

TABLE 2
OUTDOOR AIR REQUIREMENTS FOR VENTILATION*
2.1 COMMERCIAL FACILITIES (offices, stores, shops, hotels, sports facilities)

Application	Estimated Maximum** Occupancy P/1000 ft ² or 100 m ²	Outdoor Air Requirements				Comments
		cfm/ person	L/s person	cfm/ft ²	L/s·m ²	
Dry Cleaners, Laundries						Dry-cleaning processes may require more air.
Commercial laundry	10	25	13			
Commercial dry cleaner	30	30	15			
Storage, pick up	30	35	18			
Coin-operated laundries	20	15	8			
Coin-operated dry cleaner	20	15	8			
Food and Beverage Service						
Dining rooms	70	20	10			
Cafeteria, fast food	100	20	10			
Bars, cocktail lounges	100	30	15			Supplementary smoke-removal equipment may be required.
Kitchens (cooking)	20	15	8			Makeup air for hood exhaust may require more ventilating air. The sum of the outdoor air and transfer air of acceptable quality from adjacent spaces shall be sufficient to provide an exhaust rate of not less than 1.5 cfm/ft ² (7.5 L/s·m ²).
Garages, Repair, Service Stations						
Enclosed parking garage				1.50	7.5	Distribution among people must consider worker location and concentration of running engines; stands where engines are run must incorporate systems for positive engines exhaust withdrawal. Contaminant sensors may be used to control ventilation.
Auto repair rooms				1.50	7.5	
Hotels, Motels, Resorts, Dormitories				<u>cfm/room</u>	<u>L/s·room</u>	Independent of room size.
Bedrooms				30	15	
Living rooms				30	15	
Baths				35	18	Installed capacity for intermittent use.
Lobbies	30	15	8			
Conference rooms	50	20	10			
Assembly rooms	120	15	8			
Dormitory sleeping areas	20	15	8			See also food and beverage services, merchandising, barber and beauty shops, garages.
Gambling casinos	120	30	15			Supplementary smoke-removal equipment may be required.
Offices						
Office space	7	20	10			Some office equipment may require local exhaust.
Reception areas	60	15	8			
Telecommunication centers and data entry areas	60	20	10			
Conference rooms	50	20	10			
Public Spaces				<u>cfm/ft²</u>	<u>L/s·m²</u>	
Corridors and utilities				0.05	0.25	
Public restrooms, cfm/wc or cfm/urinal		50	25			Normally supplied by transfer air.
Locker and dressing rooms				0.5	2.5	Local mechanical exhaust with no recirculation recommended.
Smoking lounge	70	60	30			
Elevators				1.00	5.0	Normally supplied by transfer air.

* Table 2 prescribes supply rates of acceptable outdoor air required for acceptable indoor air quality. These values have been chosen to dilute human bioeffluents and other contaminants with an adequate margin of safety and to account for health variations among people and varied activity levels.

** Net occupiable space.

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		cfm/ person	L/s/ person			
				cfm/ft ²	L/s·m ²	
Retail Stores, Sales Floors, and Show Room Floors						
Basement and street	30			0.30	1.50	
Upper floors	20			0.20	1.00	
Storage rooms	15			0.15	0.75	
Dressing rooms				0.20	1.00	
Malls and arcades	20			0.20	1.00	
Shipping and receiving	10			0.15	0.75	
Warehouses	5			0.05	0.25	
Smoking lounge	70	60	30			Normally supplied by transfer air, local mechanical exhaust; exhaust with no recirculation recommended.
Specialty Shops						
Barber	25	15	8			
Beauty	25	25	13			
Reducing salons	20	15	8			
Florists	8	15	8			Ventilation to optimize plant growth may dictate requirements.
Clothiers, furniture				0.30	1.50	
Hardware, drugs, fabric	8	15	8			
Supermarkets	8	15	8			
Pet shops				1.00	5.00	
Sports and Amusement						
Spectator areas	150	15	8			
Game rooms	70	25	13			When internal combustion engines are operated for maintenance of playing surfaces, increased ventilation rates may be required.
Ice arenas (playing areas)				0.50	2.50	
Swimming pools (pool and deck area)				0.50	2.50	Higher values may be required for humidity control.
Playing floors (gymnasium)	30	20	10			
Ballrooms and discos	100	25	13			
Bowling alleys (seating areas)	70	25	13			
Theaters						
Ticket booths	60	20	10			Special ventilation will be needed to eliminate special stage effects (e.g., dry ice vapors, mists, etc.)
Lobbies	150	20	10			
Auditorium	150	15	8			
Stages, studios	70	15	8			
Transportation						
Waiting rooms	100	15	8			Ventilation within vehicles may require special considerations.
Platforms	100	15	8			
Vehicles	150	15	8			
Workrooms						
Meat processing	10	15	8			

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		cfm/ person	L/s/ person	cfm/ft ²	L/s-m ²	
Photo studios	10	15	8			
Darkrooms	10			0.50	2.50	
Pharmacy	20	15	8			
Bank vaults	5	15	8			
Duplicating, printing				0.50	2.50	Installed equipment must incorporate positive exhaust and control (as required) of undesirable contaminants (toxic or otherwise).

2.2 INSTITUTIONAL FACILITIES

Education						
Classroom	50	15	8			Special contaminant control systems may be required for processes or functions including laboratory animal occupancy.
Laboratories	30	20	10			
Training shop	30	20	10			
Music rooms	50	15	8			
Libraries	20	15	8			
Locker rooms				0.50	2.50	
Corridors				0.10	0.50	
Auditoriums	150	15	8			Normally supplied by transfer air. Local mechanical exhaust with no recirculation recommended.
Smoking lounges	70	60	30			
Hospitals, Nursing and Convalescent Homes						
Patient rooms	10	25	13			Special requirements or codes and pressure relationships may determine minimum ventilation rates and filter efficiency. Procedures generating contaminants may require higher rates.
Medical procedure	20	15	8			
Operating rooms	20	30	15			
Recovery and ICU	20	15	8			
				0.50	2.50	Air shall not be recirculated into other spaces.
Autopsy rooms						
Physical therapy	20	15	8			
Correctional Facilities						
Cells	20	20	10			
Dining halls	100	15	8			
Guard stations	40	15	8			

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contain information on some unregulated pollutants. Finally, acceptable outdoor air quality should be evaluated using the definition for acceptable indoor air quality in Section 3.

6.1.2 Outdoor Air Treatment. If the outdoor air contaminant levels exceed the values given in 6.1.1 (Table 1), the air should be treated to control the offending contaminants. Air-cleaning systems suitable for the particle size encountered should be used. For removal of gases and vapors, appropriate air-cleaning systems should be used. Where the best available, demonstrated, and proven technology does not allow for the removal of contaminants, the amount of outdoor air may be reduced during periods of high contaminant levels, such as those generated by rush-hour traffic. The need to control offending contaminants may depend on local regulations that require specific control measures.

6.1.3 Ventilation Requirements. Indoor air quality shall be considered acceptable if the required rates of acceptable outdoor air in Table 2 are provided for the occupied space.

Exceptions:

1. Where unusual indoor contaminants or sources are present or anticipated, they shall be controlled at the source or the procedure of 6.2 shall be followed.
2. For those areas within industrial facilities not covered by Table 2, refer to TLVs—*Threshold Limit Values and Biological Exposure Indices for 1986-87*, American Conference of Governmental Industrial Hygienists (Reference 7, 23).

Table 2 lists the required ventilation rates in cfm (L/s) per person or cfm/ft² (L/s-m²) for a variety of indoor spaces. In most cases, the contamination produced is presumed to be in

OUTDOOR AIR REQUIREMENTS FOR VENTILATION (Continued)

2.3^a RESIDENTIAL FACILITIES (private dwellings, single, multiple)

Applications	Outdoor Requirements	Comments
Living areas	0.35 air changes per hour but not less than 15 cfm (7.5 L/s) per person	For calculating the air changes per hour, the volume of the living spaces shall include all areas within the conditioned space. The ventilation is normally satisfied by infiltration and natural ventilation. Dwellings with tight enclosures may require supplemental ventilation supply for fuel-burning appliances, including fireplaces and mechanically exhausted appliances. Occupant loading shall be based on the number of bedrooms as follows: first bedroom, two persons; each additional bedroom, one person. Where higher occupant loadings are known, they shall be used.
Kitchens ^b	100 cfm (50 L/s) intermittent or 25 cfm (12 L/s) continuous or openable windows	Installed mechanical exhaust capacity. ^c Climatic conditions may affect choice of the ventilation system.
Baths, Toilets ^b	50 cfm (25 L/s) intermittent or 20 cfm (10 L/s) continuous or openable windows	Installed mechanical exhaust capacity. ^c
Garages:		
Separate for each dwelling unit	100 cfm (50 L/s) per car	Normally satisfied by infiltration or natural ventilation
Common for several units	1.5 cfm/ft ² (7.5 L/s·m ²)	See "Enclosed parking garages," Table 2.1

^a In using this table, the outdoor air is assumed to be acceptable.

^b Climatic conditions may affect choice of ventilation option chosen.

^c The air exhausted from kitchens, bath, and toilet rooms may utilize air supplied through adjacent living areas to compensate for the air exhausted. The air supplied shall meet the requirements of exhaust systems as described in 5.8 and be of sufficient quantities to meet the requirements of this table.

proportion to the number of persons in the space. In other cases, the contamination is presumed to be chiefly due to other factors and the ventilating rates given are based on more appropriate parameters. Where appropriate, the table lists the estimated density of people for design purposes.

Where occupant density differs from that in Table 2, use the per occupant ventilation rate for the anticipated occupancy load. The ventilation rates for specified occupied spaces listed in Table 2 were selected to reflect the consensus that the provision of acceptable outdoor air at these rates would achieve an acceptable level of indoor air quality by reasonably diluting human bioeffluents, particulate matter, odors, and other contaminants common to those spaces.

Human occupants produce carbon dioxide, water vapor, and contaminants including particulate matter, biological aerosols, and volatile organic compounds. Comfort (odor) criteria with respect to human bioeffluents are likely to be satisfied if the ventilation results in indoor CO₂ concentrations less than 700 ppm above the outdoor air concentration. Appendix D discusses the relationship between ventilation rates and occupant generated CO₂.

6.1.3.1 Multiple Spaces. Where more than one space is served by a common supply system, the ratio of outdoor to supply air required to satisfy the ventilation and thermal control requirements may differ from space to space. The system outdoor air quantity shall then be determined using Equation 6-1 (see References 24 and 25).

$$Y = X/[1 + X - Z] \quad (6-1)$$

where

$Y = V_{or}/V_{st}$ = corrected fraction of outdoor air in system supply

$X = V_{on}/V_{st}$ = uncorrected fraction of outdoor air in system supply

$Z = V_{oc}/V_{sc}$ = fraction of outdoor air in critical space. The critical space is that space with the greatest

required fraction of outdoor air in the supply to this space.

V_{or} = corrected total outdoor air flow rate

V_{st} = total supply flow rate, i.e., the sum of all supply for all branches of the system

V_{on} = sum of outdoor air flow rates for all branches on system

V_{oc} = outdoor air flow rate required in critical spaces

V_{sc} = supply flow rate in critical space

Equation 6-1 is plotted in Figure 3. The procedure is as follows:

1. Calculate the uncorrected outdoor air fraction by dividing the sum of all the branch outdoor air requirements by the sum of all the branch supply flow rates.
2. Calculate the critical space outdoor air fraction by dividing the critical space outdoor air requirement by the critical space supply flow rate.
3. Evaluate Equation 6-1 or use Figure 3 to find the corrected fraction of outdoor air to be provided in the system supply.

Rooms provided with exhaust air systems, such as kitchens, baths, toilet rooms, and smoking lounges, may utilize air supplied through adjacent habitable or occupiable spaces to compensate for the air exhausted. The air supplied shall be of sufficient quantity to meet the requirements of Table 2. In some cases, the number of persons cannot be estimated accurately or varies considerably. In other cases, a space may require ventilation to remove contamination generated within the space but unrelated to human occupancy (e.g., outgassing from building materials or furnishings). For these cases, Table 2 lists quantities in cfm/ft² (L/s·m²) or an equivalent term. If human carcinogens or other harmful contaminants are suspected to be present in the occupied space, other relevant standards or guidelines (e.g., OSHA, EPA) must supersede the ventilation rate procedure.