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perature, humidity, noise, lighting, and psychological stress;

c. if the ambient air is unacceptable and this air is brought into the building without first being cleaned (cleaning of ambient outdoor air is not required by this standard);
d. if the system(s) are not operated and maintained as designed; or
e. when high-polluting events occur.

2.3 This standard does not address unvented combustion space heaters.

3. DEFINITIONS

acceptable indoor air quality: air toward which a substantial majority of occupants express no dissatisfaction with respect to odor and sensory irritation and in which there are not likely to be contaminants at concentrations that are known to pose a health risk.

air cleaning: the use of equipment that removes particulate, microbial, or gaseous contaminants (including odors) from air.

air, exhaust: air discharged from any space to the outside by an exhaust system.

air, indoor: air in an occupiable space.

air, outdoor: air from outside the building taken into a ventilation system or air from outside the building that enters a space through infiltration or natural ventilation openings.

air, transfer: air moved from one occupiable space to another, usually through doorways or grilles.

air, ventilation: outdoor air delivered to a space that is intended to dilute airborne contaminants.

air change rate: airflow in volume units per hour divided by the volume of the space on which the air change rate is based in identical units (normally expressed in air changes per hour [ach]).

annual exposure: the time-integrated concentration taken over one year that would occur for a constant source strength.

balanced system: one or more fans that supply outdoor air and exhaust building air at substantially equal rates.

bathroom: any room containing a bathtub, a shower, a spa, or a similar source of moisture.

climate, hot, humid: climate in which the wet-bulb temperature is 67°F (19°C) or higher for 3500 h or more, or 73°F (23°C) or higher for 1750 h or more, during the warmest six consecutive months of a year that is typical for that geographic area (see Section 8).

climate, very cold: climates that have more than 9000 annual heating degree-days base 65°F-day (5000 annual heating degree-days base 18°C-day) (see Section 8).

conditioned space: the part of a building that is capable of being thermally conditioned for the comfort of occupants.

contaminant: a constituent of air that may reduce acceptability of that air.

dwelling unit: a single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

effective annual average infiltration rate: the constant air infiltration rate that would result in the same average indoor pollutant concentration over the annual period as actually occurs under varying conditions.

exhaust system: one or more fans that remove air from the building, causing outdoor air to enter by ventilation inlets or normal leakage paths through the building envelope.

exhaust flow, net: flow through an exhaust system minus the compensating outdoor airflow through any supply system that is interlocked to the exhaust system.

habitable space: building space intended for continual human occupancy; such space generally includes areas used for living, sleeping, dining, and cooking but does not generally include bathrooms, toilets, hallways, storage areas, closets, or utility rooms.

heating degree-day: the difference in temperature between the outdoor mean temperature over a 24 h period and a given base temperature of a building space; that is, for heating degree-day base 65°F (18°C), for any one day, when the mean temperature is less than 65°F (18°C), there are as many heating degree-days as degrees Fahrenheit (Celsius) temperature difference between the mean temperature for the day and 65°F (18°C). Annual heating degree-days are the sum of the heating degree-days over a calendar year.

high-polluting events: isolated and occupant-controllable events that release pollutants in excess quantities. Typical cooking, bathing, and laundry activities are not considered high-polluting events.

infiltration: uncontrolled inward leakage of air through cracks and interstices in any building element and around windows and doors of a building.

intermittent ventilation: intermittently operated whole-building ventilation that is automatically controlled.

kitchen: any room containing cooking appliances.

mechanical cooling: reducing the temperature of a fluid by using vapor compression, absorption, desiccant dehumidification combined with evaporative cooling, or other energy-driven thermodynamic means. Indirect or direct evaporative cooling alone is not considered mechanical cooling.

mechanical ventilation: the active process of supplying air to or removing air from an indoor space by powered equipment such as motor-driven fans and blowers but not by devices such as wind-driven turbine ventilators and mechanically operated windows.

mixed-use building: a building containing commercial space (corridors, parking garages, and other common spaces may be

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present but are not classified as commercial space) in addition to dwelling units.

multifamily building: a building containing multiple dwelling units.

natural ventilation: ventilation occurring as a result of only natural forces, such as wind pressure or differences in air density, through intentional openings such as open windows and doors.

occupiable space: any enclosed space inside the pressure boundary and intended for human activities, including but not limited to all habitable spaces, toilets, closets, halls, storage and utility areas, and laundry areas.

pressure boundary: primary air enclosure boundary separating indoor and outdoor air. For example, a volume that has more leakage to the outside than to the conditioned space would be considered outside the pressure boundary. Exposed earth in a crawlspace or basement shall not be considered part of the pressure boundary.

readily accessible: capable of being quickly and easily reached for operation, maintenance, and inspection.

source: an indoor object, person, or activity from which indoor air contaminants are released, or a route of entry of contaminants from outdoors or sub-building soil.

supply system: one or more fans that supply outdoor air to the building, causing indoor air to leave by normal leakage paths through the building envelope.

system: equipment and other components that collectively perform a specific function, such as mechanical cooling or ventilation.

time average airflow rate: the total volume of air provided during a period of time divided by the time period.

toilet: space containing a toilet, water closet, urinal, or similar sanitary service.

utility: laundry, lavatory, or other utility room containing sinks or washing equipment.

ventilation: the process of supplying outdoor air to or removing indoor air from a dwelling by natural or mechanical means. Such air may or may not have been conditioned.

4. WHOLE-BUILDING VENTILATION

A whole-building ventilation system, complying with either Sections 4.1 through 4.5 or Section 4.6, shall be installed.

4.1 Ventilation Rate. A mechanical exhaust system, supply system, or combination thereof shall be installed to operate for each dwelling unit to provide continuous whole-building ventilation with outdoor air at a rate not less than specified in Section 4.1.1.

Exception: An intermittently operating whole-building mechanical ventilation system shall be permitted if the ventilation rate complies with Section 4.5. The system shall be designed for automatic operation.

4.1.1 Total Ventilation Rate. The total required ventilation rate (Q_{tot}) shall be as specified in Table 4.1a or Table 4.1b or, alternatively, calculated using Equation 4.1a or Equation 4.1b.

$$Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1) \qquad \text{(I-P)} \quad (4.1a)$$

where

Q_{tot} = total required ventilation rate, cfm
A_{floor} = floor area of residence, ft^2
N_{br} = number of bedrooms (not to be less than 1)

$$Q_{tot} = 0.15A_{floor} + 3.5(N_{br} + 1) \qquad \text{(SI)} \quad (4.1b)$$

where

Q_{tot} = total required ventilation rate, L/s
A_{floor} = floor area of residence, m^2
N_{br} = number of bedrooms (not to be less than 1)

Exceptions: Whole-building mechanical systems are not required if the authority having jurisdiction determines that window operation is a locally permissible method of providing ventilation and provided that at least one of the following conditions is met:

a. the building has no mechanical cooling and is in zone 1 or 2 of the climate zone map shown in Figure 9.1 or
b. the building is thermally conditioned for human occupancy for less than 876 h per year.

4.1.2 Infiltration Credit. If a blower door test has been done then a credit for estimated infiltration may be taken using the following procedure.

Effective Annual Average Infiltration Rate (Q_{inf}). Effective Annual Average Infiltration Rate (Q_{inf}) shall be calculated using the normalized leakage calculated from measurements of envelope leakage using either ASTM E779[1] or CGSB 149.10[2]. The authority having jurisdiction may approve other means of calculating effective leakage area (ELA), such as the RESNET *Mortgage Industry National Home Energy Systems Standard*.[3]

ASTM Procedure. To calculate the ELA from ASTM E779[1], the leakage area for pressurization and depressurization (using a 4 Pa reference pressure) shall be averaged using Equation 4.2:

$$\text{ELA} = (L_{press} + L_{depress})/2 \qquad (4.2)$$

where

ELA = effective leakage area, ft^2 (m^2)
L_{press} = leakage area from pressurization, ft^2 (m^2)
$L_{depress}$ = leakage area from depressurization, ft^2 (m^2)

CGSB Procedure. To calculate the ELA from CGSB 149.10[2], the following modifications to the test procedure must be made: 1) all vents and intentional openings must be in the same configuration as specified in ASTM E779[1] (i.e., HVAC dampers and registers should be in the normal operating position, fireplace and other dampers should be closed unless they are required for test operation), 2) height and floor area must

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TABLE 4.1a (I-P) Ventilation Air Requirements, cfm

Floor Area, ft^2	Bedrooms				
	1	2	3	4	5
<500	30	38	45	53	60
501–1000	45	53	60	68	75
1001–1500	60	68	75	83	90
1501–2000	75	83	90	98	105
2001–2500	90	98	105	113	120
2501–3000	105	113	120	128	135
3001–3500	120	128	135	143	150
3501–4000	135	143	150	158	165
4001–4500	150	158	165	173	180
4501–5000	165	173	180	188	195

TABLE 4.1b (SI) Ventilation Air Requirements, L/s

Floor Area, m^2	Bedrooms				
	1	2	3	4	5
<47	14	18	21	25	28
47–93	21	24	28	31	35
93–139	28	31	35	38	42
140–186	35	38	42	45	49
186–232	42	45	49	52	56
232–279	49	52	56	59	63
279–325	56	59	63	66	70
325–372	63	66	70	73	77
372–418	70	73	77	80	84
418–465	77	80	84	87	91

be reported consistently with the definitions of this standard, and 3) the leakage area as calculated from the CGSB procedure must be converted using Equation 4.3:

$$ELA = 0.61 \cdot (0.4)^{n-0.5} \cdot L_{cgsb} \quad (4.3)$$

where

n = exponent measured from the CGSB 149.10[2]

L_{cgsb} = CGSB leakage area, as modified above, ft^2 (m^2)

Normalized Leakage. Normalized leakage shall be calculated using Equation 4.4:

$$NL = 1000 \cdot \frac{ELA}{A_{floor}} \cdot \left[\frac{H}{H_r}\right]^z \quad (4.4)$$

where

NL = normalized leakage

ELA = effective leakage area, ft^2 (m^2)

A_{floor} = floor area of residence, ft^2 (m^2)

H = vertical distance between the lowest and highest above-grade points within the pressure boundary, ft (m)

H_r = reference height, 8.2 ft (2.5 m)

z = 0.4 for the purpose of calculating the Effective Annual Infiltration Rate below

Effective Annual Average Infiltration Rate (Q_{inf}). Effective Annual Average Infiltration Rate (Q_{inf}) shall be calculated using Equation 4.5a or Equation 4.5b:

$$Q_{inf}(\text{cfm}) = \frac{NL \cdot wsf \cdot A_{floor}}{7.3} \quad \text{(I-P)(4.5a)}$$

where

NL = normalized leakage

wsf = weather and shielding factor from Normative Appendix B

A_{floor} = floor area of residence, ft^2

$$Q_{inf}(\text{L/s}) = \frac{NL \cdot wsf \cdot A_{floor}}{1.44} \quad \text{(SI) (4.5b)}$$

where

NL = normalized leakage

wsf = weather and shielding factor from Normative Appendix B

A_{floor} = floor area of residence, m^2

Required Mechanical Ventilation Rate (Q_{fan}). Required Mechanical Ventilation Rate (Q_{fan}) shall be calculated using Equation 4.6:

$$Q_{fan} = Q_{tot} - Q_{inf} \quad (4.6)$$

where

Q_{fan} = required mechanical ventilation rate, cfm (L/s)

Q_{tot} = total required ventilation rate, cfm (L/s)

Q_{inf} = may be no greater than 2/3 · Q_{tot} (see Normative Appendix A for exceptions for existing buildings and Section 8.2.1 for multifamily buildings)

4.1.3 Different Occupant Density. Tables 4.1a and 4.1b and Equations 4.1a and 4.1b and Equations 4.2a and 4.2b assume two persons in a studio or one-bedroom dwelling unit and an additional person for each additional bedroom. Where higher occupant densities are known, the rate shall be increased by 7.5 cfm (3.5 L/s) for each additional person. When approved by the authority having jurisdiction, lower occupant densities may be used.

4.2 System Type. The whole-building mechanical ventilation system shall consist of one or more supply or exhaust fans and associated ducts and controls. Local exhaust fans shall be permitted to be part of a mechanical exhaust system. Where

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local exhaust fans are used to provide whole-building ventilation, the local exhaust airflow may be credited towards the whole-building ventilation airflow requirement. Outdoor air ducts connected to the return side of an air handler shall be permitted as supply ventilation if manufacturers' requirements for return air temperature are met. See Chapter 10 of ASHRAE Guideline 24[4] for guidance on selection of methods.

4.3 Airflow Measurement. The airflow required by this section is the quantity of outdoor ventilation air supplied and/or indoor air exhausted by the mechanical ventilation system as installed and shall be measured using a flow hood, flow grid, or other airflow measuring device. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to meet this section.

4.4 Control and Operation. The "fan on" switch on a heating or air-conditioning system shall be permitted as an operational control for systems introducing ventilation air through a duct to the return side of an HVAC system. Readily accessible override control must be provided to the occupant. Local exhaust fan switches and "fan on" switches shall be permitted as override controls. Controls, including the "fan-on" switch of a conditioning system, must be appropriately labeled.

4.5 Intermittent Mechanical Ventilation. Whole-building mechanical systems designed to provide intermittent ventilation shall comply with this section.

4.5.1 Intermittent Ventilation. When mechanical ventilation is provided at least once every three hours by a system of one or more fans, the intermittent mechanical ventilation rate shall be calculated as the larger of the time average supply or exhaust airflow rate and shall be no less than specified in Section 4.1.

4.5.2 Extended-Cycle Intermittent Ventilation. When mechanical ventilation is not provided at least once every three hours by a single fan system, the intermittent fan airflow rate (Q_{on}) shall be calculated from Equation 4.7. Fan cycle time (T_{cyc}) shall not exceed 24 hours. Where the fan airflow rate during the on-cycle varies with time, the time average airflow rate during each hour shall meet or exceed the intermittent mechanical ventilation requirement of Equation 4.7.

$$Q_{on} \geq Q_{fan}/(\varepsilon f) \tag{4.7}$$

where

Q_{on} = intermittent fan airflow rate during the on-cycle

Q_{fan} = continuous mechanical ventilation air requirement (from Table 4.1a or 4.1b or Equation 4.1a or 4.1b)

ε = mechanical ventilation effectiveness (from Table 4.2)

f = fractional on-time, defined as the on-time for one cycle divided by the cycle time

TABLE 4.2 Mechanical Ventilation Effectiveness (ε) for Intermittent Fans

Fractional On-Time, f	Turnover, N														
	0.0	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0	8.0	12	20	40	100+
0.00	1.00	0.95	0.88	0.78	0.60	0.00									
0.05	1.00	0.96	0.90	0.81	0.67	0.41	0.00								
0.10	1.00	0.96	0.91	0.83	0.72	0.55	0.21	0.00							
0.15	1.00	0.96	0.92	0.85	0.76	0.63	0.44	0.18	0.00						
0.20	1.00	0.97	0.93	0.87	0.79	0.69	0.56	0.40	0.03	0.00					
0.25	1.00	0.97	0.94	0.89	0.82	0.74	0.64	0.53	0.26	0.02	0.00				
0.30	1.00	0.98	0.95	0.90	0.85	0.78	0.71	0.62	0.42	0.24	0.00				
0.35	1.00	0.98	0.95	0.92	0.87	0.82	0.76	0.69	0.54	0.39	0.14	0.00			
0.40	1.00	0.98	0.96	0.93	0.89	0.85	0.80	0.75	0.63	0.52	0.32	0.02	0.00		
0.45	1.00	0.99	0.97	0.94	0.91	0.88	0.84	0.79	0.70	0.61	0.45	0.21	0.00		
0.50	1.00	0.99	0.97	0.95	0.93	0.90	0.87	0.83	0.76	0.69	0.57	0.37	0.13	0.00	0.00
0.60	1.00	0.99	0.98	0.97	0.96	0.94	0.92	0.90	0.86	0.81	0.74	0.61	0.45	0.27	0.14
0.70	1.00	1.00	0.99	0.98	0.98	0.97	0.96	0.94	0.92	0.90	0.85	0.78	0.68	0.55	0.46
0.80	1.00	1.00	1.00	0.99	0.99	0.99	0.98	0.98	0.97	0.96	0.94	0.90	0.85	0.77	0.70
0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.98	0.97	0.96	0.93	0.88
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00