

CHAPTER 4 VENTILATION

SECTION 401 GENERAL

401.1 Scope. This chapter shall govern the ventilation of spaces within a building intended to be occupied. Mechanical exhaust systems, including exhaust systems serving clothes dryers and cooking *appliances*; hazardous exhaust systems; dust, stock and refuse conveyor systems; subslab soil exhaust systems; smoke control systems; energy recovery ventilation systems and other systems specified in Section 502 shall comply with Chapter 5.

401.2 Ventilation required. Every occupied space shall be ventilated by natural means in accordance with Chapter 12 of the *Building Code* or by mechanical means in accordance with Section 403. Ambulatory care facilities and Group I-2 *occupancies* shall be ventilated by mechanical means in accordance with Section 407.

Exception: Rooms within a private dwelling that contain a bathtub, shower or spa facility shall be provided with mechanical ventilation in accordance with the provisions of Table 403.3.1.1.

Note: Heating and air-conditioning controls shall conform to the *Energy Code*.

401.3 When required. Ventilation shall be provided during the periods that the room or space is occupied.

401.4 Intake opening location. Air intake openings shall comply with all of the following:

1. Intake openings shall be located not less than 10 feet (3048 mm) from lot lines or buildings on the same lot.
2. Mechanical and gravity outdoor air intake openings shall be located not less than 10 feet (3048 mm) horizontally from any hazardous or noxious contaminant source, such as gas meters, vents, streets, alleys, parking lots and loading docks, except as specified in Item 3 or Section 501.3.1. Outdoor air intake openings shall be permitted to be located less than 10 feet (3048 mm) horizontally from streets, alleys, parking lots and loading docks provided that the openings are located not less than 25 feet (7620 mm) vertically above such locations. Where openings front on a street or public way, the distance shall be measured from the closest edge of the street or public way.
3. Intake openings shall be located not less than 3 feet (914 mm) below contaminant sources where such sources are located within 10 feet (3048 mm) of the opening. Separation is not required between intake air openings and living space *exhaust air* openings of an individual *dwelling unit* or *sleeping unit* where a factory-built intake/exhaust combination termination fitting is used to separate the air streams in accordance with the manufacturer's instructions.

4. Intake openings on structures in flood hazard areas shall be at or above the elevation established by the *flood plain administrator* for utilities and attendant equipment.

401.5 Intake opening protection. Air intake openings that terminate outdoors shall be protected with corrosion-resistant screens, louvers or grilles. Openings in louvers, grilles and screens shall be sized in accordance with Table 401.5, and shall be protected against local weather conditions. Louvers that protect air intake openings in structures located in hurricane-prone regions, as defined in the *Building Code*, shall comply with AMCA 550. Outdoor air intake openings located in exterior walls shall meet the provisions for exterior wall opening protectives in accordance with the *Building Code*.

**TABLE 401.5
OPENING SIZES IN LOUVERS, GRILLES AND
SCREENS PROTECTING AIR INTAKE OPENINGS**

OUTDOOR OPENING TYPE	MINIMUM AND MAXIMUM OPENING SIZES IN LOUVERS, GRILLES AND SCREENS ^a
Intake openings in residential occupancies	Not < 1/4 inch and not > 1/2 inch
Intake openings in other than residential occupancies	> 1/4 inch and not > 1 inch

For SI: 1 inch = 25.4 mm.

- a. For rectangular openings, the table requirements apply to the shortest side. For round openings, the table requirements apply to the diameter. For square openings, the table requirements apply to any side.

401.6 Contaminant sources. Stationary local sources producing airborne particulates, heat, odors, fumes, spray, vapors, smoke or gases in such quantities as to be irritating or injurious to health shall be provided with an exhaust system in accordance with Chapter 5 or a means of collection and removal of the contaminants. Such exhaust shall discharge directly to an *approved* location at the exterior of the building.

SECTION 402 NATURAL VENTILATION

Note: Section 402 is not part of this code but is retained here for the reader's convenience. Natural ventilation is regulated under the *Building Code*.

402.1 Natural ventilation. *Natural ventilation* of an occupied space shall be through windows, doors, louvers or other openings to the outdoors. The operating mechanism for such openings shall be provided with ready access so that the openings are readily controllable by the building occupants.

402.2 Ventilation area required. The minimum openable area to the outdoors shall be 4 percent of the floor area being ventilated.

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402.3 Adjoining spaces. Where rooms and spaces without openings to the outdoors are ventilated through an adjoining room, the opening to the adjoining rooms shall be unobstructed and shall have an area not less than 8 percent of the floor area of the interior room or space, but not less than 25 square feet (2.3 m²). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

Exception: Exterior openings required for ventilation shall be permitted to open into a thermally isolated sunroom addition or patio cover, provided that the openable area between the sunroom addition or patio cover and the interior room has an area of not less than 8 percent of the floor area of the interior room or space, but not less than 20 square feet (1.86 m²). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

402.4 Openings below grade. Where openings below grade provide required *natural ventilation*, the outdoor horizontal clear space measured perpendicular to the opening shall be one and one-half times the depth of the opening. The depth of the opening shall be measured from the average adjoining ground level to the bottom of the opening.

SECTION 403 MECHANICAL VENTILATION

403.1 Ventilation system. Mechanical ventilation shall be provided by a method of supply air and return or *exhaust air* except that mechanical ventilation air requirements for Group R-2, R-3 and R-4 *occupancies* shall be provided by an exhaust system, supply system or combination thereof. The amount of supply air shall be approximately equal to the amount of return and *exhaust air*. The system shall not be prohibited from producing negative or positive pressure. The system to convey *ventilation air* shall be designed and installed in accordance with Chapter 6.

403.2 Outdoor air required. The minimum outdoor airflow rate shall be determined in accordance with Section 403.3.

Exception: Where the *registered design professional* demonstrates that an engineered ventilation system design will prevent the maximum concentration of contaminants from exceeding that obtainable by the rate of outdoor air ventilation determined in accordance with Section 403.3, the minimum required rate of outdoor air shall be reduced in accordance with such engineered system design.

403.2.1 Recirculation of air. The outdoor air required by Section 403.3 shall not be recirculated. Air in excess of that required by Section 403.3 shall not be prohibited from being recirculated as a component of supply air to building spaces, except that:

1. Ventilation air shall not be recirculated from one *dwelling* to another or to dissimilar *occupancies*.
2. Supply air to a swimming pool and associated deck areas shall not be recirculated unless such air is dehumidified to maintain the relative humidity of

the area at 60 percent or less. Air from this area shall not be recirculated to other spaces where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces. The design and installation of dehumidification systems shall comply with ANSI/ACCA 10 Manual SPS.

3. Where mechanical exhaust is required by Note b in Table 403.3.1.1, recirculation of air from such spaces shall be prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited. Where recirculation of air is prohibited, all air supplied to such spaces shall be exhausted, including any air in excess of that required by Table 403.3.1.1.
4. Where mechanical exhaust is required by Note g in Table 403.3.1.1, mechanical exhaust is required and recirculation from such spaces is prohibited where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces. Recirculation of air that is contained completely within such spaces shall not be prohibited.

403.2.2 Transfer air. Air transferred from occupiable spaces is not prohibited from serving as *makeup air* for required exhaust systems in such spaces as kitchens, baths, toilet rooms, elevators and smoking lounges. The amount of transfer air and *exhaust air* shall be sufficient to provide the flow rates as specified in Section 403.3.1.1. The required outdoor airflow rates specified in Table 403.3.1.1 shall be introduced directly into such spaces or into the occupied spaces from which air is transferred or a combination of both.

Exceptions:

1. Where recirculation from such spaces is prohibited by Table 403.3.1.1.
2. Air transferred from spaces served by other fan systems shall not be used if those systems are required to meet either Section 401.6 of this code or the *Energy Code*.
3. Where the ventilation schedule of the HVAC system supplying transfer air is not similar to the exhaust system operating schedule.

403.3 Outdoor air and local exhaust airflow rates. Group R-2, R-3 and R-4 occupancies three stories and less in height above grade plane shall be provided with outdoor air and local exhaust in accordance with Section 403.3.2. Other buildings intended to be occupied shall be provided with outdoor air and local exhaust in accordance with Section 403.3.1.

403.3.1 Other buildings intended to be occupied. The design of local exhaust systems and ventilation systems for outdoor air for *occupancies* other than Group R-2, R-3 and R-4 three stories and less above grade plane shall comply with Sections 403.3.1.1 through 403.3.1.4.

403.3.1.1 Outdoor airflow rate. Ventilation systems shall be designed to have the capacity to supply the minimum outdoor airflow rate, determined in accordance with this section. The occupant load utilized for

design of the ventilation system shall be not less than the number determined from the estimated maximum occupant load rate indicated in Table 403.3.1.1. The ventilation occupancy load and occupancy ventilation design methods shall be documented on plans and specifications. Ventilation rates for occupancies not represented in Table 403.3.1.1 shall be those for a listed *occupancy* classification that is most similar in terms of occupant density, activities and building construction; or shall be determined by an *approved* engineering analysis. The ventilation system shall be designed to supply the required rate of *ventilation air* continuously during the period the building is occupied, except as otherwise stated in other provisions of the code.

With the exception of smoking lounges, the ventilation rates in Table 403.3.1.1 are based on the absence of smoking in occupiable spaces. Where smoking is anticipated in a space other than a smoking lounge, the ventilation system serving the space shall be designed to provide ventilation over and above that required by Table 403.3.1.1 in accordance with accepted engineering practice.

Exception: The occupant load is not required to be determined based on the estimated maximum occupant load rate indicated in Table 403.3.1.1 where *approved* statistical data document the accuracy of an alternative anticipated occupant density. The occupant load shall be not less than one-half the number determined from Table 403.3.1.1.

**TABLE 403.3.1.1
MINIMUM VENTILATION RATES**

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT ² ^a	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _a CFM/FT ² ^a	EXHAUST AIRFLOW RATE CFM/FT ² ^a
Correctional facilities				
Booking/waiting	50	7.5	0.06	—
Cells				
without plumbing fixtures	25	5	0.12	—
with plumbing fixtures ^g	25	5	0.12	1.0
Day room	30	5	0.06	—
Dining halls (see “Food and beverage service”)	—	—	—	—
Guard stations	15	5	0.06	—
Dry cleaners, laundries				
Coin-operated dry cleaner	20	15	—	—
Coin-operated laundries	20	7.5	0.12	—
Commercial dry cleaner	30	30	—	—
Commercial laundry	10	5	0.12	—
Storage, pick up	30	7.5	0.12	—
Education				
Art classroom ^g	20	10	0.18	0.7
Auditoriums	150	5	0.06	—
Classrooms (ages 5–8)	25	10	0.12	—
Classrooms (age 9 plus)	35	10	0.12	—
Computer lab	25	10	0.12	—
Corridors (see “Public spaces”)	—	—	—	—
Day care (through age 4)	25	10	0.18	—
Lecture classroom	65	7.5	0.06	—
Lecture hall (fixed seats)	150	7.5	0.06	—
Locker/dressing rooms ^g	—	—	—	0.25
Media center	25	10	0.12	—
Multiuse assembly	100	7.5	0.06	—
Music/theater/dance	35	10	0.06	—
Science laboratories ^g	25	10	0.18	1.0
Smoking lounges ^b	70	60	—	—
Sports locker rooms ^g	—	—	—	0.5
Wood/metal shops ^g	20	10	0.18	0.5
Food and beverage service				
Bars, cocktail lounges	100	7.5	0.18	—
Cafeteria, fast food	100	7.5	0.18	—
Dining rooms	70	7.5	0.18	—
Kitchens (cooking) ^b	20	7.5	0.12	0.7

(continued)

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TABLE 403.3.1.1—continued
MINIMUM VENTILATION RATES

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT ² ^a	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _a CFM/FT ² ^a	EXHAUST AIRFLOW RATE CFM/FT ² ^a
Hotels, motels, resorts and dormitories				
Bathrooms/toilet—private ^g	—	—	—	25/50 ^f
Bedroom/living room	10	5	0.06	—
Conference/meeting	50	5	0.06	—
Dormitory sleeping areas	20	5	0.06	—
Gambling casinos	120	7.5	0.18	—
Lobbies/prefunction	30	7.5	0.06	—
Multipurpose assembly	120	5	0.06	—
Offices				
Conference rooms	50	5	0.06	—
Main entry lobbies	10	5	0.06	—
Office spaces	5	5	0.06	—
Reception areas	30	5	0.06	—
Telephone/data entry	60	5	0.06	—
Private dwellings, single and multiple				
Garages, common for multiple units ^b	—	—	—	0.75
Kitchens ^b	—	—	—	50/150 ^f
Living areas ^c	Based on number of bedrooms. First bed- room, 2; each addi- tional bedroom, 1	0.35 ACH but not less than 15 cfm/person	—	—
Toilet rooms and bathrooms ^{g, i, j}	—	—	—	25/80 ^f
Public spaces				
Corridors	—	—	0.06	—
Courtrooms	70	5	0.06	—
Elevator car	—	—	—	1.0
Legislative chambers	50	5	0.06	—
Libraries	10	5	0.12	—
Museums (children's)	40	7.5	0.12	—
Museums/galleries	40	7.5	0.06	—
Places of religious worship	120	5	0.06	—
Shower room (per shower head) ^g	—	—	—	50/20 ^f
Smoking lounges ^b	70	60	—	—
Toilet rooms — public ^g	—	—	—	50/70 ^e
Retail stores, sales floors and showroom floors				
Dressing rooms	—	—	—	0.25
Mall common areas	40	7.5	0.06	—
Sales	15	7.5	0.12	—
Shipping and receiving	2	10	0.12	—
Smoking lounges ^b	70	60	—	—
Storage rooms	—	—	0.12	—
Warehouses (see "Storage")	—	10	0.06	—
Specialty shops				
Automotive motor fuel-dispensing stations ^b	—	—	—	1.5
Barber	25	7.5	0.06	0.5
Beauty salons ^b	25	20	0.12	0.6
Embalming room ^b	—	—	—	2.0
Nail salons ^{b, h}	25	20	0.12	0.6
Pet shops (animal areas) ^b	10	7.5	0.18	0.9
Supermarkets	8	7.5	0.06	—

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**TABLE 403.3.1.1—continued
MINIMUM VENTILATION RATES**

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT ² a	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _a CFM/FT ² a	EXHAUST AIRFLOW RATE CFM/FT ² a
Sports and amusement				
Bowling alleys (seating areas)	40	10	0.12	—
Disco/dance floors	100	20	0.06	—
Game arcades	20	7.5	0.18	—
Gym, stadium, arena (play area)	7	20	0.18	—
Health club/aerobics room	40	20	0.06	—
Health club/weight room	10	20	0.06	—
Ice arenas without combustion engines	—	—	0.30	0.5
Spectator areas	150	7.5	0.06	—
Swimming pools (pool and deck area)	—	—	0.48	—
Storage				
Refrigerated warehouses/freezers	—	10	—	0.75
Repair garages, enclosed parking garages ^{b, d}	—	—	—	0.75
Warehouses	—	10	0.06	—
Theaters				
Auditoriums (see “Education”)	—	—	—	—
Lobbies	150	5	0.06	—
Stages, studios	70	10	0.06	—
Ticket booths	60	5	0.06	—
Transportation				
Platforms	100	7.5	0.06	—
Transportation waiting	100	7.5	0.06	—
Workrooms				
Bank vaults/safe deposit	5	5	0.06	—
Computer (without printing)	4	5	0.06	—
Copy, printing rooms	4	5	0.06	0.5
Darkrooms	—	—	—	1.0
Meat processing ^e	10	15	—	—
Pharmacy (prep. area)	10	5	0.18	—
Photo studios	10	5	0.12	—

For SI: 1 cubic foot per minute = 0.0004719 m³/s, 1 ton = 908 kg, 1 cubic foot per minute per square foot = 0.00508 m³/(s • m²), °C = [(°F) – 32]/1.8, 1 square foot = 0.0929 m².

- a. Based on net occupiable floor area.
- b. Mechanical exhaust required and the recirculation of air from such spaces is prohibited. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Item 3).
- c. Spaces unheated or maintained below 50°F are not covered by these requirements unless the occupancy is continuous.
- d. Ventilation systems in enclosed parking garages shall comply with Section 404.
- e. Rates are per water closet or urinal. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.
- f. Rates are per room unless otherwise indicated. The higher rate shall be provided where the exhaust system is designed to operate intermittently. The lower rate shall be permitted only where the exhaust system is designed to operate continuously while occupied.
- g. Mechanical exhaust is required and recirculation from such spaces is prohibited. For environmental air exhaust, where there is a wheel-type energy recovery ventilation (ERV) unit in the exhaust system design, the volume of air leaked from the exhaust airstream into the outdoor airstream within the ERV shall be less than 10 percent of the outdoor air volume. Recirculation of air that is contained completely within such spaces shall not be prohibited (see Section 403.2.1, Items 2 and 4).
- h. For nail salons, each manicure and pedicure station shall be provided with a source capture system capable of exhausting not less than 50 cfm per station. Exhaust inlets shall be located in accordance with Section 502.20. Where one or more required source capture systems operate continuously during occupancy, the exhaust rate from such systems shall be permitted to be applied to the exhaust flow rate required by Table 403.3.1.1 for the nail salon.
- i. All rooms containing bathing or residential spa facilities shall be provided with a mechanical ventilation system controlled by a dehumidistat, timer or similar means of automatic control.
- j. Rooms containing bathing or residential spa facilities: Continuous ventilation fans shall be rated for sound at a maximum of 1.0 sone. Intermittent fans shall be rated for sound at a maximum of 3 sone unless their maximum rated airflow exceeds 400 cfm. Remotely installed fans located at least 4 feet away from the inlet grill are exempt from the sone rating requirements.

403.3.1.1.1 Zone outdoor airflow. The minimum outdoor airflow required to be supplied to each zone shall be determined as a function of *occupancy* classification and space air distribution effectiveness in accordance with Sections 403.3.1.1.1.1 through 403.3.1.1.1.3.

403.3.1.1.1.1 Breathing zone outdoor airflow. The outdoor airflow rate required in the *breathing zone* (V_{bz}) of the *occupiable space* or spaces in a zone shall be determined in accordance with Equation 4-1.

$$V_{bz} = R_p P_z + R_a A_z \quad \text{(Equation 4-1)}$$

where:

A_z = Zone floor area: the net *occupiable floor area* of the space or spaces in the zone.

P_z = Zone population: the number of people in the space or spaces in the zone.

R_p = People outdoor air rate: the outdoor airflow rate required per person from Table 403.3.1.1.1.

R_a = Area outdoor air rate: the outdoor airflow rate required per unit area from Table 403.3.1.1.1.

403.3.1.1.1.2 Zone air distribution effectiveness. The zone air distribution effectiveness (E_z) shall be determined using Table 403.3.1.1.1.2.

**TABLE 403.3.1.1.1.2
ZONE AIR DISTRIBUTION EFFECTIVENESS^{a, b, c, d}**

AIR DISTRIBUTION CONFIGURATION	E_z
Ceiling or floor supply of cool air	1.0 ^e
Ceiling or floor supply of warm air and floor return	1.0
Ceiling supply of warm air and ceiling return	0.8 ^f
Floor supply of warm air and ceiling return	0.7
Makeup air drawn in on the opposite side of the room from the exhaust or return	0.8
Makeup air drawn in near to the exhaust or return location	0.5

For SI: 1 foot = 304.8 mm, 1 foot per minute = 0.00506 m/s, °C = [(°F) - 32]/1.8.

- a. "Cool air" is air cooler than space temperature.
- b. "Warm air" is air warmer than space temperature.
- c. "Ceiling" includes any point above the breathing zone.
- d. "Floor" includes any point below the breathing zone.
- e. Zone air distribution effectiveness of 1.2 shall be permitted for systems with a floor supply of cool air and ceiling return, provided that low-velocity displacement ventilation achieves unidirectional flow and thermal stratification.
- f. Zone air distribution effectiveness of 1.0 shall be permitted for systems with a ceiling supply of warm air, provided that supply air temperature is less than 15°F above space temperature and provided that the 150-foot-per-minute supply air jet reaches to within 4½ feet of floor level.

403.3.1.1.1.3 Zone outdoor airflow. The zone outdoor airflow rate (V_{oz}), shall be determined in accordance with Equation 4-2.

$$V_{oz} = \frac{V_{bz}}{E_z} \quad \text{(Equation 4-2)}$$

403.3.1.1.2 System outdoor airflow. The outdoor air required to be supplied by each ventilation system shall be determined in accordance with Sections 403.3.1.1.2.1 through 403.3.1.1.2.3.4 as a function of system type and zone outdoor airflow rates.

403.3.1.1.2.1 Single zone systems. Where one air handler supplies a mixture of outdoor air and recirculated return air to only one zone, the system outdoor air intake flow rate (V_{ot}) shall be determined in accordance with Equation 4-3.

$$V_{ot} = V_{oz} \quad \text{(Equation 4-3)}$$

403.3.1.1.2.2 100-percent outdoor air systems. Where one air handler supplies only outdoor air to one or more zones, the system outdoor air intake flow rate (V_{ot}) shall be determined using Equation 4-4.

$$V_{ot} = \sum_{all\ zones} V_{oz} \quad \text{(Equation 4-4)}$$

403.3.1.1.2.3 Multiple zone recirculating systems. Where one air handler supplies a mixture of outdoor air and recirculated return air to more than one zone, the system outdoor air intake flow rate (V_{ot}) shall be determined in accordance with Sections 403.3.1.1.2.3.1 through 403.3.1.1.2.3.4.

403.3.1.1.2.3.1 Primary outdoor air fraction.

The primary outdoor air fraction (Z_p) shall be determined for each zone in accordance with Equation 4-5.

$$Z_p = \frac{V_{oz}}{V_{pz}} \quad \text{(Equation 4-5)}$$

where:

V_{pz} = Primary airflow: The airflow rate supplied to the zone from the airhandling unit at which the outdoor air intake is located. It includes outdoor intake air and recirculated air from that air-handling unit but does not include air transferred or air recirculated to the zone by other means. For design purposes, V_{pz} shall be the zone design primary airflow rate, except for zones with variable air volume supply and V_{pz} shall be the lowest expected primary airflow rate to the zone when it is fully occupied.