Residential Mechanical Ventilation, Build Tight and Ventilate Right

Mechanical ventilation is a code requirement that is necessary for occupant health and ensures acceptable indoor air quality in tighter, more energy efficient homes. This guide is intended to help contractors understand mechanical ventilation requirements and design strategies in order to comply with the 2013 Building Energy Efficiency Standards (Title 24, Part 6 of the California Building Standards Code). It will also help homeowners, contractors, and building department staff understand why these requirements were adopted and how they will be enforced. "Build Tight, Ventilate Right" is the building science principle behind this guide.

California's 2013 Building Energy Efficiency Standards have mandatory requirements for two ventilation functions:

1. Local exhaust fans in bathrooms and kitchens, for removing excess moisture and odors at their source, and
2. Whole-building ventilation systems (including individual dwelling units in low-rise multifamily buildings), for ensuring an adequate supply of outdoor air when windows are closed.[1]

These requirements apply to **all new single-family homes, homes with additions greater than 1,000 ft^2, and multifamily homes in buildings of three stories or less**.[2] Local exhaust fan requirements also apply in most alterations and additions.[3]

Local Exhaust Fans

Codes have required exhaust fans for decades, but poor quality fans, controls and installation practices have limited their use, and therefore their effectiveness. As home construction becomes tighter, consistent and effective use of these fans become even more important for good indoor air quality. Excess indoor moisture compromises indoor air quality by supporting the growth of mold, dust mites, and other sources of allergens.

- ✦ The most effective way to control indoor moisture is to use bathroom exhaust fans as needed during and after bathing or showering.
- ✦ In kitchens, excess moisture and odors from cooking need to be removed by an exhaust fan, typically located inside the range hood.

Relative Humidity

Relative humidity (RH) is the degree to which air is saturated with moisture, expressed in percent. Indoor relative humidity should be kept below 60% because higher levels support the growth of mold and mildew.

A **humidistat** measures RH, and automatically turns an exhaust fan on or off in response. For best results, set the humidistat to 50% RH - the fan will operate automatically when RH exceeds 50%, and turn off automatically when RH drops below 50%.

Minimum Local Exhaust Requirements

A local exhaust fan is required in every room that has cooking appliances, and every room that has a shower, bathtub or spa, and all fans must be ducted directly to the outdoors. California's green building code (Title 24 Part 11) requires that local exhaust fans be Energy Star labelled, and bathroom fans that are not part of a whole-building ventilation system must be controlled by a humidistat that is adjustable from 50-80% RH. The humidistat is usually located on the fan housing.[4]

- ✦ Intermittently operated bathroom exhaust fans must move at least 50 cfm of air.
- ✦ Continuously operated bathroom exhaust fans must move at least 20 cfm of air.
- ✦ Intermittently operated kitchen range hood exhaust fans must move at least 100 cfm of air.
- ✦ Continuously operated exhaust fans elsewhere in the kitchen must provide at least 5 air changes per hour (ACH).

Duct Type	Flex Duct				Smooth Duct			
Fan Rating, cfm @ 0.25 in. w.c.	50	80	100	125	50	80	100	125
Diam (in)	Maximum length (ft)							
3	X	X	X	X	5	X	X	X
4	70	3	X	X	105	35	5	X
5	NL	70	35	20	NL	135	85	55
6	NL	NL	125	95	NL	NL	NL	145
7+	NL	NL	NL	NL	NL	NL	NL	NL

X = not allowed NL = no limit

Installing Local Exhaust Fans

Installers are responsible for ensuring that local exhaust fans actually deliver at least the minimum required ventilation rate. Most installers can simply follow the fan manufacturer's installation instructions. If instructions are not available or incomplete, they can use the prescriptive duct sizing table shown to the left. Or after installation is complete, they can physically measure delivered airflow using a flow hood, flow grid or other airflow measuring device.

Efficacy and Sound Levels for Local Exhaust Fans

The Home Ventilating Institute rates and the Energy Star program labels fans for airflow in cfm, and noise level in sones. Standards require that whole-building fans and continuously operated local exhaust fans have a maximum sone rating of 1.0. Intermittently operated local exhaust fans must have a maximum sone rating of 3.0. However, only fans designed to be surface-mounted in the living space, in a ceiling or wall, can be tested and rated for sones.

1. ASHRAE Standard 62.2-2010 CA, §8.2
2. 2013 Building Energy Efficiency Standards Subchapter 9, §150.2(a)1.C.
3. 2013 Residential Compliance Manual, 4.6.1, pg.4-57
4. Title 24, Part 11, § 4.505, pg. 29-30

Whole-building Ventilation Systems

Until recently, residential buildings received outdoor air through operable windows and infiltration – air leaking through cracks and holes in the building. However, leaky homes are difficult to heat and cool. Mechanical ventilation is now required in all new homes, and homes undergoing additions of over 1,000 ft^2, for the following reasons:

- New homes are tighter, have fewer leaks and less infiltration.
- Occupants leave windows closed, for reasons including outdoor noise, air pollution, allergies, asthma, security, and privacy.
- Tighter homes result in greater concentrations of indoor air pollutants, including volatile organic compounds (VOCs).[5]

Types of Whole-building Ventilation Systems

1. **Exhaust systems** remove indoor air, which is replaced by air entering the home through holes and leaks. For example, a fan operates continuously on low speed for whole-building ventilation, and boosts to high speed for local exhaust.
2. **Supply systems** use a fan to pull outdoor air from a clean location and deliver it to the home. For example, a fan pulls outdoor air through an air filter, and ducts it to bedrooms and living areas.
3. **Balanced systems** use two fans that exhaust and supply the same amount of air at the same time. For example, a heat recovery ventilator (HRV) exhausts air from each bathroom and delivers filtered air to bedrooms.

System Pros & Cons

- **Exhaust Pros**: The easiest, most affordable and energy efficient system to install and operate.
  Exhaust Cons: Entering air can come from the attic, crawlspace, garage or other polluted area; cannot be filtered.
- **Supply Pros:** Enables outdoor air to be filtered and delivered directly to living areas. Creates positive pressure in the house.
  Supply Cons: Filters must be accessible for maintenance. Ductwork increases installation costs.
- **Balanced Pros:** Enables use of a heat exchanger to transfer sensible heat between exhaust and supply air, to temper outdoor air before delivery.
  Balanced Cons: Two fans, a heat exchanger and additional ducts increase installation and operating costs, and reduce efficiency.

Minimum Requirements for Whole-building Ventilation Systems

The energy code provides two methods for sizing whole-building ventilation fans: **Fan Ventilation Rate** & **Total Ventilation Rate.** These methods determine the minimum continuous airflow rate. If a whole-building ventilation system operates intermittently, instead of continuously, the fan must be up-sized according to its fractional on-time and reduced ventilation effectiveness.[6]

Which Method?

The **Fan Ventilation Rate method** assumes a significant infiltration rate, and is therefore more appropriate for homes in which no special attempt is made to tighten the building. In tighter homes, this method could result in under-ventilation.

The **Total Ventilation Rate method** accounts for actual, measured building tightness and in tighter homes, increases the fan size to account for reduced infiltration. This method is more appropriate for zero-net-energy or other advanced homes that are designed to be tight, and whose tightness will be measured.

The **Total Ventilation Rate Method** calculates minimum fan flow using both equations below, where the infiltration value is estimated from the results of a blower door test.[7]

$$\text{Total cfm} = 0.03\ (\text{floor area, ft}^2) + 7.5\ (\text{no. of bedrooms} + 1)$$

$$\text{Fan cfm} = \text{Total cfm} - \text{Infiltration cfm}$$

The **Fan Ventilation Rate Method** determines minimum fan flow based on the following equation or table below:

$$\text{Fan cfm} = 0.01\ (\text{floor area, ft}^2) + 7.5\ (\text{no. of bedrooms} + 1)$$

Ventilation Air Requirements, cfm					
Floor Area (ft^2)	Bedrooms				
	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

HERS Verification of Whole-building Ventilation Airflow

The Standards require HERS verification that whole-building ventilation rates comply with minimum requirements. Builders should consult HERS raters early in the process to ensure that the ventilation system is installed in such a way that airflow can be measured.

Building inspectors will look for the following:

- Energy Star labelled exhaust fans in bathrooms and kitchens, properly sized, ducted and controlled.
- Certificates of Installation from contractor (CF2R-MECH-27-H) documenting the type, make, model, required or rated cfm.
- Certificates of Verification from the HERS rater (CF3R-MECH-27-H) of whole building ventilation system airflow.

5. http://www.epa.gov/iaq/voc.html
6. Consult an energy consultant or HERS rater
7. ASHRAE Standard 62.2-2010 CA, § 4.1.2