Ventilation for New Low-Rise Residential Buildings

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1. PURPOSE

This criterion defines the roles of and minimum requirements for mechanical ventilation systems in new low-rise residential buildings.

2. SCOPE

This criterion applies to spaces intended for human occupancy within single-family houses and multifamily structures of three stories or fewer above grade, including manufactured and modular houses.

3. DEFINITIONS

***acceptable indoor air quality*:** air toward which a substantial majority of occupants would have no dissatisfaction with respect to odor and sensory irritation.

***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.

***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]).

atmospherically vented: combustion appliance venting that is not powered by a fan and relies on air inside the pressure boundary to replace the vented air.

balanced system: two or more fans that simultaneously supply outdoor air and exhaust building air at substantially equal rates such that both the total supply and total exhaust flow rates meet the required fan flow rate. If the supply and exhaust points are both connected to a central forced air distribution system then the central system fan must operate simultaneously with the ventilation fan.

bathroom**:** any room containing a bathtub, a shower, a spa, or a similar source of moisture or a toilet, urinal, or similar sanitary device.

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.

direct-vented: combustion appliance venting that is powered by a fan and does not rely on air inside the pressure boundary to replace the vented air.

direct exhaust-vented: combustion appliance venting that is powered by a fan and relies on air inside the pressure boundary to replace the vented air.

distributed ventilation system**:** a ventilation system that supplies outdoor air directly to the common area and each bedroom.

forced air distribution system**:** an air duct and fan system whereby ducts supply air to all habitable spaces and a provision for return air exists from all habitable spaces served with supply air.

exhaust system**:** one or more fans that remove air from the building, causing outdoor air to enter by leakage paths through the building enclosure.

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.

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.

***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 or removing air to or 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.

***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.

recirculation turnover: the volume of house air moved through a forced-air distribution system divided by house volume.

***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 leakage paths through the building enclosure.

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

***utility room*:** any space containing a laundry, sink, or other washing equipment not part of a bathroom, toilet room, or kitchen.

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

4. WHOLE-BUILDING VENTILATION SYSTEMS

4.1 Ventilation Flow Rate

Outdoor air shall be mechanically supplied to each dwelling unit using a ventilation system providing no less than the rate specified in Equations 4.1a and 4.1b. The whole-building ventilation system may be balanced, intermittently balanced, or unbalanced.

$Q_v = 0.01\ A_{floor} + 7.5(N_{br} + 1)$ (4.1a)

where

Q_v = ventilation flow rate in cubic feet per minute (cfm)

A_{floor} = floor area in square feet (ft^2)

N_{br} = number of bedrooms; not to be less than one.

$Q_v = 0.05\ A_{floor} + 3.75(N_{br} + 1)$ (4.1b)

where

Q_v = ventilation flow rate in litres per second (L/s)

A_{floor} = floor area in square meters (m^2)

N_{br} = number of bedrooms; not to be less than one.

4.1.1 Fan Flow Rate

The required ventilation flow rate specified in Equations 4.1a and 4.1b, shall be provided by fan flow rate as follows:

$Q_{fan} = Q_v C_s$ (4.2)

where

Q_{fan} = fan flow rate (cfm)

C_s is the system coefficient from Table 4.1

Table 4.1

System Coefficient based on system type[1]

System Type	Distributed	Not Distributed
Balanced	1.0	1.25
Not Balanced	1.25	1.5

[1] Where there is whole-building air mixing of at least 70% recirculation turnover each hour, the system coefficient may be reduced by 0.25.

4.4 Delivered Ventilation

The delivered ventilation rate shall be calculated as the larger of the total supply or total exhaust and shall be no less than specified in Section 4.1 averaged over each two hours of operation. For intermittent ventilation systems, the fan flow rate shall be calculated according to Equation 4.2.

$$Q_{fan.intermittent} = Q_{fan} / f \qquad (4.2)$$

where

$Q_{fan.intermittent}$ = fan flow rate during the intermittent operation on-time (cfm)

f = fractional on time, defined as the on-time for one total cycle (on+off) divided by the total cycle time [i.e. fractional on time = on-time/(on-time+off-time)].

5. LOCAL EXHAUST SYSTEMS

5.1 Local Mechanical Exhaust

A local mechanical exhaust system shall be installed in each kitchen, bathroom, and toilet room.

5.1.1 Kitchen Exhaust

Each kitchen exhaust shall be an Energy Star compliant range hood that exhausts directly to outdoors per the manufacturer's instructions. Each exhaust outlet or kitchen exhaust fan must be equipped with a back-draft damper.

Electrical control shall be a minimum of an on/off switch readily accessible to the cook.

Exhaust airflow when the appliance is on shall be a minimum of 100 cfm.

5.1.2 Bathroom Exhaust

Each bathroom exhaust system shall be an Energy Star compliant fan that exhausts directly to outdoors per the manufacturer's instructions but with no less than 1 inch larger diameter duct size than the exhaust fan outlet diameter, or equivalent rectangular section, and with no less than a 6 inch diameter wall or roof cap, or equivalent exhaust outlet termination. Each exhaust outlet and exhaust fan must be equipped with a back-draft damper.

Electrical control shall be a minimum of an on/off switch readily accessible to the bathroom occupant.

The exhaust airflow when the fan is on shall be a minimum of 50 cfm.

5.2 Multibranch Exhaust Ducting

If multiple exhaust fans in a dwelling unit share a common exhaust duct, the common exhaust duct must be sized to accommodate the total exhaust flow when all fans are running at the same time without causing the system static pressure to exceed 0.3 inch w.c. In multi-family dwellings, exhaust fans from more than one dwelling unit may empty into a combined exhaust stack if that stack is served by an exhaust fan designed and intended to run continuously.

5.3 Airflow Measurement

The airflow required by this section is the quantity of indoor air exhausted by the ventilation system as installed and shall be measured using a powered or unpowered flow hood, flow grid, or other airflow measuring device.

> **Exception:** The airflow rating at a pressure of 0.25 in. w.c. (62.5 Pa) may be used, provided that the airflow is HVI certified and provided that for bathroom and toilet room exhaust the duct sizing meets the requirements of Paragraph 5.1.2.

6. OTHER REQUIREMENTS

6.1 Adjacent Spaces

Measures shall be taken to minimize air movement across enclosure components separating dwelling units, and to dwelling units from garages, unconditioned crawl spaces, and unconditioned attics.

6.1.1 Multifamily Buildings

All doors between dwelling units and common hallways shall be gasketed or made substantially airtight with weather stripping.

6.2 Instructions and Labeling

Information on the ventilation design and/or ventilation systems installed, instructions on their proper operation to meet the requirements of this criterion, and instructions detailing any required maintenance (similar to that provided for HVAC systems) shall be provided to the owner and the occupant of the dwelling unit. Controls shall be labeled as to their function unless that function is obvious.

6.3 Clothes Dryers

Clothes dryers shall be exhausted directly to the outdoors.

Exception: Condensing dryers plumbed to a drain.

6.4 Combustion and Solid-Fuel Burning Appliances

Combustion and solid-fuel burning appliances shall be direct exhaust-vented or direct-vented. Venting shall be installed in accordance with manufacturers' installation instructions, *NFPA 54/ANSI Z223.1, National Fuel Gas Code, NFPA 31, Criterion for the Installation of Oil-Burning Equipment,* or *NFPA 211, Criterion for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances*, or other equivalent code acceptable to the building official. Atmospherically vented combustion appliances or solid-fuel burning appliances are not permissible inside the pressure boundary.

6.5 Airtightness/Separation Requirements

6.5.1 Garages

When an occupiable space adjoins a garage, the design must minimize migration of contaminants to the adjoining occupiable space. Air seal the walls, ceilings, and floors that separate garages from occupiable space. To be considered air sealed, all joints, seams, penetrations, openings between door assemblies and their respective jambs and framing, and other sources of air leakage through wall and ceiling assemblies separating the garage from the residence and its attic area shall be caulked, gasketed, weatherstripped, wrapped, or otherwise sealed to limit air movement. Doors between garages and occupiable spaces shall be gasketed or made substantially airtight with weather stripping. Install an automatic door closer on all connecting doors between living spaces and attached garages.

6.5.2 Space-Conditioning System Ducts

All air distribution joints located outside the pressure boundary shall be sealed. HVAC systems that serve occupiable space shall not be designed to supply air to, or return air from, the garage. HVAC systems that include air handlers or ducts located outside the pressure boundary shall have total air leakage of no more than 6% of total fan flow when measured at 0.1 in. w.c. (25 Pa) using California Title 24 or equivalent. Air handlers and/or ducts shall not be located in a garage unless they are enclosed such that the enclosure meets the separation requirements of Paragraph 6.5.1.

6.6 Minimum Filtration

Mechanical space conditioning systems shall be provided with a filter having a designated minimum efficiency of MERV 9 or better when tested in accordance with *ANSI/ASHRAE Criterion 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.* If the whole-house ventilation system delivers outdoor air to the space conditioning system for tempering and/or distribution, the whole-house ventilation system shall be designed such that the outdoor air is filtered to protect the thermal conditioning components. All filters shall be located and installed in such a manner as to facilitate access and regular service by the owner.

6.7 Ventilation System Air Intakes

Outdoor air intake openings shall be located a minimum of 10 feet (3048 mm) from any hazardous or noxious contaminant, such as combustion and plumbing vents, chimneys, streets, alleys, parking lots and loading docks. Where an exiting source of contaminant is located within 10 feet (3048 mm) of an intake opening, such opening shall be located a minimum of 3 feet (914 mm) below the exiting contaminant source. The intake shall be placed so that entering air is not obstructed by snow, plantings, or other material, and shall be provided with rodent/insect screens (mesh not larger than 1/4 in. [13 mm]).

6.8 Duct Insulation

6.8.1 Duct Insulation for Whole-building Ventilation Systems

All outdoor air intake duct shall be insulated with minimum R4.2 duct insulation. In IECC Climate Zones 4 and higher, where an exhaust duct passes through unconditioned space for more than 4 feet, the exhaust duct shall be insulated with minimum R4.2 duct insulation.

6.8.2 Duct Insulation for Local Exhaust Systems

In IECC Climate Zones 4 and higher, where an exhaust duct passes through unconditioned space for more than 4 feet, the exhaust duct shall be insulated with minimum R4.2 duct insulation.

6.9 Building Enclosure

In IECC Climate Zones 3 and lower, no Class II or lower vapor retarder materials shall be installed on the interior wall or ceiling surfaces to impede drying to the conditioned space.

6.9 Exhaust Make-up Air

Where kitchen exhaust operation or dryer exhaust operation would depressurize the conditioned space with respect to outside more than 5 Pa, then an exhaust make-up air system shall be installed, reducing net exhaust flow, to reduce depressurization due to kitchen exhaust operation or dryer exhaust operation to less than 5 Pa.

7. REFERENCES

ANSI/ASHRAE Criterion 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.

California Energy Commission (2001). California Title 24 Standards, ACM Manual, Appendix F, Sections 4.3.8.2.1 and 4.3.7.2.

Energy Star, Ventilating Fans criteria, http://www.energystar.gov/index.cfm?c=vent_fans.pr_crit_vent_fans

HVI 916, "HVI Airflow Test Procedure": (Procedure that establishes uniform methods for laboratory testing of powered residential ventilating equipment for airflow rate. This publication covers the test equipment, tests of specific HVI classification groups, and test reports for maintaining the standard.)

HVI 920, "HVI Product Performance Certification Procedure Including Verification and Challenge": (Publication that describes HVI's certification, verification, and challenge testing procedures.)

IECC Climate Zone Map

NFPA 54/ANSI Z223.1, National Fuel Gas Code

NFPA 31, Criterion for the Installation of Oil-Burning Equipment

NFPA 211, Criterion for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances