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 other than enclosed parking garages, loading docks and motor vehicle repair garages shall be ventilated in accordance with Section 401.2.1 or 401.2.2. Enclosed parking garages, loading docks and motor vehicle repair garages shall be ventilated by mechanical means in accordance with Sections 403 and 404.

[W] 401.2.1 Group R occupancies. Ventilation in Group R occupancies shall be provided in accordance with Sections 403.8 and 403.9.

401.2.2 All other occupancies. Ventilation in all other occupancies shall be provided by natural means in accordance with Section 402 or by mechanical means in accordance with Section 403. ((~~Where the air infiltration rate in a dwelling unit is less than 5 air changes per hour when tested with a blower door at a pressure of 0.2 inch water column (50 Pa) in accordance with Section 402.4.1.2 of the *International Energy Conservation Code*, the dwelling unit shall be ventilated by mechanical means in accordance with Section 403.~~))

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 a minimum of 10 feet (3048 mm) from lot lines or buildings on the same lot. Where openings front on a street or public way, the distance shall be measured from the opposite side of the street or public way.
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 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. The exhaust from a bathroom, clothes dryer or kitchen in a dwelling shall not be considered to be a hazardous or noxious contaminant.

   Exception: Enclosed parking garage and repair garage intakes are permitted to be located less than 10 feet horizontally of the street, alley, parking lots and loading docks.
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.
4. Intake openings on structures in flood hazard areas shall be at or above the elevation required by Section 1612 of the *International Building Code* for utilities and attendant equipment.
5. Intake openings shall not be located:

   5.1. In a crawl space;

   5.2. Less than one foot (305 mm) above a roof, adjacent grade, or other surface directly below the intake; or

   5.3. Under a deck having a surface height less than three feet above grade or other surface directly below the intake.

Interpretation: For purposes of this section, lot line includes any property line separating one lot from another lot, but does not include any property line separating a lot from a public street or alley right-of-way.

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 *International 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 *International 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 MEASURED IN ANY DIRECTION
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.

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.

401.7 Compliance and commissioning. Compliance with Sections 402 and 403.1 through 403.8 shall be demonstrated through engineering calculations. Documentation of calculations shall be submitted on the permit plan sets. Testing and commissioning shall be performed and documented in accordance with the *International Energy Conservation Code*.

SECTION 402
NATURAL VENTILATION

[B] 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.

Exception: Automatically controlled natural ventilation systems do not require ready access and control by building occupants.

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

[B] 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 m^2). 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 m^2). The minimum openable area to the outdoors shall be based on the total floor area being ventilated.

[B] 402.4 Openings below grade. Where openings below grade provide required *natural ventilation*, the outside 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*. 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.

[W] 403.2 Outdoor air required. The minimum outdoor airflow rate shall be determined in accordance with Section 403.3. ((~~Ventilation supply systems shall be designed to deliver the required rate of outdoor airflow to the *breathing zone* within each *occupiable space*.~~))

[W] Exceptions:

1. 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.
2. Alternate systems designed in accordance with ASHRAE Standard 62.1 Section 6.2, Ventilation Rate Procedure shall be permitted.

[W] 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 or more of the resulting supply airstream consists of air recirculated from these spaces.
3. Where mechanical exhaust is required by Note b in Table 403.3, recirculation of air from such spaces shall be prohibited. All air supplied to such spaces shall be exhausted, including any air in excess of that required by Table 403.3.
4. Building HVAC air used as transfer air for heat removal may be recirculated. ((~~Where mechanical exhaust is required by Note g in Table 403.3, mechanical exhaust is required and recirculation is prohibited where more than 10 percent of the resulting supply airstream consists of air recirculated from these spaces.~~))

403.2.2 Transfer air. Except where recirculation from such spaces is prohibited by Table 403.3, 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. The required outdoor airflow rates specified in Table 403.3 shall be introduced directly into such spaces or into the occupied spaces from which air is transferred or a combination of both.

403.2.3 Outdoor air delivery. The *outdoor air* shall be ducted in a fully enclosed path directly to every air-handling unit in each zone not provided with sufficient operable opening area for natural ventilation to occur.

Exception: Ducts may terminate within 12 inches of the intake to an HVAC unit if they are physically fastened so that the *outdoor air* duct is directed into the unit intake.

403.3 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 not be less than the number determined from the estimated maximum occupant load rate indicated in Table 403.3. Ventilation rates for occupancies not represented in Table 403.3 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 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 in accordance with accepted engineering practice.

[W] Exception: ((~~The occupant load is not required to be determined based on the estimated maximum occupant load rate indicated in Table 403.3 where *approved* statistical data document the accuracy of an alternate anticipated occupant density.~~)) Where occupancy density is known and documented in the plans, the *outside air* rate may be based on the design occupant density. Under no circumstance shall the occupancies used result in *outside air* less than one-half that resulting from application of Table 403.3 estimated maximum occupancy rates.

403.3.1 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 through 403.3.1.3.

403.3.1.1 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.

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

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.

R_a = Area outdoor air rate: the outdoor airflow rate required per unit area from Table 403.3.

403.3.1.2 Zone air distribution effectiveness. The zone air distribution effectiveness (E_z) shall be determined using Table 403.3.1.2.

TABLE 403.3.1.2
ZONE AIR DISTRIBUTION EFFECTIVENESS[a,b,c,d,e]

AIR DISTRIBUTION CONFIGURATION	E_z
Ceiling or floor supply of cool air	1.0[f]
Ceiling or floor supply of warm air and floor return	1.0
Ceiling supply of warm air and ceiling return	0.8[g]
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, °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. "Makeup air" is air supplied or transferred to a zone to replace air removed from the zone by exhaust or return systems.

f. 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.

g. 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 $4^1/_2$ feet of floor level.

[W] TABLE 403.3
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				
Cells				
without plumbing fixtures	25	5	0.12	—
with plumbing fixtures[g,k]	25	5	0.12	1.0
Dining halls (see food and beverage service)	—	—	—	—
Guard stations	15	5	0.06	—
Day room	30	5	0.06	—
Booking/waiting	50	7.5	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				
Auditoriums	150	5	0.06	—
Corridors (see public spaces)	—	—	—	—
Media center	25	10	0.12	—
Sports locker rooms[g,k]	—	—	—	0.5
Music/theater/dance	35	10	0.06	—
((~~Smoking lounges~~[b]	~~70~~	~~60~~		—))
Day care (through age 4)	25	10	0.18	—
Classrooms (ages 5-8)	25	10	0.12	—
Classrooms (age 9 plus)	35	10	0.12	—
Lecture classroom	65	7.5	0.06	—
Lecture hall (fixed seats)	150	7.5	0.06	—
Art classroom[g]	20	10	0.18	0.7
Science laboratories[g,k]	25	10	0.18	1.0
Wood/metal shops[g,k]	20	10	0.18	0.5
Computer lab	25	10	0.12	—
Multiuse assembly	100	7.5	0.06	—
Locker/dressing rooms[g,k]	—	—	—	0.25
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
Hospitals, nursing and convalescent homes				
Autopsy rooms[b]	—	—	—	0.5
Medical procedure rooms	20	15	—	—
Operating rooms	20	30	—	—
Patient rooms	10	25	—	—
Physical therapy	20	15	—	—
Recovery and ICU	20	15	—	—

(continued)

[W] TABLE 403.3—continued
MINIMUM VENTILATION RATES

OCCUPANCY CLASSIFICATION	OCCUPANT DENSITY #/1000 FT² [a]	PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_p CFM/PERSON	AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R_a CFM/FT² [a]	EXHAUST AIRFLOW RATE CFM/FT² [a]
Hotels, motels, resorts and dormitories				
Multipurpose assembly	120	5	0.06	—
Bathrooms/toilet—private[g, k]	—	—	—	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	—
Offices				
Conference rooms	50	5	0.06	—
[W] Kitchenettes	—	—	—	0.30
Office spaces	5	5	0.06	—
Reception areas	30	5	0.06	—
Telephone/data entry	60	5	0.06	—
Main entry lobbies	10	5	0.06	—
[W] Private dwellings, single and multiple				
Garages, common for multiple units[b]	—	—	—	0.75
Garages, separate for each dwelling[b]	—	—	—	100 cfm per car
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~~)) See Tables 403.8.1 and 403.8.5.1	—	—
Toilet rooms, ((~~and~~)) bathrooms[k] and laundry areas[g, i]	—	—	—	20/50[f]
Public spaces				
Corridors	—	—	0.06	—
Elevator car	—	—	—	1.0
Elevator lobbies in garages	—	—	1.0	—
Shower room (per shower head)[g, k]	—	—	—	50/20[f]
((~~Smoking lounges[b]~~	~~70~~	~~60~~	—	—))
Toilet rooms — public[g, k]	—	—	—	50/70[e]
Places of religious worship	120	5	0.06	—
Courtrooms	70	5	0.06	—
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	—
Retail stores, sales floors and showroom floors				
Sales (except as below)	15	7.5	0.12	—
Dressing rooms	—	—	—	0.25
Mall common areas	40	7.5	0.06	—
Shipping and receiving	—	—	0.12	—
((~~Smoking lounges[b]~~	~~70~~	~~60~~	—	—))
Storage rooms	—	—	0.12	—
Warehouses (see storage)	—	—	—	—

(continued)

[W] TABLE 403.3—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~~)) 20	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	—
[W] Sports and amusement				
Disco/dance floors	100	20	0.06	—
Bowling alleys (seating areas)	40	10	0.12	—
Game arcades	20	7.5	0.18	—
Ice arenas without combustion engines[i]	—	—	0.30	0.5
Gym, stadium, arena (play area)[i]	—	—	0.30	—
Spectator areas	150	7.5	0.06	—
Swimming pools (pool and deck area)	—	—	0.48	—
Health club/aerobics room	40	20	0.06	—
Health club/weight room	10	20	0.06	—
Storage				
[W] Janitor closets, trash rooms, recycling rooms	—	—	—	1.0
Repair garages[d] ((~~, enclosed parking garages[b,d]~~))	—	—	—	0.75
Enclosed loading docks [d]	—	—	—	1.5
Enclosed parking garages[b, d]	—	—	—	0.75
Ticket booths (within enclosed parking garages)[l]	60	—	—	—
[W] Storage rooms, chemical	—	—	—	1.5
Warehouses	—	—	0.06	—
Non-retail storage spaces >100 sf[k]	—	—	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	—
Darkrooms	—	—	—	1.0
Copy, printing rooms	4	5	0.06	0.5
Meat processing[c]	10	15	—	—
Pharmacy (prep. area)	10	5	0.18	—
Photo studios	10	5	0.12	—
Computer (without printing)	4	5	0.06	—

For SI: 1 cubic foot per minute = 0.0004719 m^3/s, 1 ton = 908 kg, 1 cubic foot per minute per square foot = 0.00508 $m^3/(s \cdot m^2)$, °C = [(°F) -32]/1.8, 1 square foot = 0.0929 m^2.

(continued)

Notes to [W] TABLE 403.3 MINIMUM VENTILATION RATES

a. Based upon *net occupiable floor area*.

b. Mechanical exhaust required and the recirculation of air from such spaces is 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.

[W] g.Mechanical exhaust is required and recirculation 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 (see Section 403.2.1, Items 2 and 4).~~))

h. For nail salons, each nail station shall be provided with a *source capture system* capable of exhausting not less than 50 cfm per station.

[W] i.A laundry area within a kitchen or bathroom is not required to have *local exhaust*. For the laundry area to qualify as being within the kitchen, the laundry room door must open directly into the kitchen and not into an adjacent corridor. Where there are doors that separate the laundry area from the kitchen or bathroom the door shall be louvered.

[W] j.When combustion equipment is intended to be used on the playing surface, additional dilution ventilation and/or source control shall be provided.

k. Transfer air permitted in accordance with Section 403.2.2. For non-retail storage areas, transfer air is also permitted from an adjacent open parking garage, or an enclosed parking garage or loading dock that is mechanically ventilated in accordance with Section 404.

l. This space shall be maintained at a positive pressure. See Section 404.3.

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

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

403.3.2 System outdoor airflow. The outdoor air required to be supplied by each ventilation system shall be determined in accordance with Sections 403.3.2.1 through 403.3.2.3 as a function of system type and zone outdoor airflow rates.

403.3.2.1 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.

$$V_{ot} = V_{oz} \qquad \textbf{(Equation 4-3)}$$

403.3.2.2 100-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.

$$V_{ot} = \Sigma_{all\ zones} V_{oz} \qquad \textbf{(Equation 4-4)}$$

403.3.2.3 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 403.3.2.3.1 through 403.3.2.3.4.

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

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

where:

V_{pz} = Primary airflow: The airflow rate supplied to the zone from the air-handling 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.

403.3.2.3.2 System ventilation efficiency. The system ventilation efficiency (E_v) shall be determined using Table 403.3.2.3.2 or Appendix A of ASHRAE 62.1.

TABLE 403.3.2.3.2
SYSTEM VENTILATION EFFICIENCY[a,b]

Max (Z_p)	E_v
≤ 0.15	1
≤ 0.25	0.9
≤ 0.35	0.8
≤ 0.45	0.7
≤ 0.55	0.6
≤ 0.65	0.5
≤ 0.75	0.4
> 0.75	0.3

a. *Max* (Z_p) is the largest value of Z_p calculated using Equation 4-5 among all the zones served by the system.

b. Interpolating between table values shall be permitted.

403.3.2.3.3 Uncorrected outdoor air intake. The uncorrected outdoor air intake flow rate (V_{ou}) shall be determined in accordance with Equation 4-6.

$$V_{ou} = D\Sigma_{all\ zones} R_p P_z + \Sigma_{all\ zones} R_a A_z \qquad \textbf{(Equation 4-6)}$$

where:

D = Occupant diversity: the ratio of the system population to the sum of the zone populations, determined in accordance with Equation 4-7.

$$D = \frac{P_s}{\Sigma_{all\ zones} P_z} \quad \textbf{(Equation 4-7)}$$

where:

P_s = System population: The total number of occupants in the area served by the system. For design purposes, P_s shall be the maximum number of occupants expected to be concurrently in all zones served by the system.

403.3.2.3.4 Outdoor air intake flow rate. The outdoor air intake flow rate (V_{ot}) shall be determined in accordance with Equation 4-8.

$$V_{ot} = \frac{V_{ou}}{E_v} \quad \textbf{(Equation 4-8)}$$

403.4 Exhaust ventilation. Exhaust airflow rate shall be provided in accordance with the requirements in Table 403.3. Exhaust *makeup air* shall be permitted to be any combination of outdoor air, recirculated air and transfer air, except as limited in accordance with Section 403.2.

403.5 System operation. The minimum flow rate of outdoor air that the ventilation system must be capable of supplying during its operation shall be permitted to be based on the rate per person indicated in Table 403.3 and the actual number of occupants present.

403.6 Variable air volume system control. Variable air volume air distribution systems, other than those designed to supply only 100-percent outdoor air, shall be provided with controls to regulate the flow of outdoor air. Such control system shall be designed to maintain the flow rate of outdoor air at a rate of not less than that required by Section 403.3 over the entire range of supply air operating rates. Calculations and a description of controls operation shall be submitted with the permit drawings.

403.7 Balancing. The *ventilation air* distribution system shall be provided with means to adjust the system to achieve at least the minimum ventilation airflow rate as required by Sections 403.3 and 403.4. Ventilation systems shall be balanced by an *approved* method. Such balancing shall verify that the ventilation system is capable of supplying and exhausting the airflow rates required by Sections 403.3 and 403.4.

[W] 403.8 Ventilation systems for Group R occupancies. Each dwelling unit or sleeping unit shall be equipped with *local exhaust* and whole house ventilation systems and shall comply with Sections 403.8.1 through 403.8.10. All occupancies other than Group R occupied spaces that support the Group R occupancy shall meet the ventilation requirements of Section 402 or Sections 403.1 to 403.7.

403.8.1 Minimum ventilation performance. Ventilation systems shall be designed and installed to satisfy the ventilation requirements of Table 403.3 or Table 403.8.1. *Breathing zone* ventilation rates from Table 403.3 shall be calculated per Section 403.3.1.1 and corrected per zone air distribution effectiveness requirements per Section 403.3.1.2.

TABLE 403.8.1
VENTILATION RATES FOR ALL GROUP R PRIVATE DWELLINGS, SINGLE AND MULTIPLE
(Continuously Operating Systems)

FLOOR AREA (ft^2)	BEDROOMS[1]				
	0-1	2-3	4-5	6-7	> 7
< 1500	30	45	60	75	90
1501 - 3000	45	60	75	90	105
3001 - 4500	60	75	90	105	120
4501 - 6000	75	90	105	120	135
6001 - 7500	90	105	120	135	150
> 7500	105	120	135	150	165

1. Ventilation rates in table are minimum outdoor airflow rates measured in cfm.

403.8.2 Control and operation. Controls for and operation of ventilation systems shall comply with this section.

Exception: Engineered central ventilation systems serving dwelling units or sleeping units are not required to have individual controls for each dwelling unit or sleeping unit when designed for continuous operation and *approved* by the code official.

1. Location of controls. Controls for all ventilation systems shall be readily accessible by the occupant.
2. Instructions. Operating instructions for whole house ventilation systems shall be provided to the occupant by the installer of the system.
3. Local exhaust ventilation systems. Local exhaust ventilation systems shall be controlled by manual switches, dehumidistats, timers, or other *approved* means.
4. Continuous whole house ventilation systems. Continuous whole house ventilation systems shall operate continuously. Exhaust fans, forced-air system fans, or supply fans shall be equipped with "fan on" as override controls. Controls shall be capable of operating the ventilation system without energizing other energy-consuming appliances. A label shall be affixed to the controls that reads "Whole House Ventilation (see operating instructions)."
5. Intermittent whole house ventilation systems. Intermittent whole house ventilation systems shall comply with the following:
   - 5.1. They shall be capable of operating intermittently and continuously.
   - 5.2. They shall have controls capable of operating the exhaust fans, forced-air system fans, or supply fans without energizing other energy-consuming appliances.
   - 5.3. The ventilation rate shall be adjusted according to the exception in Section 403.8.5.1.

5.4. The system shall be designed so that it can operate automatically based on the type of control timer installed.

5.5. The intermittent mechanical ventilation system shall operate at least one hour out of every four.

5.6. The system shall have a manual control and automatic control, such as a 24-hour clock timer.

5.7. At the time of final inspection, the automatic control shall be set to operate the whole house fan according to the schedule used to calculate the whole house fan sizing.

5.8. A label shall be affixed to the control that reads "Whole House Ventilation (see operating instructions)."

403.8.3 Outdoor air intake locations. *Outdoor air* intakes shall be classified as either operable openings or mechanical air intakes. The intake locations for operable openings and mechanical air intakes shall comply with the following:

1. Openings for mechanical air intakes shall comply with Section 401.4. Operable openings shall comply with Section 401.4, Items 2, 4 and 5 only.
2. Intake openings shall not be located closer than 10 feet from an appliance vent outlet unless such vent outlet is 3 feet above the *outdoor air* inlet. The vent shall be permitted to be closer if specifically allowed by Chapter 8 or by the *International Fuel Gas Code*.
3. Intake openings shall be located where they will not pick up objectionable odors, fumes, or flammable vapors.
4. Intake openings shall be located where they will not take air from a hazardous or unsanitary location.
5. Intake openings shall be located where they will not take air from a room or space having a fuel-burning appliance.
6. Intake openings shall not be located closer than 10 feet from a vent opening of a plumbing drainage system unless the vent opening is at least 3 feet above the air inlet.
7. Intake openings shall not be located where they will take air from an attic, crawl space, or garage.

403.8.4 Local exhaust ventilation requirements. Local exhaust ventilation systems shall exhaust at least the volume of air required for exhaust in Table 403.3. Exhaust shall be provided in each kitchen, bathroom, water closet, laundry area, indoor swimming pool, spa, and other rooms where water vapor or cooking odor is produced. Local exhaust ventilation ducts shall terminate outdoors.

403.8.4.1 Local exhaust systems. Exhaust systems shall be designed and installed to meet all of the criteria below:

1. Local exhaust shall be discharged outdoors.
2. Exhaust outlets shall comply with Section 501.3.
3. Pressure equalization shall comply with Section 501.4.
4. Exhaust ducts in systems which are designed to operate intermittently shall be equipped with backdraft dampers.
5. All exhaust ducts in *unconditioned spaces* shall be insulated to a minimum of R-4.
6. Terminal outlet elements shall have at least the equivalent net free area of the ductwork.
7. Terminal outlet elements shall be screened or otherwise protected as required by Section 501.3.2.
8. Exhaust fans in separate dwelling units or sleeping units shall not share common exhaust ducts unless the system is engineered for this operation.
9. Where permitted by Chapter 5, multiple local exhaust ducts may be combined. If more than one of the exhaust fans in a dwelling unit or sleeping unit shares a common exhaust duct then each exhaust fan shall be equipped with a backdraft damper to prevent the recirculation of *exhaust air* from one room to another room via the exhaust ducting system.

403.8.4.2 Local exhaust fans. Exhaust fan construction and sizing shall meet the following criteria.

1. Exhaust fans shall be tested and rated in accordance with the airflow and sound rating procedures of the Home Ventilating Institute: HVI 915 Loudness Testing and Rating Procedure; HVI 916 Airflow Test Procedure; and HVI 920 Product Performance Certification Procedure.

   Exception: Range hoods and down-draft exhaust fans used for local exhaust for kitchens are not required to be rated.

2. Fan airflow rating and duct systems shall be designed and installed to deliver at least the exhaust airflow required by Table 403.3. The airflows required refer to the delivered airflow of the system as installed and tested using a flow hood, flow grid, or other airflow measurement device.

   Exceptions:

   1. An exhaust airflow rating at a pressure of 0.25 in. w.g. may be used, provided the duct sizing meets the prescriptive requirements of Table 403.8.4.2.
   2. Where a range hood or down-draft exhaust fan is used to satisfy the local exhaust requirements for kitchens, the range hood or down draft exhaust shall not be less than 100 cfm at 0.10 in. w.g.

TABLE 403.8.4.2
PRESCRIPTIVE EXHAUST DUCT SIZING

FAN TESTED CFM AT 0.25 INCHES W.G.	MINIMUM FLEX DIAMETER	MAXIMUM LENGTH IN FEET	MINIMUM SMOOTH DIAMETER	MAXIMUM LENGTH IN FEET	MAXIMUM ELBOWS[1]
50	4 inches	25	4 inches	70	3
50	5 inches	90	5 inches	100	3
50	6 inches	No Limit	6 inches	No Limit	3
80	4 inches[2]	NA	4 inches	20	3
80	5 inches	15	5 inches	100	3
80	6 inches	90	6 inches	No Limit	3
100	5 inches[2]	NA	5 inches	50	3
100	6 inches	45	6 inches	No Limit	3
125	6 inches	15	6 inches	No Limit	3
125	7 inches	70	7 inches	No Limit	3

1. For each additional elbow, subtract 10 feet from length.
2. Flex ducts of this diameter are not permitted with fans of this size.

403.8.5 Whole house ventilation requirements. All whole house ventilation systems shall comply with Sections 403.8.5.1 and 403.8.5.2. Each dwelling unit or sleeping unit shall be equipped with one of the following four types of mechanical whole house ventilation systems:

1. A system using exhaust fans (see Section 403.8.6);
2. A system integrated with forced-air systems (see Section 403.8.7);
3. A system using supply fans (see Section 403.8.8); or
4. A heat or energy recovery ventilation system (see Section 403.8.9).

The whole house exhaust system is permitted to be one of the local exhaust systems required by Section 403.8.4 as long as the requirements of this section, in addition to the requirements of Section 403.8.4, are met.

403.8.5.1 Outdoor air. *Outdoor air* shall be distributed to each habitable space. Where *outdoor air* supply intakes are separated from exhaust vents by doors, means shall be provided to ensure airflow to all separated habitable spaces by installing distribution ducts, installed grilles, transoms, doors undercut to a minimum of $^{1}/_{2}$-inch above the surface of the finish floor covering, or other similar means where permitted by the *International Building Code*.

The mechanical system shall operate continuously to supply at least the volume of *outdoor air* required in Table 403.3 or Table 403.8.1.

Exception: Intermittently operating ventilation systems: The whole house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25 percent of each 4-hour segment and the ventilation rate prescribed in Table 403.3 or Table 403.8.1 is multiplied by the factor determined in accordance with Table 403.8.5.1.

The intermittent mechanical ventilation system shall operate at least one hour out of every four. A minimum of six cycles are required per day.

TABLE 403.8.5.1
INTERMITTENT WHOLE HOUSE MECHANICAL VENTILATION RATE FACTORS[a, b]

Run-Time Percentage in Each 4-Hour Segment	25%	33%	50%	66%	75%	100%
Ventilation Rate Factor (F_v)[a]	4	3	2	1.5	1.3	1.0

a. For ventilation system run-time values between those given, the factors are permitted to be determined by interpolation.
b. Extrapolation beyond the table is prohibited.

Intermittent Mechanical Ventilation Airflow Calculation Examples:

Example #1: Calculating fan airflow based on Table 403.8.5.1 values:

An intermittently operated whole house fan that serves a dwelling unit with a continuous ventilation requirement of 30 CFM (from Table 403.3 or 403.8.1) is controlled to operate with an on-time of 3 hours and off-time of 1 hour throughout the day.

The minimum intermittent ventilation rate is calculated as follows:

Q_r = 30 CFM (from Table 403.3 or 403.8.1)
Cycle time = 4 hours
(where: cycle time is equal to the on-time plus the off-time)
Run-time percentage = 3/4 = 75%
(where: f is equal to the on-time divided by the cycle time)
Ventilation rate factor (F_v) 1.3 (from Table 403.8.5.1)
$Q_f = Q_r \times F_v$ = 30 CFM x 1.3 = 39

Example #2: Calculating fan airflow based on footnote a to Table 403.8.5.1:

An intermittently operated whole house fan that serves a dwelling unit with a continuous ventilation requirement of 30 CFM (from Table 403.3 or 403.8.1) is controlled to operate with an on-time of 1 hour and off-time of 3 hours throughout the day.

The minimum intermittent ventilation rate is calculated as follows:

Q_r = 30 CFM (from Table 403.3 or 403.8.1)
Cycle time = 4 hours
(where: cycle time is equal to the on-time plus the off-time)
Run-time percentage = $^1/_4$ = 25% (this is greater than 50%)
(where: f is equal to the on-time divided by the cycle time)
Ventilation rate factor (F_v) = 4 (per footnote a of Table 403.8.5.1)
$Q_f = Q_r \times F_v$ = 30 CFM x 4 = 120 cfm

See ASHRAE 62.2 Appendix B for further explanation and examples.

403.8.5.2 Whole house supply system general requirements. Whole house ventilation systems integrated with a forced-air system, systems using supply fans and systems using a heat or energy recovery ventilation system shall comply with the following.

1. *Outdoor air* louvers shall be adequately sized for the required airflow and shall comply with Section 401.5. *Outdoor air* intake locations shall comply with mechanical air intake requirements of Section 403.8.3.
2. *Outdoor air* ducts for ventilation integrated with forced air systems and exhaust ducts for heat or energy recovery systems shall be provided with a means for balancing the system to the required airflow via balance dampers or other devices.
3. *Outdoor air* ducts, for ventilation integrated with forced air systems shall be provided with motorized dampers.

   Exceptions:

   1. *Outdoor air* ducts at heat or energy recovery ventilation systems are not required to have motorized dampers.
   2. *Outdoor air* ducts at continuous ventilation systems are not required to have motorized dampers.

4. *Outdoor air* ducts in the *conditioned space* shall be insulated to a minimum of R-4. In heat or energy recovery ventilation systems, ducts upstream of the heat exchanger shall also be insulated to at least R-4.

   Note: See *Seattle Energy Code* for additional insulation requirements.

5. All *outdoor air* ducts shall be designed and installed to deliver at least the outdoor airflow required by Section 403.8.5.1. The airflows required refer to the delivered airflow of the system as installed and tested using a flow hood, flow grid, or other airflow measurement device.

   Exception: The *outdoor air* duct for supply fan systems and heat or energy recovery systems may be prescriptively sized per Table 403.8.5.2 for dedicated *outdoor air* ducts upstream of the supply fan. Supply fans shall have the capacity to provide the amount of *outdoor air* required by Section 403.8.5.1 at 0.40 in. w.g. in accordance with HVI 916, Home Ventilation Institute Airflow Test Procedure. When prescriptively sized the system shall be tested and balanced using a flow hood, flow-grid, or other airflow measurement device.

6. Whole house ventilation controls for intermittent operation shall allow concurrent operation of the forced-air fan and the associated *outdoor air* motorized damper.
7. Whole house ventilation controls for continuous operation shall be provided at the forced-air fan.

TABLE 403.8.5.2
PRESCRIPTIVE SUPPLY FAN DUCT SIZING

SUPPLY FAN TESTED CFM AT 0.40" w.g.		
Specified Volume from Table 408.1	Minimum Smooth Duct Diameter	Minimum Flexible Duct Diameter
50 - 90 cfm	4 inch	5 inch
90 - 150 cfm	5 inch	6 inch
150 - 250 cfm	6 inch	7 inch
250 – 400 cfm	7 inch	8 inch

403.8.6 Whole house ventilation with exhaust fan systems. This section establishes minimum requirements for mechanical whole house ventilation systems using exhaust fans.

403.8.6.1 Outdoor air. Exhaust fan only ventilation systems shall provide *outdoor air* to each occupiable space through one of the following methods:

1. *Outdoor air* may be drawn through air inlets installed in exterior walls or windows.

   The air inlets shall comply with all of the following:

   1.1. Inlets shall have controllable, secure openings and shall be designed to not compromise the thermal properties of the building envelope.

   1.2. Inlets shall be readily accessible to occupants, including compliance with Section 1109.13 of the *International Building Code* for designated Accessible units, Type A units and Type B units.

   1.3. Inlets shall be screened or otherwise protected from entry by insects, leaves, or other material.

   1.4. Inlets shall provide not less than 4 square inches of net free area of opening for each 10 cfm of *outdoor air* required in Table 403.3 or Table 403.8.1.

   1.5. Any inlet or combination of inlets which provide 10 cfm at 10 pascals as in accordance with HVI 916 Home Ventilation Institute Air Flow Test Procedure, and HVI 920 Home Ventilation Institute Product Performance Certification Procedure are deemed equivalent to 4 square inches of net free area.

   1.6. Each occupiable space shall have a minimum of one air inlet that has a minimum of 4 square inches of net free area.

2. In *high-rise buildings*, *outdoor air* may be drawn in through operable windows, doors, louvers or other operable openings to the outdoors. Exterior spaces shall have a minimum openable area of 4 percent of the total floor area being ventilated. Doors exiting to a corridor, court or public way shall not be used to provide *outdoor air*.

   The operable openings shall comply with the following:

   2.1. Openings shall be controllable, securable, and shall be designed to not compromise the thermal properties of the building envelope.

   2.2. Openings shall be readily accessible to occupants, including compliance with Section 1109.13 of the *International Building Code* for designated Accessible units, Type A units and Type B units.

3. For interior adjoining spaces without *outdoor air* openings, one of the following two options shall be used to ventilate the interior adjoining space:

   3.1. Provide a whole house transfer fan at the interior adjoining space sized to provide a minimum of the ventilation rate required per Section 403.8.5.1. The transfer fan shall circulate air between the interior room or space and the adjacent habitable space. The transfer fan may operate continuously or intermittently using controls per Section 403.8.2.

   3.2. Provide a permanent opening to the interior adjoining space. Opening shall be unobstructed and shall have an area of not less than 8 percent of the floor area of the interior adjoining space, but not less than 25 square feet.

403.8.6.2 Outside air intake locations. All *outside air* intake opening types described in Section 403.8.6.1 shall be classified as operable openings and shall not be classified as mechanical air intakes. The intake locations shall comply with Section 403.8.3.

403.8.6.3 Whole house exhaust system. Whole house exhaust system shall be designed and installed to meet all of the applicable criteria below:

1. Whole house ventilation exhaust shall be discharged outdoors.
2. Exhaust outlets shall comply with Section 501.3.2.
3. Exhaust ducts in systems which are designed to operate intermittently shall be equipped with backdraft dampers.

4. All exhaust ducts in *unconditioned spaces* shall be insulated to a minimum of R-4.5. Terminal outlet elements shall have at least the equivalent net free area of the ductwork.
5. Terminal outlet elements shall be screened or otherwise protected as required by Section 501.3.2.
6. One of the required local exhaust fans for the laundry room or bathroom may be designated as the whole house exhaust fan.
7. Exhaust fans in separate dwelling units or sleeping units shall not share common exhaust ducts unless the system is engineered for this operation.
8. Where permitted by Chapter 5, whole house exhaust ducts may be combined with other local exhaust ducts. If more than one of the exhaust fans in a dwelling unit or sleeping unit shares a common exhaust duct then each exhaust fan shall be equipped with a backdraft damper to prevent the recirculation of *exhaust air* from one room to another room via the exhaust ducting system.

403.8.6.4 Whole house exhaust and transfer fans. Exhaust fan construction and sizing shall meet the following criteria.

1. Exhaust and transfer fans shall be tested and rated in accordance with the airflow and sound rating procedures of the HVI 915 Loudness Testing and Rating Procedure; HVI 916 Airflow Test Procedure, and HVI 920 Product Performance Certification Procedure.
2. Installation of system or equipment shall be carried out in accordance with manufacturer's design requirements and installation instructions.
3. Fan airflow rating and duct system shall be designed and installed to deliver at least the outdoor airflow required by Table 403.3 or Table 403.8.1. The airflows required refer to the delivered airflow of the system as installed and tested using a flow hood, flow grid, or other airflow measurement device.

   Exception: An airflow rating at a pressure of 0.25 in. w.g. may be used, provided the duct sizing meets the prescriptive requirements of Table 403.8.5.2.

403.8.6.5 Fan noise. Whole house exhaust and transfer fans located 4 feet or less from the interior grille shall have a sone rating of 1.0 or less measured at 0.10 inches water gauge. Manufacturer's noise ratings shall be determined in accordance with HVI 915 Loudness Testing and Rating Procedure. Remotely mounted fans shall be acoustically isolated from the structural elements of the building and from attached ductwork using insulated flexible duct or other *approved* material.

403.8.7 Whole house ventilation integrated with forced-air systems. This section establishes minimum requirements for mechanical whole house ventilation systems using forced-air system fans.

403.8.7.1 Outdoor air. Forced-air system fan ventilation systems shall provide *outdoor air* through one of the following methods:

1. A dedicated *outdoor air* louver and *outdoor air* duct for each dwelling unit or sleeping unit shall supply *outdoor air* to the return side of the forced-air system fan; or
2. A central *outdoor air* delivery system that supplies multiple dwelling units or sleeping units shall supply *outdoor air* to the return side of the forced air system fan.

403.8.7.2 Whole house forced-air system. Where *outdoor air* is provided to each habitable dwelling unit or sleeping unit by a forced air system, the *outdoor air* duct shall be connected to the return air stream at a point within 4 feet upstream of the forced-air unit. It shall not be connected directly to the forced-air unit cabinet in order to prevent thermal shock to the heat exchanger. At a minimum, filtration of the *outdoor air* shall be provided at the forced-air unit. The filter shall be accessible for regular maintenance and replacement. The filter shall have a Minimum Efficiency Rating Value (MERV) of at least 6.

403.8.8 Whole house ventilation with supply fan systems. This section establishes minimum requirements for mechanical whole house ventilation systems using supply fan systems.

403.8.8.1 Outdoor air. Supply fan ventilation systems shall provide *outdoor air* through one of the following methods:

1. A dedicated *outdoor air* louver and *outdoor air* duct for each dwelling unit or sleeping unit shall supply *outdoor air* to a supply fan; or
2. A central *outdoor air* supply fan system shall distribute unconditioned or conditioned air to multiple dwelling units or sleeping units.

403.8.8.2 Whole house supply system. Where *outdoor air* is provided to each habitable dwelling unit or sleeping unit by supply fan systems the *outdoor air* shall be filtered.

The system filter may be located at the intake device or in line with the fan. The filter shall be accessible for regular maintenance and replacement. The filter shall have a Minimum Efficiency Rating Value (MERV) of at least 6.

403.8.9 Whole house ventilation with heat recovery or energy recovery ventilation systems. This section establishes minimum requirements for mechanical whole house ventilation systems using heat recovery or energy recovery ventilation systems.

403.8.9.1 Outdoor air. Heat recovery or energy recovery ventilation systems shall provide *outdoor air* through one of the following methods:

1. A dedicated *outdoor air* louver and *outdoor air* duct for each dwelling unit or sleeping unit shall supply *outdoor air* to the heat recovery or energy recovery ventilator; or
2. A central *outdoor air* heat recovery or energy recovery unit shall distribute *conditioned air* to multiple dwelling units or sleeping units.

403.8.9.2 Whole house heat recovery ventilator system. Where *outdoor air* is provided to each habitable dwelling unit or sleeping unit by heat recovery or energy recovery ventilator the *outdoor air* shall be filtered. The filter shall be located on the upstream side of the heat exchanger in both the intake and exhaust airstreams with a Minimum Efficiency Rating Value (MERV) of at least 6. The system filter may be located at the intake device or in line with the fan. The filter shall be accessible for regular maintenance and replacement.

403.8.10 Local exhaust ventilation and whole house ventilation alternate performance or design requirements. In lieu of complying with Sections 403.8.4 or 403.8.5, compliance with the section shall be demonstrated through engineering calculations by an engineer licensed to practice in the state of Washington or by performance testing. Documentation of calculations or performance test results shall be submitted to and approved by the code official. Performance testing shall be conducted in accordance with approved test methods.

403.8.11 Alternate systems. When approved by the code official, systems designed in accordance with ASHRAE Standard 62.2 shall be permitted.

403.9 Corridors. Air movement in corridors shall comply with Section 601 of this code and the *International Building Code*.

SECTION 404
VENTILATION OF ENCLOSED MOTOR VEHICLE OCCUPANCIES ((~~ENCLOSED PARKING GARAGES~~))

404.1 Enclosed parking garage((~~s~~)), loading dock, and motor vehicle repair garage exhaust ventilation systems. Mechanical ventilation systems for enclosed parking garages, loading docks, and motor vehicle repair garages shall ((~~be permitted to~~)) operate intermittently in accordance with Item 1, Item 2 or both.

1. The system shall be arranged to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices.
2. The system shall be arranged to operate automatically by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors that modulate the ventilation system by staging fans or varying fan speed to maintain gas concentrations below specified maximum levels. Such detectors shall be designed for the specific use and installed in accordance with their manufacturers' recommendations. Mechanical ventilation systems and gas sensor systems controls shall comply with Section 1412.9 of the *International Energy Conservation Code*.

404.1.1 Ventilation makeup air. Ventilation *makeup air* shall be mechanically supplied to levels of enclosed loading docks and parking garages more than 3 stories above or below the nearest garage or loading dock entrance or exit.

404.1.2 Exhaust termination point. Exhaust termination points shall comply with Section 501.3.1.1.

404.2 Minimum ventilation.

404.2.1 Enclosed parking garages and motor vehicle repair garages. In enclosed parking garages and motor vehicle repair garages, ((~~A~~))automatic operation of the system shall not reduce the ventilation airflow rate below 0.05 cfm per square foot (0.00025 $m^3/s \cdot m^2$) of the floor area and the ventilation system shall be capable of producing a ventilation airflow rate of 0.75 cfm per square foot (0.0038 $m^3/s \cdot m^2$) of floor area.

Exception: Ventilation systems located in areas with automated parking systems where the engines of the motor vehicles are not operating shall provide a continuous ventilation airflow rate of 50 cfm per parking stall. This exception does not apply to the vehicle drop off area.

404.2.2 Enclosed loading docks. In enclosed loading docks, automatic operation of the system shall not reduce the ventilation airflow rate below 1.0 cfm per square foot (0.00507 $m^3/s \cdot m^2$) of the floor area and the ventilation systems shall be capable of producing a ventilation airflow rate of 1.5 cfm per square foot (0.0076 $m^3/s \cdot m^2$) of floor area.

404.3 Occupied spaces accessory to public garages and motor vehicle repair garages. Connecting offices, waiting rooms, ticket booths, elevator lobbies and similar uses that are accessory to a public garage or motor vehicle repair garage shall be maintained at a positive pressure relative to the garage and shall be provided with ventilation in accordance with Section 403.3.

404.4 Motor vehicle repair garages. In buildings used for the repair of motor vehicles, each repair stall or stand shall be equipped with an exhaust capture system that connects directly to the repair engine exhaust source and prevents the escape of fumes. The exhaust system shall exhaust to the outdoor atmosphere. See Section 502.15 for additional requirements. Ventilation shall be provided for the motor vehicle repair garage in accordance with Section 404.

SECTION 405
SYSTEMS CONTROL

405.1 General. Mechanical ventilation systems shall be provided with manual or automatic controls that will operate such systems whenever the spaces are occupied. Air-condi-

tioning systems that supply required *ventilation air* shall be provided with controls designed to automatically maintain the required outdoor air supply rate during occupancy. Additional mechanical system control requirements are contained in the *International Energy Conservation Code*.

SECTION 406
VENTILATION OF UNINHABITED SPACES

406.1 General. ((~~Uninhabited spaces, such as crawl~~)) Crawl spaces and attics((~~,~~)) shall be provided with *natural ventilation* openings as required by the *International Building Code* or shall be provided with a mechanical exhaust and supply air system. The mechanical exhaust rate shall be not less than 0.02 cfm per square foot (0.00001 $m^3/s \cdot m^2$) of horizontal area and shall be automatically controlled to operate when the relative humidity in the space served exceeds 60 percent.