluation programs such as ASHRAE Building EQ (bEQ), Leadership in Energy and Environmental Design for Existing Buildings: Operations and Maintenance (LEED EBOM), Energy Star, etc. Zone minimum primary airflow is included as guidance in evaluating and adjusting minimum box settings. This informative appendix is not intended to be used as the Basis of Design or for regulatory applications.

G2. OUTDOOR AIR INTAKE

For multiple-zone recirculating systems serving only occupancy categories listed in Table G-1, the target outdoor air intake flow (V_{target}) is determined in accordance with Equation G-1. For all other systems, V_{target} is set equal to V_{ot} in accordance with Section 6.2.4.4. If the minimum outdoor air intake flows measured at the system level meet or exceed V_{target}, then the system meets the criteria of this informative appendix.

$$V_{target} = \Sigma_{\,all\ zones} A_z \times R_s \tag{G-1}$$

where

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

R_s = outdoor airflow rate required per unit area as determined from Table G-1

G3. ZONE MINIMUM PRIMARY AIRFLOW

For each zone, the minimum primary airflow ($V_{pz\text{-}min}$) is determined in accordance with Equation G-2.

$$V_{pz\text{-}min} = A_z \times R_{pz} \tag{G-2}$$

where

R_{pz} = minimum primary airflow rate required per unit area as determined from Table G-1. This is the minimum zone airflow required for ventilation purposes.

Table G-1 Minimum Outdoor and Primary Airflow Rates

Occupancy Category	Zone Minimum Airflow: Outdoor Airflow Rate R_s		Minimum Primary Airflow Rate, R_{pz}	
	cfm/ft^2	L/s·m^2	cfm/ft^2	L/s·m^2
Educational Facilities				
Classrooms (ages 5 to 8)	0.65	3.25	1.12	5.60
Classrooms (ages 9 plus)	0.82	4.10	1.41	7.05
Computer lab	0.65	3.25	1.12	5.60
Media center	0.65	3.25	1.12	5.60
Music/theater/dance	0.72	3.60	1.24	6.20
Multiuse assembly	1.42	7.10	2.45	12.25
General				
Conference/meeting	0.44	2.20	0.76	3.80
Corridors	0.11	0.55	0.19	0.95
Office Buildings				
Breakrooms	0.65	3.25	1.12	5.60
Main entry lobbies	0.19	0.95	0.33	1.65
Occupiable storage rooms for dry materials	0.12	0.60	0.21	1.05
Office space	0.15	0.75	0.26	1.30
Reception areas	0.37	1.85	0.64	3.20
Telephone/data entry	0.63	3.15	1.09	5.45
Public Assembly Spaces				
Libraries	0.30	1.50	0.52	2.60

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INFORMATIVE APPENDIX H
APPLICATION

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

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

For the most part, Standard 62.1 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 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.

H1. APPLICATION

H1.1 New Buildings. All sections and normative appendices should apply to new buildings falling within the scope of this standard.

H1.2 Existing Buildings. The standard should be applied to existing buildings at least in the circumstances described in the following subsections.

H1.2.1 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.

H1.2.2 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.

H1.2.3 Replacement. Any component of a building that is removed and replaced should meet the applicable requirements of Section 5, “Systems and Equipment,” 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).

H1.2.4 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.

H1.2.5 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.

H1.2.6 Contaminants. Ventilation requirements of this standard are based on chemical, physical, and biological contaminants that can affect air quality.

H1.2.7 Thermal Comfort. Control of thermal comfort is not required by this standard. Requirements for thermal comfort are contained in ASHRAE Standard 55. Note that there are strong correlations between peoples’ perception of IAQ and their perception of thermal comfort.

H1.2.8 Limitations. Acceptable IAQ might 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 might affect occupant perception and acceptance of IAQ, 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 might be unacceptable or might not be adequately cleaned

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(The following section provides 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 I DOCUMENTATION

This appendix summarizes the requirements for documentation contained in the body of the standard using a series of templates that summarize 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.

I1. 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.

I2. 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 5.10.3, is specifically required by the standard. Use of the other columns is motivated by the general documentation requirement described in Section 6.6.

I3. 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 5.13.4 and 6.6.

I4. INDOOR AIR QUALITY 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.

Regional Outdoor Air Quality Pollutants	**Attainment or Nonattainment According to the United States Environmental Protection Agency (U.S. EPA)**
Particulates (PM2.5)	(Yes/No)
Particulates (PM10)	(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	
(h) Conclusions	(Remarks concerning the acceptability of the outdoor air quality)

Building Ventilation Design Criteria

Total Building Outdoor Air Intake	**Total Building Exhaust Air (see Section 5.17)**	**Outdoor Air Cleaning Required (See Section 6.1.4)**		**Indoor Air Dew Point (Section 5.12)**		**Air Balancing (See Section 5.10.3)**
		Particulate Matter	**Ozone**	**Peak Outdoor DP at Dehumidification Design Condition**	**Calculated Space DP at Concurrent Outdoor Condition**	
(cfm)	(cfm)	(Yes/No)	(Yes/No)	(Dew point)	(Dew point)	(NEBB, AABC, etc.)

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, or classroom number.)	(List occupancy category of the space from Table 6-1, such as Office Space, Retail Sales, Classroom Ages 5 to 8, etc.)	(People/ ft^2 or m^2)	(cfm or L/s)	(cfm or L/s)	(Table 6-4)	(Section 6.2.4.2; Normative Appendix A)	(Table 6-1 or 6-3; include justification for classification if not in these tables)

IAQ Procedure Assumptions

Contaminant of Concern	Contaminant Source	Contaminant Strength	Contaminant Target Concentration			Perceived IAQ	Design Approach
			Limit	Exposure Period	Cognizant Authority Reference		
(Identify and list)	(Identify and list)	(Determine and list)	(List)	(List)	(List)	(Percentage of satisfied building occupants)	(Select from Section 6.3.4 and include justification.)

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INFORMATIVE APPENDIX J
RATE RATIONALE

Table J-1 provides description and rationale for the Ventilation Rate Procedure (VRP) rates in Table 6-1, "Minimum Ventilation Rates in Breathing Zone." This information may be helpful to designers and other practitioners.

Table J-1 Rate Rationale (see Table 6-1)

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, L/s·m^2	Air Class
Correctional Facilities						
Booking/waiting	Occupant activity varies between sedentary and moderate walking. Occupants are generally more vocal. Occupants may not be as well-groomed as typical occupants. Occupant stress levels are generally high. All of which result in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	2
Cell	Occupant activity is primarily sedentary (seated or sleeping). There are typically higher levels of space-related contaminants due to presence of a water closet, sink, and stored clothing. The presence of a water closet is the primary reason why this space has an Air Class of 2.	5	2.5	0.12	0.6	2
Day room	Occupant activity is primarily sedentary (seated, watching television). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Guard stations	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Educational Facilities						
Art classroom	Occupant activity is moderate. There is considerable aerobic activity in addition to the occupants being very vocal. Also, the occupants are primarily children with higher metabolic rates. There are significant space-related contaminants, including open paints, glues, and cleaning agents. The presence of these open contaminants result in this space being classified as Air Class 2.	10	5	0.18	0.9	2
Classrooms (ages 5 through 8)	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal. Also, the occupants are primarily children with higher metabolic rates and often more bioeffluents. There are some significant space-related contaminants, typically stored arts-and-crafts supplies and cleaning agents.	10	5	0.12	0.6	1
Classrooms (age 9 plus)	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal. Also, the occupants are primarily children with higher metabolic rates and often more bioeffluents. There are some significant space-related contaminants, typically stored arts-and-crafts supplies and cleaning agents.	10	5	0.12	0.6	1
Computer lab	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal. Also, the occupants can be children/young adults with higher metabolic rates. There are some significant space-related contaminants, typically toner cartridges and paper.	10	5	0.12	0.6	1

Table J-1 Rate Rationale (see Table 6-1) *(Continued)*

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, L/s·m^2	Air Class
Daycare (through age 4)	Occupant activity is moderate. There is considerable aerobic activity in addition to the occupants being very vocal. Also, the occupants are primarily young children with higher metabolic rates. There are significant space-related contaminants, including diapers, arts-and-crafts supplies, and cleaning agents. These contaminants, particularly the diapers, result in this space being classified as Air Class 2.	10	5	0.18	0.9	2
Lecture classroom	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Lecture hall (fixed seats)	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Media center	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal. Also, the occupants are primarily children/young adults with higher metabolic rates and often more bioeffluents. There are some significant space-related contaminants, typically toner cartridges and paper (both loose leaf and bound).	10	5	0.12	0.6	1
Multiuse assembly	Occupant activity is primarily sedentary (seated or light walking). However, occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Music/theater/dance	Occupant activity is high. There is considerable aerobic activity in addition to the occupants being very vocal. There are no significant space-related contaminants.	10	5	0.06	0.3	1
Science laboratories	Occupant activity is moderate. There is considerable aerobic activity in addition to the occupants being very vocal. Also, the occupants are primarily children with higher metabolic rates. There are significant space-related contaminants, including open chemicals and cleaning agents. The presence of these open contaminants result in this space being classified as Air Class 2. OSHA regulated exposure limits must be maintained, ensuring Class 2 defined air is present. This condition is covered in Table 6-2.	10	5	0.18	0.9	2
University/college laboratories	Occupant activity is moderate. There is considerable aerobic activity in addition to the occupants being very vocal. Also, the occupants have higher metabolic rates. There are significant space-related contaminants, including open chemicals and cleaning agents. The presence of these open contaminants results in this space being classified as Air Class 2. OSHA regulated exposure limits must be maintained, ensuring Class 2 defined air is present. This condition is covered in Table 6-2.	10	5	0.18	0.9	2
Wood/metal shop	Occupant activity is moderate. There is considerable aerobic activity in addition to the occupants being very vocal. Also, the occupants can be children/young adults with higher metabolic rates. There are significant space-related contaminants, including sawdust, oils, metal shavings, and chemical agents. The presence of these open contaminants result in this space being classified as Air Class 2.	10	5	0.18	0.9	2
Food and Beverage Service						
Bars, cocktail lounges	Occupant activity is moderate (standing, talking, eating/drinking, waiting tables). The presence of large quantities of open drinks and prepared foods creates higher levels of space-related contaminants. The associated food and drink odors results in this space being classified as Air Class 2.	7.5	3.8	0.18	0.9	2
Cafeteria/ fast-food dining	Occupant activity is moderate (standing, talking, eating, cleaning tables). The presence of large quantities of unpackaged, prepared foods creates higher levels of space-related contaminants. The associated food odors result in this space being classified as Air Class 2.	7.5	3.8	0.18	0.9	2

Table J-1 Rate Rationale (see Table 6-1) *(Continued)*

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, L/s·m^2	Air Class
Kitchen	Occupant activity is very active (walking, talking, eating, food preparation and cooking). The presence of large quantities of unpackaged, cooking prepared foods creates higher levels of space-related contaminants. The associated food odors results in this space being classified as Air Class 2.	7.5	3.8	0.12	0.6	2
Restaurant dining rooms	Occupant activity is moderate (standing, talking, eating, waiting tables). The presence of large quantities of unpackaged, prepared foods creates higher levels of space-related contaminants. The associated food odors result in this space being classified as Air Class 2.	7.5	3.8	0.18	0.9	2
Food and Beverage Service, General						
Break rooms	Occupant activity is primarily sedentary (seated). There are limited space-related contaminants.	5	2.5	0.06	0.3	
Coffee stations	Occupant activity is primarily sedentary. There are limited space-related contaminants.	5	2.5	0.06	0.3	
Conference/meeting	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Corridors	Persons passing through the corridor are considered to be transitory and thus not occupants. There are no significant space-related contaminants.	—	—	0.06	0.3	1
Occupiable storage rooms for liquids or gels	Occupant activity is primarily sedentary (seated) The concentration of stored products increases the level of space-related contaminants. Current ventilation rate is consistent with other minimal/transient occupancy environments.	5	2.5	0.12	0.6	2
Hotels, Motels, Resorts, Dormitories						
Barracks sleeping areas	Occupant activity is primarily sedentary (sleeping). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Bedroom/living room	Occupant activity is primarily sedentary (seated or sleeping). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Laundry rooms, central	Occupant activity is primarily moderate. There are often usual space-related contaminants related to cleaning.	5	2.5	0.12	0.6	2
Laundry rooms within dwelling units	Occupant activity is primarily moderate. There are often usual space-related contaminants related to cleaning.	5	2.5	0.12	0.6	1
Lobbies/prefunction	Occupant activity is primarily standing and light walking. However, occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Multipurpose assembly	Occupant activity is primarily sedentary (seated or light walking). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Miscellaneous Spaces						
Banks or bank lobbies	Occupant activity is primarily standing and light walking. However, occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	
Bank vaults/safe deposit	Occupant activity is light, typically standing. There are no significant space-related contaminants.	5	2.5	0.06	0.3	2
Computer (not printing)	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1

Table J-1 Rate Rationale (see Table 6-1) *(Continued)*

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, $L/s \cdot m^2$	Air Class
Freezer and refrigerated spaces (<50°F [10°C])	Refrigerated warehouse spaces are significantly different from conventional warehouses in a number of ways. The low temperatures will slow the emission of contaminants, such as VOCs, from the materials stored in the space; the characteristics of the items being stored will be different; and the amount of time spent in the space by occupants may be shorter (particularly for spaces kept at subfreezing temperatures).	10	5	0	0	2
General manufacturing (excludes heavy industrial and processes using chemicals)	Occupant activity is moderate (standing, walking, assembly). Moderate levels of space-related contaminants are expected. The unknown nature of the contaminants leads to a category of Air Class 3.	10	5	0.18	0.9	3
Pharmacy (prep. area)	Occupant activity is primarily light work and standing. There are space-related contaminants, including open containers of liquid medicines. The presence of these open containers results in this space being classified as Air Class 2.	5	2.5	0.18	0.9	2
Photo studios	Occupant activity is primarily standing and light work. There are large quantities of chemicals, many of them open, resulting in higher levels of space-related contaminants.	5	2.5	0.12	0.6	1
Shipping/receiving	Persons moving materials have a higher level of activity. The flow of products increases the level of space-related contaminants in addition to the typical use of forklifts.	10	5	0.12	0.6	1
Sorting, packing, light assembly	Occupant activity is moderate (standing, walking, assembly). There may be moderate levels of space-related contaminants.	7.5	3.8	0.12	0.6	2
Telephone closets	This should be handled as unoccupied space.					
Transportation waiting	Occupant activity is primarily standing and moderate-to-heavy walking. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Warehouses	Occupant activity is moderate (standing, walking, assembly). There may be moderate levels of space-related contaminants.	10	5	0.06	0.3	2
Office Buildings						
Breakrooms	Occupant activity is primarily sedentary (seated). There are limited space-related contaminants.	5	2.5	0.06	0.3	1
Main entry lobbies	Occupant activity is primarily transitory light walking. There are few anticipated space-related contaminants.	5	2.5	0.06	0.3	1
Occupiable storage rooms for dry materials	Occupant activity is primarily sedentary (seated). The concentration of stored products increases the level of space-related contaminants; however, dry material emissions are expected to be low.	5	2.5	0.06	0.3	1
Office space	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Reception areas	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Telephone/data entry	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Public Assembly Spaces						
Auditorium seating area	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1

Table J-1 Rate Rationale (see Table 6-1) *(Continued)*

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, $L/s \cdot m^2$	Air Class
Courtrooms	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Legislative chambers	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Libraries	Occupant activity is primarily sedentary (seated or light walking). The large quantities of books create higher levels of space-related contaminants (dust and odors).	5	2.5	0.12	0.6	1
Lobbies	Occupant activity is primarily sedentary (seated or light walking). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Museums (children's)	Occupant activity is moderate. There is considerable aerobic activity in addition to the occupants being very vocal. Also, the occupants are typically young children with higher metabolic rates. There are typically some significant space-related contaminants, such as food and drink.	7.5	3.8	0.12	0.6	1
Museums/galleries	Occupant activity is primarily standing and light walking. However, occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Places of religious worship	Occupant activity is primarily sedentary (seated). There are no significant space-related contaminants.	5	2.5	0.06	0.3	1
Residential						
Common corridors	Persons passing through the corridor are considered to be transitory and thus not occupants. There are no significant space-related contaminants.	—	—	0.06	0.3	—
Retail						
Sales (except as below)	Occupant activity is moderate. There is considerable occupant movement, including carrying packages and being more vocally active. The presence of new merchandise creates higher levels of space-related contaminants. This is primarily the reason for the space being classified as Air Class 2.	7.5	3.8	0.12	0.6	2
Barber shop	Occupant activity is primarily sedentary, with moderate work being performed by the staff. Occupants are generally more vocal, resulting in higher metabolic rates. There are some significant space-related contaminants (shampoos, disinfecting agents, high levels of human hair). However, these are directly related to the occupancy rather than the floor area. This is the primary reason why this space is classified as Air Class 2.	7.5	3.8	0.06	0.3	2
Beauty and nail salons	Occupant activity is primarily sedentary, with moderate work being performed by the staff. Occupants are generally more vocal, resulting in higher metabolic rates. There are some significant space-related contaminants (shampoos, disinfecting agents, high levels of hair).	20	10	0.12	0.6	2
Coin-operated laundries	Occupant activity is primarily moderate-to-heavy walking and may include carrying packages. There are some significant space-related contaminants (detergents, disinfecting agents, soiled laundry). However, these are directly related to the occupancy rather than the floor area. This is the primary reason why this space is classified as Air Class 2.	7.5	3.8	0.12	0.6	2
Mall common areas	Occupant activity is primarily moderate to heavy walking and may include carrying packages. Occupants are generally more vocal, resulting in higher metabolic rates. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1

Table J-1 Rate Rationale (see Table 6-1) *(Continued)*

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, L/s·m^2	Air Class
Pet shops (animal areas)	Occupant activity is moderate (standing, talking, stooping, walking, and carrying packages). The concentration of animals of various species in containment creates higher levels of space-related contaminants. This concentration of animals, and the fact that they are kept in open containment, results in this space being classified as Air Class 2.	7.5	3.8	0.18	0.9	2
Supermarket	Occupant activity is primarily moderate to heavy walking and may include carrying packages. There are no significant space-related contaminants.	7.5	3.8	0.06	0.3	1
Sports and Entertainment						
Bowling alley (seating)	Occupant activity is moderate (seated, standing, walking, talking, drinking). The presence of open food and drink creates moderately high levels of significant contaminants.	10	5	0.12	0.6	1
Disco/dance floors	Occupant activity is high. There is considerable aerobic activity. There are often considerable quantities of open drink, creating high levels of space-related contaminants related to the people using the space.	20	10	0.06	0.3	1
Gambling casinos	Occupant activity is moderate (seated, standing, walking, talking, drinking). The presence of open food and drink creates moderately high levels of significant contaminants.	7.5	3.8	0.18	0.9	1
Game arcades	Occupant activity is moderate (seated, standing, walking, talking, drinking). The presence of open food and drink creates moderately high levels of significant contaminants.	7.5	3.8	0.18	0.9	1
Gym, stadium (play area)	Occupant activity is high. There is considerable aerobic activity. There are no significant space-related contaminants. Occupancy is variable, and the high area outdoor air rate compensates for the varying occupancy and local source. CO_2-based demand controlled ventilation in these spaces should consider that the volume per person in these spaces is typically large, which means that CO_2 concentration changes will have longer than usual lag times behind occupancy changes.	20	10	0.18	0.9	2
Health club/ aerobics room	Occupant activity is high. There is considerable aerobic activity in addition to the occupants being very vocal. There are significant space-related contaminants related to the people using the space.	20	10	0.06	0.3	2
Health club/ weight rooms	Occupant activity is high. There is considerable aerobic activity in addition to the occupants being very vocal. There are significant space-related contaminants related to the people using the space.	20	10	0.06	0.3	2
Spectator areas	Occupant activity is moderate. While the occupants may be primarily seated, there is considerable vocal activity, as well as standing, cheering, and walking to concessions, etc. There are often considerable quantities of open food and drink, creating high levels of space-related contaminants.	7.5	3.8	0.06	0.3	1
Sports arena (play area)	Occupant activity is high. There is considerable aerobic activity. Occupancy is variable, and the high area outdoor air rate compensates for the varying occupancy and local sources. The presence of playing surface cleaning/resurfacing equipment results in significantly high levels of space-related contaminants.	20	10	0.18	0.9	2
Stages, studios	Occupant activity is moderate. While the occupants may be primarily seated, there is considerable vocal activity, as well as standing, cheering, and walking to concessions, etc. The stage props result in higher levels of space-related contaminants. Contaminant level is not high enough to justify an Air Class 2.	10	5	0.06	0.3	1

Table J-1 Rate Rationale (see Table 6-1) *(Continued)*

Occupancy Category	Description/Rationale	People Outdoor Air Rate, cfm/person	People Outdoor Air Rate, L/s/person	Area Outdoor Air Rate, cfm/ft^2	Area Outdoor Air Rate, L/s·m^2	Air Class
Swimming (pool and deck)	While the occupant activity (swimming) is high, it is primarily anaerobic. Occupancy is variable, and the high area outdoor air rate compensates for the varying occupancy and local source. Also, the bioeffluents, such as sweat are discharged into the water rather than the air. For these reasons, there is no occupancy-related outdoor air rate. The high level of chemicals in the pool water that are absorbed into the air as the pool water evaporates create exceptionally high levels of space-related contaminants. The presence of these chemicals, and their noxious odor, result in the space being classified as Air Class 2.	—	—	0.48	2.4	2

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INFORMATIVE APPENDIX K
INFORMATION ON NATURAL VENTILATION

K1. OUTDOOR AIR QUALITY DATA

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

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

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

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

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

K2. NATURAL VENTILATION RATE

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

a. In the case of an engineered natural ventilation system that results in multiple flow scenarios, each force must be examined and considered separately.
b. Specific pressure-based calculation of natural ventilation flow rate is documented in *ASHRAE Handbook—Fundamentals*, Chapter 16, Section 10:
    1. Buoyancy-induced airflow can be calculated following Equation 46.
    2. Wind-driven airflow can be calculated following Equation 45.
    3. The overall pressure (driven by both wind and stack effect) converted to resulting pressure difference between openings can found in Equation 44.

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

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

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

Table K-1 Ventilation Intensity Brackets

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

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

K3. PRESCRIPTIVE PATH A CALCULATIONS

K3.1 Ventilation Intensity. Spaces have been defined by a ventilation intensity, which represents the amount of flow rate needed per Equation 6-1, divided by the floor area of the space. Its units are (L/s)/m² of floor area or cfm/ft² of floor area.

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

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

K3.2 Single Openings. The flow through a single sharp opening due to bidirectional buoyancy-driven flow (V_{bd_sharp}) (see Etheridge and Sandberg [1996] in Informative Appendix P) is expressed as follows:

$$V_{so\_sharp} = 0.21 \times A_w \times \sqrt{gH_s \frac{\Delta T}{T_{ref}}} \quad \text{(K-2)}$$

where

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

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

H_s = vertical dimension of the opening

g = gravity constant

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

A safety factor is incorporated assuming that an awning window is used. Awning (or top-hinged) windows are among the most common windows used for natural ventilation and, because of their uneven vertical area distribution, are more inefficient than a sliding window (sharp opening) at driving flow. An efficiency (ε_v) of around 83% (value used in these calculations) when compared to sliding windows is inferred from

$$V_{so} = V_{so\_sharp} \times \varepsilon_w \quad \text{(K-3)}$$

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

$$A_w = \frac{H_S^2}{R_{H/W}} \quad \text{(K-4)}$$

The required openable area as a fraction of the zone's floor area is therefore calculated by equating the bidirectional buoyancy-driven flow through a single awning opening (V_{so}) to the goal flow rate (V_{bz}) obtained from Table 6-1.

$$V_{so} = V_{bz} \quad \text{(K-5)}$$

And solving for window area,

$$\frac{A_w}{A_z} = \left(\frac{V_{bz}}{0.21 \times 0.83 \times R_{H/W}^4 \times \sqrt{g\frac{\Delta T}{T_{ref}}}}\right)^{4/5} \times \frac{1}{A_z} \times 100 \qquad \text{(K-6)}$$

K3.3 Vertically Spaced Openings. The flow rate (V_{vs}) through vertically spaced openings of areas A_s (the smallest sum of opening areas, either upper openings or lower openings) and A_l (the largest sum of opening areas, either upper openings or lower openings) is obtained using the following equation:

$$V_{vs} = A_{eff} \times C_d \times \sqrt{2g\Delta H\frac{\Delta T}{T_{ref}}} \qquad \text{(K-7)}$$

where

A_{eff} = effective window area, defined as

$$A_{eff} = \frac{1}{\sqrt{\frac{1}{A_s^2}+\frac{1}{A_l^2}}} = \frac{A_s}{\sqrt{1+R^2}} = \frac{A_w}{\sqrt{1+R^2}\times\left(1+\frac{1}{R}\right)} \qquad \text{(K-8)}$$

A_w = total sum of all opening areas

$$A_w = A_s + A_t \qquad \text{(K-9)}$$

R = area ratio between A_s and A_l

$$R = \frac{A_s}{A_l} \qquad \text{(K-10)}$$

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

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

The required openable area as a fraction of the zone's floor area is therefore calculated by equating the flow through two sets of vertically spaces openings (V_{vs}) to the goal flow rate (V_{bz}) obtained from Table 6-1.

$$V_{vs} = V_{bz} \qquad \text{(K-11)}$$

Solving for window area:

$$\frac{A_w}{A_z} = \frac{V_{bz}}{C_d \times \sqrt{2g\Delta H\frac{\Delta T}{T_{ref}}}} \times \sqrt{1+R^2} \times \left(1+\frac{1}{R}\right) \times \frac{1}{A_z} \times 100 \qquad \text{(K-12)}$$

K4. CONTROL AND ACCESSIBILITY (MIXED-MODE VENTILATION)

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

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

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

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INFORMATIVE APPENDIX L COMPLIANCE

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

L1. SECTION 4

- ☐ Is documentation of outdoor air quality included as required in Section 4.3?

L2. SECTION 5

- ☐ Are air balancing provisions included in design documentation as required in Section 5.10?
- ☐ If the system is a plenum system, are provisions for providing minimum breathing zone airflow specified?
- ☐ Do exhaust ducts comply with the requirements of Section 5.14?
- ☐ Are ventilation systems controls specified as per Section 5.18?
- ☐ Do specifications include resistance to mold and erosion for airstream surfaces per Section 5.11?
- ☐ Are separation distances between outdoor air intakes and sources listed and in compliance with Section 5.4?
- ☐ Is there any noncombustion equipment that requires exhaust (Section 5.16)?
- ☐ Is combustion air provided for fuel-burning appliances (Section 5.15)?
- ☐ Are appropriate filters specified upstream of cooling coils or wetted surfaces (Section 5.5)?
- ☐ Are dehumidification capability and building exfiltration calculations provided (Section 5.12)?
- ☐ Do specifications for drain pans comply with requirements of Section 5.7?
- ☐ Are coils specified per the requirements of Section 5.6?
- ☐ If present, do humidifiers and water spray systems comply with the requirements of Section 5.8?
- ☐ Is access provided for inspection, cleaning, and maintenance of all ventilation equipment and air distribution equipment (Section 5.19)?
- ☐ Is moisture management (Section 5.1) included in building envelope design, including specifically,
  - ☐ weather barrier;
  - ☐ vapor retarder;
  - ☐ sealing exterior joints, seams, and penetrations; and
  - ☐ insulation on pipes, ducts, or other surfaces whose temperatures are expected to fall below dew point of surrounding air?
- ☐ If there is an attached parking garage, do airflow control measures comply with requirements of Section 5.2?
- ☐ Is recirculation from spaces containing Class 2 air limited to spaces with the same purpose and with the same pollutants following requirements of Section 5.13.3.2?
- ☐ Is air from spaces containing Class 3 air contained and not transferred to any other space (Section 5.13.3.3)?
- ☐ Is all air from spaces containing Class 4 air exhausted directly to the outdoors (Section 5.13.3.4)?
- ☐ If ETS is expected to be present, does the design comply with all separation requirements of Section 5.3?

L3. SECTION 6 VENTILATION RATE PROCEDURE

- ☐ Are occupancy categories consistent with the space design documents?
- ☐ Are there any unusual sources of contaminants or compounds? If yes, ventilation must be added per Section 6.3.5.

L3.1 Filtration

☐ If PM10 standard is exceeded as reported in Section 4, is required filtration per Section 6.1.4.1 provided?

☐ If PM2.5 standard is exceeded as reported in Section 4, is required filtration per Section 6.1.4.2 provided?

☐ If ozone standard is exceeded, and the area is Serious, Severe15, Severe17, or Extreme, filtration per Section 6.1.4.3 is required unless an exception is documented.

L3.2 Ventilation Rates. Check compliance with the outdoor air ventilation rate at the intake (V_{ot}) using the following process.

☐ Calculate $V_{otdefault}$ using Equation L-1 using the combined default rate (R_c) from Informative Appendix M and the occupiable area (A_z) of each zone.

$$V_{otdefault} = \Sigma_{\ all\ zones}\ R_c \times A_z \tag{L-1}$$

☐ Calculate additional ventilation required by Section 6.2.1.1.2. Additional ventilation is $V_{otadditional}$.

☐ Calculate V_{otmax} using Equation L-2.

$$V_{otmax} = V_{otdefault} + V_{otadditional} \tag{L-2}$$

☐ Calculate V_{otmin} using Equation L-3.

$$V_{otmin} = V_{otmax} \times 0.75 \tag{L-3}$$

☐ Designed system ventilation rate at the outdoor air intake (V_{ot}) should fall between V_{otmin} and V_{otmax}.

☐ Values of V_{ot} for multiple-zone recirculating VAV systems should be close to V_{otmax}.

☐ Values of V_{ot} for 100% (dedicated) outdoor air systems providing tempered air should be equivalent to V_{otmin}.

☐ Values of V_{ot} for other systems should fall between these values.

☐ If dynamic reset is included as a part of the design, does it comply with all requirements of Section 6.2.6?

Exceptions to L3.2:

1. Minimum outdoor airflow for multiple-zone recirculating systems designed using Normative Appendix A could be below V_{otmin}. A calculation spreadsheet should be provided to confirm that E_v for the system is greater than 0.75.
2. Minimum outdoor airflow for systems designed using Normative Appendix C could be below V_{otmin}. Calculation assumptions of any modeling criteria and results should be provided to confirm that E_z values are greater than 1.0.

L4. SECTION 6 INDOOR AIR QUALITY PROCEDURE

For the IAQP:

☐ Do the design documents provide evaluation of the following?

- ☐ Compounds included in the design (Section 6.3.1)
- ☐ List includes all contaminants of concern
- ☐ Indoor sources and emissions rates for each compound
- ☐ Outdoor sources and expected concentrations for each compound
- ☐ Exposure periods and concentration limits
- ☐ Evaluation of mixtures
- ☐ Specification of perceived IAQ acceptability
- ☐ Calculation of resultant concentrations from the design by mass balance

☐ Do specifications include test methods?

☐ Do specifications require that the subjective evaluation process be performed in the completed building?

- ☐ If a substantially similar zone is used for subjective evaluation, are previous test results, conditions, and system design provided to verify that the zone is substantially similar?

☐ If applicable, are appropriate specifications for dynamic reset monitoring and controls included?

L5. SECTION 6 NATURAL VENTILATION PROCEDURE

Natural ventilation systems follow either the prescriptive or the engineered system compliance path.

For the prescriptive compliance path:

- ☐ Is a mechanical system compliant with either Section 6.2 or 6.3 included?
  - ☐ If no, does design comply with Exceptions 1 or 2 of Section 6.4.1?
- ☐ Do maximum distances from openings comply with Sections 6.4.1.2, Section 6.4.1.3, or Section 6.4.1.4?
- ☐ Do opening sizes comply with the requirements of Section 6.4.2?
  - ☐ Is net free area of openings specified?
  - ☐ Are sill-to-head heights specified?
  - ☐ Are aggregate widths specified?
- ☐ Are controls readily accessible?

For the engineered compliance path:

- ☐ Do the design documents provide evaluation of the following?
  - ☐ Hourly environmental conditions, including, but not limited to, outdoor air dry-bulb temperature; dew-point temperature; outdoor concentration of contaminants of concern (including but not limited to PM2.5, PM10, and ozone), where data are available; wind speed and direction; and internal heat gains during expected hours of natural ventilation operation.
  - ☐ The effect of pressure losses along airflow paths of natural ventilation airflow on the resulting flow rates, including, but not limited to, inlet vents, air transfer grills, ventilation stacks, and outlet vents.
  - ☐ Qualification of natural ventilation airflow rates of identified airflow paths accounting for wind and thermally induced driving pressures.
  - ☐ Outdoor air is provided in sufficient quantities to ensure pollutants and odors of indoor origin do not result in unacceptable IAQ as established under Section 6.2.1.1 and/or 6.3.
  - ☐ Outdoor air introduced into the space through natural ventilation system openings does not result in unacceptable IAQ according to Sections 6.1.4.1 through 6.1.4.4.
  - ☐ Effective interior air barriers and insulation are provided that separate naturally ventilated spaces from mechanically cooled spaces, ensuring that high-dew-point outdoor air does not come into contact with mechanically cooled surfaces.
- ☐ Are controls readily accessible?

L6. SECTION 6 EXHAUST

Exhaust ventilation systems follow either the prescriptive or the performance compliance path.

For the prescriptive compliance path:

- ☐ Does airflow comply with requirements of Tables 6-1 and 6-3?
  - ☐ If no for any space, does it qualify as an exception?
- ☐ Have source strengths been evaluated as required in Section 6.5.1.1?

For the performance compliance path:

- ☐ Do the design documents provide evaluation of the following?
  - ☐ Compounds of interest for the design
  - ☐ Indoor sources and emissions rates for each compound
  - ☐ Outdoor sources and emissions rates brought in by ventilation air
  - ☐ Exposure periods and concentration limits
  - ☐ Evaluation of mixtures
  - ☐ Calculation of resultant concentrations from the design
- ☐ If applicable, are appropriate specifications for dynamic reset monitoring and controls included?

L7. VENTILATION FOR EXISTING BUILDINGS

This section provides guidance for determining compliance with the standard for existing buildings. Many sustainability and energy programs require that ventilation rates for systems comply with ASHRAE Standard 62.1; however, the methods for determining compliance vary widely. This appendix is intended to provide a standardized approach and clear guidance for practitioners who work with existing buildings.

A ventilation system in an existing building may be deemed to comply with the current version of Standard 62.1 if the system complies with all the sections in this appendix. The building may be deemed to comply if all systems in the building comply with all the sections in this appendix (Sections L7.1, Section L7.2, and L7.3).

L7.1 Filtration. Filtration complies with Sections L7.1.1 and Section L7.1.2.

L7.1.1 Filtration Before Coils. Filtration complies with Section 5.5, which requires a minimum of MERV-8 or ISO ePM10 filtration upstream of cooling coils serving occupied spaces.

L7.1.2 Filtration of Outdoor Air. Filtration complies with Section 6.1.4, which requires treating outdoor air with appropriate filters or air cleaners if local air quality conditions do not meet national air quality standards for PM10, PM2.5, ozone, or other outdoor contaminants.

L7.2 Outdoor Airflow. The following process may be used to determine if outdoor airflow rates comply with the VRP of the current standard. Occupied areas may be determined by measurement, dimensioned floor plans, or from the building manager's data. Occupancy categories should reflect how spaces are currently used, which may differ from the original design intent. Check design criteria and assumptions documented according to Section 6.6, if available.

L7.2.1 Measure System Outdoor Airflow. Measure system outdoor airflow. Measurements may be made directly or by installed flow measurement devices in the system that are calibrated. This rate is $V_{otmeasured}$.

L7.2.2 Determine System Type and Design Outdoor Airflow. Determine the system type and then follow the guidance in the appropriate section to determine the design outdoor airflow, $V_{otdesign}$.

L7.2.2.1 Single Zone Systems. Determine $V_{otdesign}$ using Section 6.2.2. Section 6.2.2 provides Equation 6-3, which sets the system outdoor air intake flow equal to the zone outdoor airflow. Zone outdoor airflows are calculated in Equation 6-2 using the zone air distribution effectiveness (E_z) listed in Table 6-4.

L7.2.2.2 100% Outdoor Air Systems. Determine $V_{otdesign}$ using Section 6.2.3. Section 6.2.3 provides Equation 6-4, which sums all zone outdoor airflow requirements to determine the system outdoor airflow requirement. Zone outdoor airflows are calculated in Equation 6-2 using the zone air distribution effectiveness (E_z) listed in Table 6-4.

L7.2.2.3 Multiple Zone Recirculating Systems. Determine $V_{otdesign}$ using any process listed in this section. Calculations are ordered from simplest to most complex. The simpler methods typically result in more conservative (higher) ventilation airflows.

L7.2.2.3.1 Appendix G. Determine $V_{otdesign}$ using Informative Appendix G, which provides a table of minimum outdoor and primary airflow rates for specified occupancy categories in existing buildings: some educational facilities, conference rooms, corridors, office spaces, and libraries.

L7.2.2.3.2 Simplified Procedure. Determine $V_{otdesign}$ using Section 6.2.4 and the Simplified Procedure in Section 6.2.4.3, which provides a simplified method to determine system ventilation efficiency (E_v) based on occupant distribution. System ventilation efficiency values can vary from 0.22 to 0.75.

L7.2.2.3.3 Alternative Procedure. Determine $V_{otdesign}$ using Section 6.2.4 and the Alternative Procedure in Normative Appendix A, which provides credit for secondary recirculation but requires detailed system and occupancy information at the zone level. The system ventilation efficiency is determined by the ventilation efficiency of the "critical zone." The alternative procedure provides credit for secondary recirculation.

L7.2.3 Determine Outdoor Airflow Compliance. If $V_{otmeasured} > V_{otdesign}$, the system complies with the outdoor airflow requirements of the VRP.

L7.3 Controls. Confirm that ventilation system controls comply with requirements of Section 5.18, which requires that minimum ventilation airflows be maintained under all load conditions through manual or automatic controls.

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INFORMATIVE APPENDIX M
VENTILATION RATE CHECK TABLE

Table M-1 is not for design purposes. It is intended to provide check values. Default rate per unit area is based on a multiple-zone system with default occupancy and default E_v that equals 0.75. This is the default E_v in the simplified rate when $D > 0.60$.

Table M-1 Check Table for the Ventilation Rate Procedure (VRP)

Occupancy Category	Combined Outdoor Air Rate (R_c) cfm/ft^2	Combined Outdoor Air Rate (R_c) L/s·m^2
Animal Facilities		
Animal exam room (veterinary office)	0.43	2.13
Animal imaging (MRI/CT/PET)	0.51	2.53
Animal operating rooms	0.51	2.53
Animal postoperative recovery room	0.51	2.53
Animal preparation rooms	0.51	2.53
Animal procedure room	0.51	2.53
Animal surgery scrub	0.51	2.53
Large-animal holding room	0.51	2.53
Necropsy	0.51	2.53
Small-animal-cage room (static cages)	0.51	2.53
Small-animal-cage room (ventilated cages)	0.51	2.53
Correctional Facilities		
Booking/waiting	0.58	2.93
Cell	0.33	1.63
Dayroom	0.28	1.40
Guard stations	0.18	0.90
Educational Facilities		
Art classroom	0.51	2.53
Classrooms (ages 5 through 8)	0.49	2.47
Classrooms (ages 9 plus)	0.63	3.13
Computer lab	0.49	2.47
Daycare sickroom	0.57	2.87
Daycare (through age 4)	0.57	2.87
Lecture classroom	0.73	3.69
Lecture hall (fixed seats)	1.58	8.00
Libraries	0.23	1.13
Media center	0.49	2.47

Table M-1 Check Table for the Ventilation Rate Procedure (VRP) *(Continued)*

	Combined Outdoor Air Rate (R_c)	
Occupancy Category	**cfm/ft^2**	**L/s· m^2**
Multiuse assembly	1.08	5.47
Music/theater/dance	0.55	2.73
Science laboratories	0.57	2.87
University/college laboratories	0.57	2.87
Wood/metal shop	0.51	2.53
Food and Beverage Service		
Bars, cocktail lounges	1.24	6.27
Cafeteria/fast-food dining	1.24	6.27
Kitchen (cooking)	0.36	1.81
Restaurant dining rooms	0.94	4.75
Food and Beverage Service, General		
Break rooms	0.25	1.23
Coffee stations	0.21	1.07
Conference/meeting	0.41	2.07
Corridors	0.08	0.40
Occupiable storage rooms for liquids or gels	0.17	0.87
Hotels, Motels, Resorts, Dormitories		
Barracks sleeping areas	0.21	1.07
Bedroom/living room	0.15	0.73
Laundry rooms (central)	0.23	1.13
Laundry rooms within dwelling units	0.23	1.13
Lobbies/prefunction	0.38	1.92
Multipurpose assembly	0.88	4.40
Miscellaneous Spaces		
Banks or bank lobbies	0.23	1.16
Bank vaults/safe deposit	0.11	0.57
Computer (not printing)	0.11	0.53
Freezer and refrigerated spaces (<50°F [10°C])	0.03	0.13
General manufacturing (excludes heavy industrial and processes using chemicals)	0.33	1.67
Pharmacy (prep area)	0.31	1.53
Photo studios	0.23	1.13
Shipping/receiving	0.19	0.93
Sorting, packing, light assembly	0.23	1.15
Telephone closets	0.00	0.00
Transportation waiting	1.08	5.47
Warehouses	0.09	0.47

Table M-1 Check Table for the Ventilation Rate Procedure (VRP) *(Continued)*

Occupancy Category	Combined Outdoor Air Rate (R_c) cfm/ft^2	Combined Outdoor Air Rate (R_c) L/s· m^2
Office Buildings		
Breakrooms	0.49	2.47
Main entry lobbies	0.15	0.73
Occupiable storage rooms for dry materials	0.09	0.47
Office space	0.11	0.57
Reception areas	0.28	1.40
Telephone/data entry	0.48	2.40
Outpatient Health Care Facilities		
Birthing room	0.44	2.20
Class 1 imaging rooms	0.19	0.97
Dental operatory	0.51	2.53
General examination room	0.36	1.81
Other dental treatment areas	0.11	0.57
Physical therapy exercise area	0.43	2.13
Physical therapy individual room	0.35	1.73
Physical therapeutic pool area	0.64	3.20
Prosthetics and orthotics room	0.51	2.53
Psychiatric consultation room	0.21	1.07
Psychiatric examination room	0.21	1.07
Psychiatric group room	0.41	2.07
Psychiatric seclusion room	0.15	0.73
Urgent care examination room	0.36	1.81
Urgent care observation room	0.21	1.07
Urgent care treatment room	0.44	2.21
Urgent care triage room	0.51	2.53
Speech therapy room	0.21	1.07
Public Assembly Spaces		
Auditorium seating area	1.08	5.40
Courtrooms	0.55	2.73
Legislative chambers	0.41	2.07
Libraries	0.23	1.13
Lobbies	1.08	5.40
Museums (children's)	0.56	2.83
Museums/galleries	0.48	2.43
Places of religious worship	0.88	4.40

Table M-1 Check Table for the Ventilation Rate Procedure (VRP) *(Continued)*

Occupancy Category	Combined Outdoor Air Rate (R_c) cfm/ft^2	Combined Outdoor Air Rate (R_c) L/s· m^2
Retail		
Sales (except as below)	0.31	1.56
Barbershop	0.33	1.67
Beauty and nail salons	0.83	4.13
Coin-operated laundries	0.36	1.81
Mall common areas	0.48	2.43
Pet shops (animal areas)	0.34	1.71
Supermarket	0.16	0.81
Sports and Entertainment		
Bowling alley (seating)	0.69	3.47
Disco/dance floors	2.75	13.73
Gambling casinos	1.44	7.28
Game arcades	0.44	2.21
Gym, sports arena (play area)	0.43	2.13
Health club/aerobics room	1.15	5.73
Health club/weight rooms	0.35	1.73
Spectator areas	1.58	8.00
Stages, studios	1.01	5.07
Swimming (pool and deck)	0.64	3.20

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INFORMATIVE APPENDIX N
INDOOR AIR QUALITY PROCEDURE

N1. SUMMARY OF SELECTED AIR QUALITY GUIDELINES

If the IAQP is used, acceptable indoor concentration limits are needed for design compounds (DCs) and particles. When using this procedure, these concentration limits need to be referenced from a cognizant authority as defined in the standard. At present, no single organization develops acceptable concentrations limits for all substances in indoor air, nor are limits available for all potential DCs or particles.

Cognizant authorities, such as the United States Environmental Protection Agency (U.S. EPA), California EPA, and the Committee for Health Related Evaluation of Building Products (AgBB) publish concentration limits for compounds, many of which may be present in the indoor environment. Compounds included in the IAQP design need to be included if data were judged sufficient to indicate a compound was likely to be found in buildings at concentrations that were a substantial fraction of the proposed design target. The goal is not to include every possible compound that may appear in indoor air but rather sufficient numbers of diverse compounds, such that control of the compounds is anticipated to result in air quality that meets the standard's definition of "acceptable."

A summary of considerations is presented below:

a. Is a compound expected to be present in indoor air with reasonable frequency at concentrations relevant to (but not necessarily above) the design target? Specifically, the design outdoor airflow rate (V_{oz}) and design features will be controlled by the compounds with the highest emission rates and lowest targets (taking mixtures into account); thus, compounds with low concentrations and high targets will have little or no impact on the calculated V_{oz}.
b. Is there a design target that has been proposed by a cognizant authority?
c. Does it seem reasonable to expect that product emissions rates may be available for the proposed compound?
d. It there an established sampling and analytical method for the proposed compound?

Occupational exposure limits (e.g., permissible exposure limits and threshold limit values) are not appropriate as DTs, as they are not established for acceptable IAQ or for typical commercial buildings. In general, they were developed for industrial applications evaluating effects of substances on healthy adult male workers.

N2. GUIDELINE FOR EMISSION RATES

Several published peer-reviewed papers provide a reference for design teams to use to compile reasonable DC emission rates. A nonexhaustive list of peer-reviewed papers is shown in Section N4. In addition, multiple established certification programs include empirical measures of emission rates for construction materials as well as finishes, furniture, and equipment intended for indoor use. These include third-party programs as well as industry trade association programs and programs in support of government regulations (e.g., the AgBB evaluation scheme used in Germany and parts of Europe, Blue Angel, BIFMA, Green Label, France A+, CDPH Standard Method for testing and evaluation of VOC emissions [CDPH Section 01350], Greenguard, SCS Indoor Advantage Gold, and Floorscore). Engineers may use the emission rates for the specific materials that a designer is including or considering for use. The IAQP (Section 6.3) requires that emission rates must consider DCs emitted by occupants and their activities, by materials, and by specific sources within the occupied spaces and introduced into the building with outdoor air.

N3. SUBJECTIVE EVALUATION

Section 7.3.2 requires that an occupant survey be conducted. Many subjective evaluation approaches have been used with varying degrees of success. The following is an example of an evaluation approach that focuses on adapted occupants:

a. After the building is completed and substantially occupied, provide all occupants with an electronic or written survey of questions, including, "Do you perceive the air quality in your environment to be acceptable or unacceptable?"

b. Anonymous surveys with neutrally framed questions provide the best responses.
c. When conducting an evaluation of adapted occupants, respondents must record their perception of zone air quality after 30 minutes of residency in the occupied zone.
d. All occupants should be surveyed, if possible. Otherwise, at least 50% of typical occupancy, or 300, whichever is less, should be randomly selected.
e. A minimum 30% response rate from those surveyed is desirable. Each zone must be surveyed per requirements of Section 6.3. The subjective evaluation validates the acceptability of indoor air if 80% of respondents in the area do not express dissatisfaction. The Center for the Built Environment at UC Berkeley has developed a survey that includes IAQ questions and may be a useful template.

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INFORMATIVE APPENDIX O
CROSSWALK FOR REORGANIZED SECTION 5

ASHRAE Standard 62.1-2022 features a reorganized Section 5, "Systems and Equipment," in which the order of equipment presented follows the path of air from the exterior of the building to air distribution in the space. Previously, additions to the standard were located at the end of the section, resulting in a somewhat randomly ordered list of system and equipment considerations. The new, more logical order should be helpful to new users. Table O-1 shows how the 2019 section numbers are numbered in the 2022 edition.

Table O-1 Crosswalk for Reorganized Section 5

2019 Edition Section	Title	2022 Edition Section
5.1	Ventilation Air Distribution	5.10
5.1.1	Designing for Air Balancing	5.10.1
5.1.1.1	Designing for Varying Loads and Operating Conditions	5.10.1.1
5.1.2	Plenum Systems	5.10.2
5.1.3	Documentation	5.10.3
5.2	Exhaust Duct Location	5.14
5.2.1		5.14.1
5.2.2		5.14.2
5.3	Ventilation System Controls	5.18
5.4	Airstream Surfaces	5.11
5.4.1	Resistance to Mold Growth	5.11.1
5.4.2	Resistance to Erosion	5.11.2
5.5	Outdoor Air Intakes	5.4
5.5.1	Location	5.4.1
5.5.1.1	Exhaust/Relief Outlets	5.4.1.1
5.5.1.2	Fuel Burning Equipment	5.4.1.2
5.5.1.3	Roof, Landscaped Grade, or Another Surface Directly Below Intake	5.4.1.3
5.5.1.4	Laboratory Exhaust	5.4.1.4
5.5.2	Rain Entrainment	5.4.2
5.5.3	Rain Intrusion	5.4.3
5.5.4	Snow Entrainment	5.4.4
5.5.5	Bird Screens	5.4.5
5.6	Local Capture of Contaminant	5.16
5.7	Ozone Generating Devices	5.9
5.7.1	Air-Cleaning Devices	5.9.1
5.7.2	Ultraviolet Devices	5.9.2
5.8	Combustion Air	5.15

Table O-1 Crosswalk for Reorganized Section 5 *(Continued)*

2019 Edition Section	Title	2022 Edition Section
5.9	Particulate Matter Removal	5.5
5.10	Mechanically or Indirectly Evaporatively Cooled Buildings	5.12
5.11	Building Exfiltration	5.17
5.12	Drain Pans	5.7
5.12.1	Drain Pan Slope	5.7.1
5.12.2	Drain Outlet	5.7.2
5.12.3	Drain Seal	5.7.3
5.12.4	Pan Size	5.7.4
5.13	Finned-Tube Coils and Heat Exchangers	5.6
5.13.1	Drain Pans	5.6.1
5.13.2	Finned-Tube-Coil Selection for Cleaning	5.6.2
5.14	Humidifiers and Water Spray Systems	5.8
5.14.1	Water Quality	5.8.1
5.14.2	Obstructions	5.8.2
5.15	Access for Inspection, Cleaning, and Maintenance	5.19
5.15.1	Equipment Clearance	5.19.1
5.15.2	Ventilation Equipment Access	5.19.2
5.15.3	Air Distribution	5.19.3
5.16	Building Envelope and Interior Surfaces	5.1
5.16.1	Building Envelope	5.1.1
5.16.2	Condensation on Interior Surfaces	5.1.2
5.17	Buildings with Attached Parking Garages	5.2
5.18	Air Classification and Recirculation	5.13
5.18.1	Classification	5.13.1
5.18.2	Redesignation	5.13.2
5.18.2.1	Air Cleaning	5.13.2.1
5.18.2.2	Transfer	5.13.2.2
5.18.2.3	Ancillary Spaces	5.13.2.3
5.18.3	Recirculation Limitations	5.13.3
5.18.3.1	Class 1 Air	5.13.3.1
5.18.3.2	Class 2 Air	5.13.3.2
5.18.3.2.1		5.13.3.2.1
5.18.3.2.2		5.13.3.2.2
5.18.3.2.3		5.13.3.2.3
5.18.3.2.4		5.13.3.2.4
5.18.3.2.5		5.13.3.2.5
5.18.3.3	Class 3 Air	5.13.3.3

Table O-1 Crosswalk for Reorganized Section 5 *(Continued)*

2019 Edition Section	Title	2022 Edition Section
5.18.3.3.1		5.13.3.3.1
5.18.3.3.2		5.13.3.3.2
5.18.3.4	Class 4 Air	5.13.3.4
5.18.4	Documentation	5.13.4
5.19	Requirements for Buildings Containing ETS Area and ETS-Free Areas	5.3
5.19.1	Classification	5.3.1
5.19.2	Pressurization	5.3.2
5.19.3	Separation	5.3.3
5.19.4	Transfer Air	5.3.4
5.19.5	Recirculation	5.3.5
5.19.6	Exhaust Systems	5.3.6
5.19.7	Signage	5.3.7
5.19.8	Reclassification	5.3.8
Addendum y	Legionella Risk	5.20

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INFORMATIVE APPENDIX P
INFORMATIVE REFERENCES

		Section
American Conference of Governmental Industrial Hygienists (ACGIH) **3640 Park 42 Drive** **Cincinnati, OH** **(513) 742-2020; www.acgih.org**		
2017	TLVs and BEIs—Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (Section 6)	Table 6-6
Air Movement and Control Association International (AMCA) **30 W University Dr.** **Arlington Heights, IL 60004** **(847) 394-0150; www.amca.org**		
AMCA 511 (Rev. 2016)	Certified Ratings Program—Product Rating Manual for Air Control Devices	5.4.2
ASHRAE **1791 Tullie Circle NE** **Atlanta, GA 30329** **(800) 527-4723; www.ashrae.org**		
2017 ASHRAE Handbook—Fundamentals		Informative Appendix K
ASHRAE RP-1009 (2001)	Simplified Diffuser Boundary Conditions for Numerical Room Airflow Models	Normative Appendix C
ASHRAE RP-1373 (2009)	Air Distribution Effectiveness with Stratified Air Distribution Systems	Normative Appendix C
ASHRAE Standard 55 (2020)	Thermal Environmental Conditions for Human Occupancy	H1.2.7
Chartered Institution of Building Services Engineers (CIBSE) **222 Balham High Road** **London** **SW12 9BS** **United Kingdom** **+44 (0)20 8675 5211; www.cibse.org**		
CIBSE AM10 (2005)	Natural Ventilation in Non-Domestic Buildings	Informative Appendix K
Wiley & Sons		
Etheridge, D.W., and M. Sandberg (1996)	Building Ventilation: Theory and Measurement, Vol. 50	Informative Appendix K
***Energy and Buildings* 65:516–22**		
von Grabe, J. (2013)	Flow resistance for different types of windows in the case of buoyancy ventilation	Informative Appendix K
***International Journal of Environmental Research and Public Health* 11(11):11753-71.**		
Ahn, J.H., J.E. Szulejko, K.H. Kim, Y.H. Kim, and B.W. Kim (2014)	Odor and VOC emissions from pan frying of mackerel at three stages: Raw, well-done, and charred	Informative Appendix N

		Section
National Institute of Standards and Technology (NIST) **100 Bureau Dr.,** **Gaithersburg, MD 20899** **(301) 975-2000; www.nist.gov**		
Dols, W.S., and G.N. Walton (2002)	CONTAMW 2.0 User Manual	Informative Appendix F

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INFORMATIVE APPENDIX Q
ADDENDA DESCRIPTION

ANSI/ASHRAE Standard 62.1-2022 incorporates ANSI/ASHRAE Standard 62.1-2019 and Addenda a, b, c, d, f, g, i, p, y, aa, and ao to ANSI/ASHRAE Standard 62.1-2019. Table Q-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.

Informative: Many sections and appendices have been renumbered in the 2022 edition. The designations listed below reflect those prior to reorganization. Final designations may differ.

Table Q-1 Addenda to ANSI/ASHRAE Standard 62.1-2019

Addendum	Section(s) Affected	Description of Changes*	Approval Dates
a	6.2.1.1.3	Addendum a clarifies that air density adjustments are permitted but are not required.	January 27, 2021 (Stdcomm) February 4, 2021 (BOD) February 26, 2021 (ANSI)
b	3.1; Figure 3-1	Addendum b clarifies the definition of *recirculated air* by removing the requirement that recirculated air must leave the space and by updating Figure 3-1 to include air-condition units that are inside the space	June 30, 2020 (ASHRAE/ANSI)
c	3.1	Addendum c clarifies what the committee considers an *unusual source*. The new definition makes clear that the unusual nature of a source has to do with its relationship to common items and activities within the space.	October 30, 2020 (ASHRAE/ANSI)
d	3.1; Table 5-1	Addendum d clarifies that open-circuit cooling towers, closed-circuit cooling towers, and evaporative condensers are all covered by the minimum separation distance requirements.	October 30, 2020 (ASHRAE/ANSI)
f	5.10	Addendum f clarifies the intent of Section 5.10, “Maximum Indoor Air Dew Point in Mechanically Cooled Buildings,” which had previously been interpreted by some users to mean that the standard requires humidity sensors in every space served by a mechanically cooled system.	June 30, 2021 (ASHRAE/ANSI)
g	Table 6-1; Table 6-3; 6.2.1.14; 6.2.1.1.7.1; Table J-1 (previously Table I-1); Table M-1 (previously Table L-1)	Addendum g removes some items related to nontransient occupancies that are now under the scope of ANSI/ASHRAE Standard 62.2, “Ventilation and Acceptable Indoor Air Quality in Residential Buildings.”	September 30, 2021 (ASHRAE/ANSI)

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

Table Q-1 Addenda to ANSI/ASHRAE Standard 62.1-2019 *(Continued)*

Addendum	Section(s) Affected	Description of Changes*	Approval Dates
i	Table 6-1; 6.2.1	Addendum i relocates Table 6-1 values related to low-risk outpatient facilities to new Normative Appendix D. ASHRAE/ASHE Standard 170-2021 previously added a new Table 8-2 covering low-risk outpatient facilities and listing R_a and R_p values for such spaces, which supersede the values listed in Standard 62.1-2019, Table 6-1. Rather than delete the values entirely from Standard 62.1, they are relocated to accommodate building codes (e.g., International Mechanical Code®) that still do not reference Standard 170 for business occupancy (B) outpatient facilities.	April 29, 2022 (ASHRAE/ANSI)
p	3.1, 5.18.3.2.5, 5.18.3.3.2, 9	Addendum p modifies the 2019 term “energy recovery ventilation system” to be “energy recovery device,” as the original term was not used in the standard, and the latter term wasn’t defined. The 2019 standard contained exceptions for leakage from “energy recovery devices,” but due to ambiguity in how the relevant terms were listed and defined, those exceptions had been misinterpreted and misapplied.	February 1, 2020 (Stdcomm) February 5, 2020 (BOD) February 6, 2020 (ASHRAE/ANSI)
y	5.20, 9	Addendum y requires advising the owner of the basic requirements of ASHRAE Standard 188, *Legionellosis: Risk Management for Building Water Systems*.	October 16, 2019 (Stdcomm) November 1, 2019 (BOD) November 5, 2019 (ASHRAE/ANSI)
aa	3.1, 6.1.2, 6.3, 6.3.1, 6.3.2, 6.3.3, 6.3.3.1, 6.3.3.2, 6.3.6, 7, 7.3, 7.3.1, 7.3.1.1, 7.3.2, 7.3.3, 9; Tables 6-5, 6-6, 7-1, 7-2, 7-3	Addendum aa adds a minimum requirement of percentage of people satisfied and requirements for designing to specific limits for design compounds and particulate matter. The design compounds are specifically identified. Mixtures are specifically identified. Objective and subjective testing are added.	October 19, 2021 (Stdcomm) November 10, 2021 (BOD) November 10, 2021 (ASHRAE/ANSI)
ao	Title	Addendum ao revises the title of the standard, because Standard 62.1 is not a standard only about ventilation. It is about indoor air quality in general, and many requirements are nonventilation. Some of these include drain pans, frequency of maintenance activities, and combustion air requirements (see Sections 5, 7, and 8).	October 16, 2019 (Stdcomm) November 1, 2019 (BOD) November 5, 2019 (ASHRAE/ANSI)
Editorial	5	Section 5 was reorganized editorially to reflect the path of airflow and better illustrate how buildings, systems, and equipment are related in the context of the standard. No substantive changes were made in the process.	N/A

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

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

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.

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Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

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Product code: 86308 8/22