

culated to some other space or occupancy and does not prevent recirculation of air within the subject space. Air other than the required outdoor airflow rate required by Table 403.3.1.1 can be recirculated within the space designated with Note g, but cannot be circulated outside of such space, except for the 10-percent limit. In other words, mixed air delivered to some other space could contain up to 10 percent air taken from the space designated with Note g (see commentary, Section 403.2.1).

Note h addresses nail salons and requires a source capture system for each table/station in addition to the other requirements for ventilation and exhaust in Table 403.3.1.1. Of course, it is likely that some beauty salons will contain nail stations which would trigger the requirements of Note h. The intent is to require a moveable hood that can be placed over the nails (hands or feet) being serviced or a special table with exhaust air intake openings and baffles that will capture the chemical vapors at their source and exhaust them to the outdoors [see Commentary Figures 403.3.1.1(1) and 403.3.1.1(2)]. See the definitions of “Exhaust system” and “Source capture system.” An exhaust fan located in a ceiling or anywhere else other than right next to the chemical source does not meet the intent of the code. Also, an exhaust system that captures the vapors, passes them through a filtering system and discharges the air back into the room does not meet the intent of the code and any such system would have to be approved by the code official under Section 105.2. See the commentary for Item 3 of Section 403.2.1 for discussion of recirculation of space conditioning air. Note the allowance to count the exhaust flow from continuously operating source capture systems toward the required exhaust flow in Table 403.3.1.1. See Section 502.20.

Notes b and g in Table 403.3.1.1 have also been misinterpreted so that designers thought they should prevent the air within a space from being recirculated within that space—and that all return air from the HVAC system had to be exhausted. The notes were misread and the intent misunderstood. Note b says that recirculation of air “from such spaces” is prohibited, which means that the air in the space could not be transferred to some other space. For example, a beauty salon could be affected by Note b, and the air in that salon could not be circulated to another occupancy. However, the air in the salon could be recirculated within the salon to the extent that the ventilation complies with Section 403.2.1. If this were not the case, the beauty salon owner/tenant could not afford to heat and cool the space. Recent revisions to Notes b and g correlate with changes to Section 403.2.1. The prohibitions on recirculation of air apply where air is circulated among multiple spaces, not where the air is recirculated within the same space.

Changes to Section 403.2.1 and Table 403.3.1.1 clarify that recirculation of air within a space is allowed. In previous editions of the code, Item 3 in

Section 403.2.1 has been misinterpreted. It states that in a space identified by Note b in the table, air cannot be circulated from such space to some other space. Therefore, if different spaces are served by the same HVAC air handler, the only way to prevent air in one space from being picked up by the air handler and distributed to other spaces is to exhaust all of the air supplied to that one space.

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.

❖ See the definition of “Zone” in Chapter 2. The zone is where the occupants are located and the required zone outdoor airflow rate is determined (in most cases) by a combined rate per person and rate per area. It is also affected by the configuration of the air distribution system (see Sections 403.3.1.1.1.1 and 403.3.1.1.1.2).

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.

R_a = Area outdoor air rate: the outdoor airflow rate required per unit area from Table 403.3.1.1.

❖ The equation sums the rate per person times the number of occupants and the rate per area times the square footage of the zone floor. As can be seen from this equation, the code now combines two different airflow requirements that were previously independent in editions of the code prior to 2009. The basis for this approach is that studies have shown that the effects of people-produced contaminants and the effects of building- and building content-produced contaminants are additive in their effect on occupants (see Example 1 under Section 403.3.1.1.2.3.4).

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.

❖ The location of supply and return air grilles, diffusers and registers and the temperature of the supply air all affect the movement of air through a conditioned space. Some air distribution configurations are better (more effective) than others at achieving a uniform flow through a space. Uniform flow helps to prevent dead (stagnant) zones and short-circuited flow. Venti-

lation works best when airflow sweeps through the entire cross section of a space, thereby reaching all occupants and flushing out contaminants. The intent of this section is to rate the air distribution system as to its ability to produce effective ventilation. Table 403.3.1.1.1.2 was developed based on fluid modeling analysis that considers the buoyancy of air masses and predicts air movement, eddy flow, air mixing and flow patterns. The table ratings may not be what one

would expect based on the system configuration, but they are logical when the fluid flow analysis is viewed.

The effectiveness number (E_z) is applied in Equation 4-2 of Section 403.3.1.1.1.3 and the purpose of that calculation is to adjust the breathing zone airflow rate to account for the effectiveness of the air distribution system in delivering the ventilation air (see commentary, Section 403.3.1.1.1.3).

**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	0.06	—
Commercial dry cleaner	30	30	—	—
Commercial laundry	10	25	—	—
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	—	—	—	0.7

(continued)

VENTILATION

**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	—	—	—	25/100 ^f
Living areas ^c	Based upon number of bedrooms. First bedroom, 2; each additional bedroom, 1	0.35 ACH but not less than 15 cfm/person	—	—
Toilet rooms and bathrooms ^g	—	—	—	20/50 ^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	—	—	0.12	—
Smoking lounges ^b	70	60	—	—
Storage rooms	—	—	0.12	—
Warehouses (see storage)	—	—	—	—

(continued)

**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
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
Nail salons ^{b,h}	25	20	0.12	0.6
Embalming room ^b	—	—	—	2.0
Pet shops (animal areas) ^b	10	7.5	0.18	0.9
Supermarkets	8	7.5	0.06	—
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)	—	—	0.30	—
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				
Repair garages, enclosed parking garages ^{b,d}	—	—	—	0.75
Warehouses	—	—	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	—

(continued)

**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 and/or return	0.8
Makeup air drawn in near to the exhaust and/or return location	0.5

For SI: 1 foot = 304.8 mm, 1 foot per minute = 0.00506 m/s,

$$^{\circ}\text{C} = [(^{\circ}\text{F}) - 32]/1.8.$$

- 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.

$$V_{oz} = \frac{V_{bz}}{E_z} \tag{Equation 4-2}$$

- ❖ The (E_z) value determined in the previous section is applied in Equation 4-2 to determine the required out-

**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
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 ^c	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 upon *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 except that recirculation shall be permitted where the resulting supply airstream consists of not more than 10 percent air recirculated from these spaces. 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.

door airflow rate. The result, (V_{oz}), is adjusted upward in many cases; unaffected in some cases; and even adjusted downward in the case described in Note f of Table 403.3.1.1.1.3. For example, if E_z is 1, the rate determined in accordance with Equation 4-1 of Section 403.3.1.1.1.1 is unchanged; and if E_z is 0.5, the rate from Section 403.3.1.1.1.1 is doubled to account for the poor performance of the air distribution system (see Sections 403.3.1.1.2 through 403.3.1.1.2.3.4).

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 as a function of system type and zone outdoor airflow rates.

❖ The actual amount of outdoor air that a ventilation system must deliver is determined in accordance with Section 403.3.1.1.2.1, 403.3.1.1.2.2 or 403.3.1.1.2.3, depending on whether the delivery system serves multiple zones or only one zone, and depending upon whether the system supplies mixed outdoor and recirculated air or only outdoor air.

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.

$$V_{ot} = V_{oz} \tag{Equation 4-3}$$

❖ This type of system calculation is as simple as it gets. If the ventilation system delivers outdoor air and recirculated air to only one zone (see the definition of “Zone”), the total outdoor air component of the delivered air is the same as calculated in Section 403.3.1.1.1.3. In other words, since there is only one zone, the zone outdoor air rate is also the total outdoor air rate (see Example 1 under Section 403.3.1.1.2.3.4).

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.

$$V_{ot} = \sum_{all\ zones} V_{oz} \tag{Equation 4-4}$$

❖ If the ventilation system supplies only outdoor air, with no recirculated air component, and serves multiple zones, the total amount of outdoor air is simply the sum of the zone outdoor air rates. The Greek letter Σ (Sigma) in Equation 4-4 means “sum” and the subscript “all zones” that follows Σ mean that the summing is applied to all of the zones in a multiple zone system. Recall Section 403.3.1.1.2.1, which dealt with single zone systems.

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