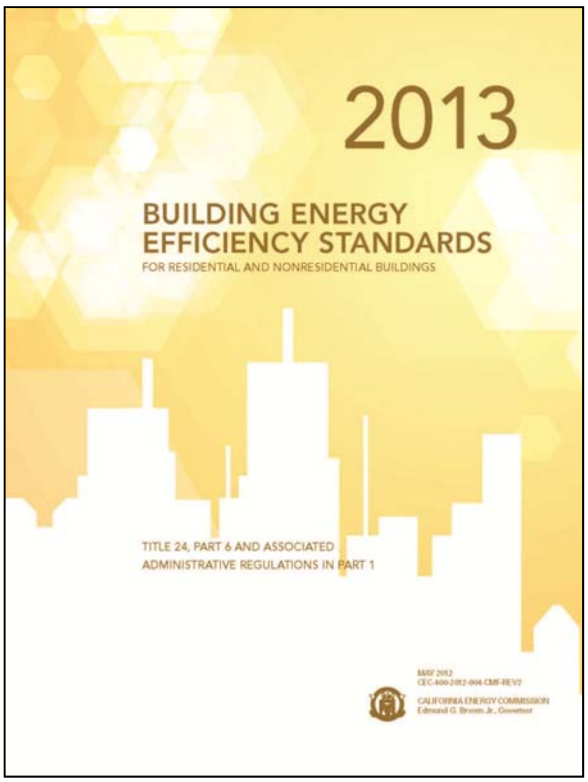
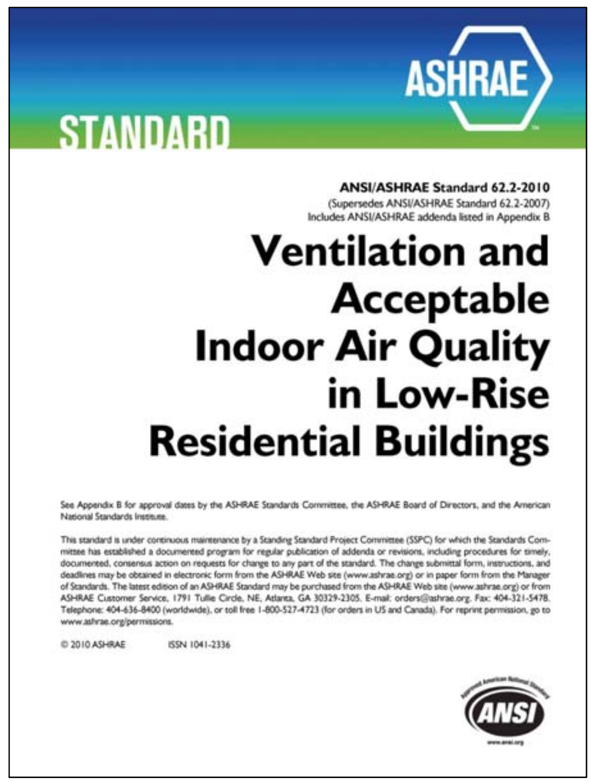
Residential Ventilation ASHRAE 62-2-2010

2013 Title 24 Part 6





Building Energy Science Series Part 3

Advanced Rater Training Series

Wollin Group, Inc.

Energy, Efficiency, Education, Earth

Notes and Questions

Building Energy Science Series—III

2013 California Energy Code

Ventilation—ASHRAE 62-2 2010

Presenter

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Disclaimer

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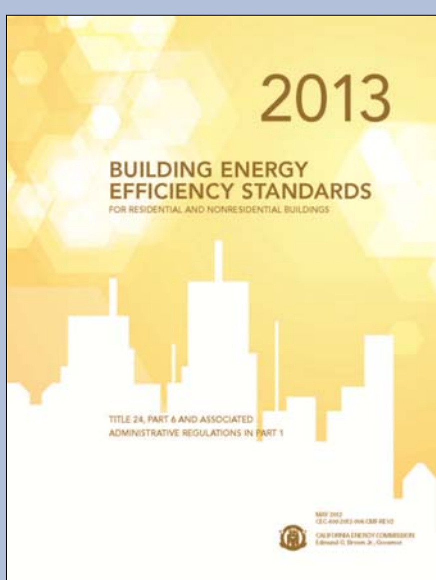

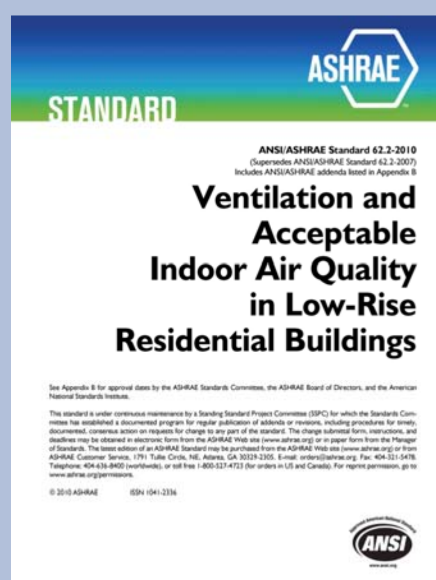

Benjamin Franklin

"I considered fresh air as an enemy and closed with extreme care every crack and crevice in the room I inhabited."

"Experience has convinced me of my error. I am certain that no air is so unwholesome as air in a closed room that has been often breathed and not changed."

The Environmental Protection Agency (EPA)

"Most Americans spend about 90 percent of their time indoors, where pollutant levels may be 2-5 times higher, and occasionally 100 times higher, than outdoors."

Training Objective

What are three basic types of building ventilation?

What are the determining factors in sizing appropriate residential ventilation?

What is the formula for calculating continuous ventilation?

How is Intermittent Ventilation calculated?

What affect has air sealing of buildings had the necessity to Ventilate homes?

How is ACH calculated?

How is California SLA Calculated?

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VENTILATION CONCERNS

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Context

In the context of Building Performance ventilation plays a vital part in the concept of delivering tighter homes that are energy efficient.

As Performance contractors align thermal boundaries with air barriers. As insulation installation is improved and thermal by-passes are eliminated or at least greatly reduced, Ventilation strategies become increasingly important.

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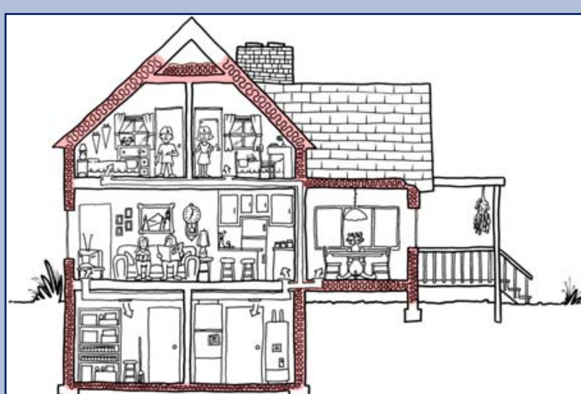
Building Performance

Ventilation and Indoor Air Quality depend on the quality of the Building Shell, let's call it the 'enclosure'.



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Building Performance Needs





A building enclosure that controls:

- Air flow,
- Heat flow,
- Water and water vapor flow,
- Rain penetration,

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Moisture Transport

Vapor, as warm moist air, will move from the high pressure area to a lower pressure area where the air is cooler and drier.

Liquid water will move as a result of differences in hydrostatic pressure or wind pressure.

Pressure differentials drive the rate of moisture migration in either Vapor or Liquid state.

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Building Durability

Equipment—Lack of exhaust fans, improper installation, disuse, leaking ductwork or drainage.

Examples:

Bathroom vents that try to move 50 cfm of air through a 3” duct snaked 25’ through an attic.

OR

A furnace filter that hasn’t been changed since the builder turned the home over to the homeowner.

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Examine Some Alterations Ventilation isn’t just Attic Ventilation

Installing Ventilation Equipment

Installing new equipment and ducts

Type of equipment in place.

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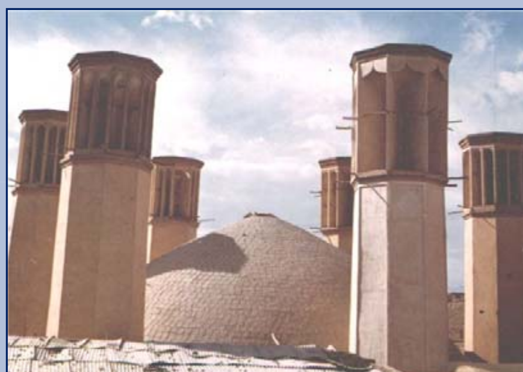
Whole House Ventilation

Whole building ventilation has been part of the cooling process for centuries.



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Residential Ventilation

Residential ventilation comes in various shapes and sizes. We have multiple solutions when providing adequate ventilation for residential construction.

The first step is calculating the correct rate.

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How Much?

Ventilation Requirements are based on:

Size of Building Enclosure


Air tightness


Number of Occupants


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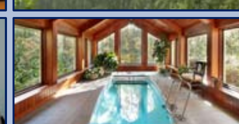
How Much?

Ventilation Requirements are based on:

Pollutants


Moisture (Humidity)



Special conditions—Certain types of equipment, health conditions of occupants, etc.

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Air Tightness of an Enclosure
Air Change Rate

Air change rate - air changes per hour - can be expressed as:

ACH = (60 × CFM) / V

Where:

ACH = Air Changes per Hour

CFM = fresh air flow through the room (Cubic Feet per Minute)

V = volume of the room (Cubic Feet)

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Example Calculating ACH
(Air Change per Hour)

If:

1500 ft^2 home with 8′ ceilings

Blower Door Results = 1500 CFM_{50}

$$ACH_{50} = \frac{(60\ \text{Minutes/Hour} \times CFM_{50})}{(CFA \times \text{Floor Height})}$$

$$ACH_{50} = (60 \times 1500)/12{,}000\ ft^3$$

$$\mathbf{ACH_{50} = 7.5}$$

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Example—ELA Calculation
Equation R3-15

If:

1500 ft^2 home with 8′ ceilings

Blower Door Results = 1500 CFM_{50}

$$ELA = 0.055 \times CFM_{50}$$

$$ELA = 0.055 \times 1500\ CFM_{50}$$

$$82.5\ in^2 = ELA = 0.055 \times 1500\ CFM_{50}$$

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Example—SLA Calculation
Equation R3-16

If:

1500 ft^2 home with 8′ ceilings

Blower Door Results = 1500 CFM_{50}

$$SLA = 3.819 \times CFM_{50}/CFA$$

$$SLA = 3.819 \times 1500/1500$$

$$3.819 = SLA = 3.819 \times 1500/1500$$

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Passive Home Requirements

< 0.6 ACH @ CFM_{50}

If:

1500 ft^2 home with 8′ ceilings

Blower Door Results = ? CFM_{50}

(ACH_{50} x CFA x Floor Height) / 60 = Target CFM_{50}

(.6 x 1500 ft^2 x 8′)/60 = Target CFM_{50} = 120 CFM_{50}

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Performance Characteristics Passive Homes

Airtight building shell ≤ 0.6 ACH_{50} pascal pressure, measured by blower-door test.

Annual heat requirement ≤ 4.75 kBtu/ft^2/year

Primary Energy ≤ 38.1 kBtu/ft^2/year

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Ensure Efficient Source Exhaust

Bathrooms and kitchens generate the most indoor pollution (moisture and VOCs).

A powered exhaust system that vents directly to the outdoors needs to be specified. Opening a window is often not enough.

In the bathroom, fans should provide 50 CFM.

A Kitchen up-draft range hood should provide 100 CFM of ventilation and needs to be vented to the outside.

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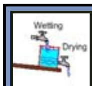

Wetting Potential

The balance tips when:

More moisture enters the wall system (wetting) than leaves (drying).

A new 2,000 ft^2 home slab on grade can potentially release ~585 gallons from the concrete slab during the first couple of years.

Consider the paint, drywall mud and other processes that release moisture into the new home during the first couple of years.

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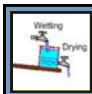

Ventilate indoor moisture

Inhabitants of a home generate moisture when they cook, shower, and do laundry.

Just by breathing and perspiring, a typical family adds about three gallons of water per day to their indoor air.

If a clothes dryer is not vented outside, or if the outdoor vent is closed off or clogged, all that moisture will enter the living space, too.

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Moisture Transmission

In addition to air movement, we need to control temperature and moisture content.

Insulation reduces the flow of heat and moderates the effect of temperature across the building envelope cavity.

Except in deliberately ventilated spaces, such as attics, insulation and vapor diffusion retarders work together to reduce the opportunity for condensation in a house's ceilings, walls, and floors.

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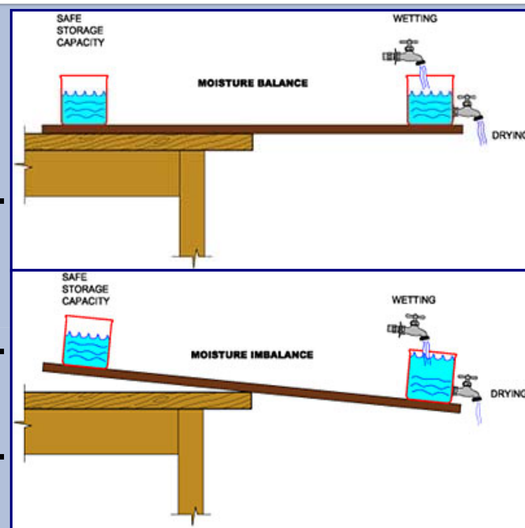
Moisture Balance
Hygric Buffer Capacity

A 2,000 ft^2 Home

Steel frame with
Gypsum Sheathing—
~5 gallons.

Wood Frame with
Wood Sheathing—
~50 gallons.

Masonry wall—
~500 Gallons.



ASHRAE Journal Feb 2002—Joseph Lstiburek

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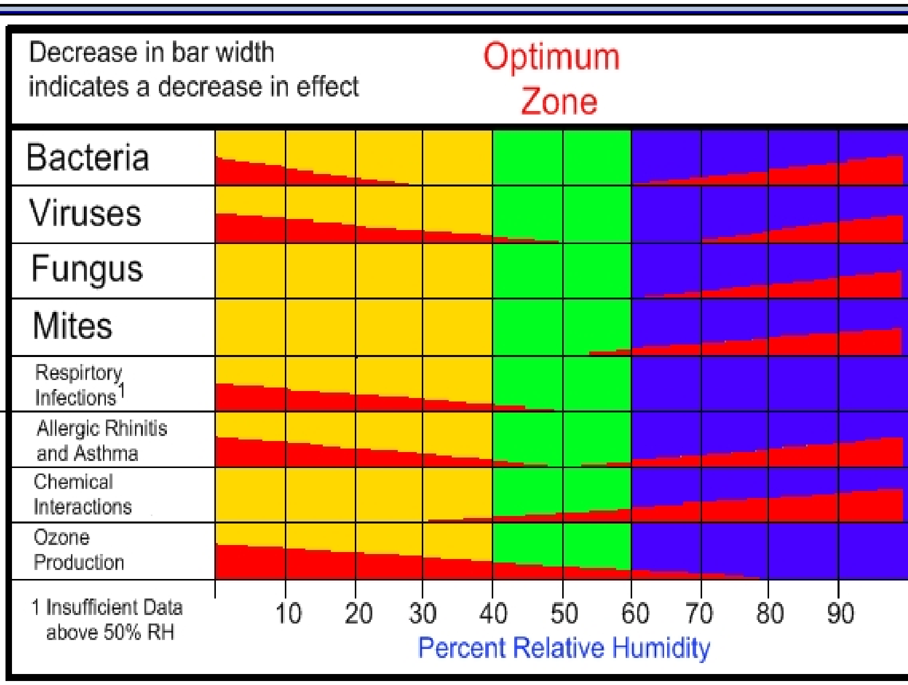

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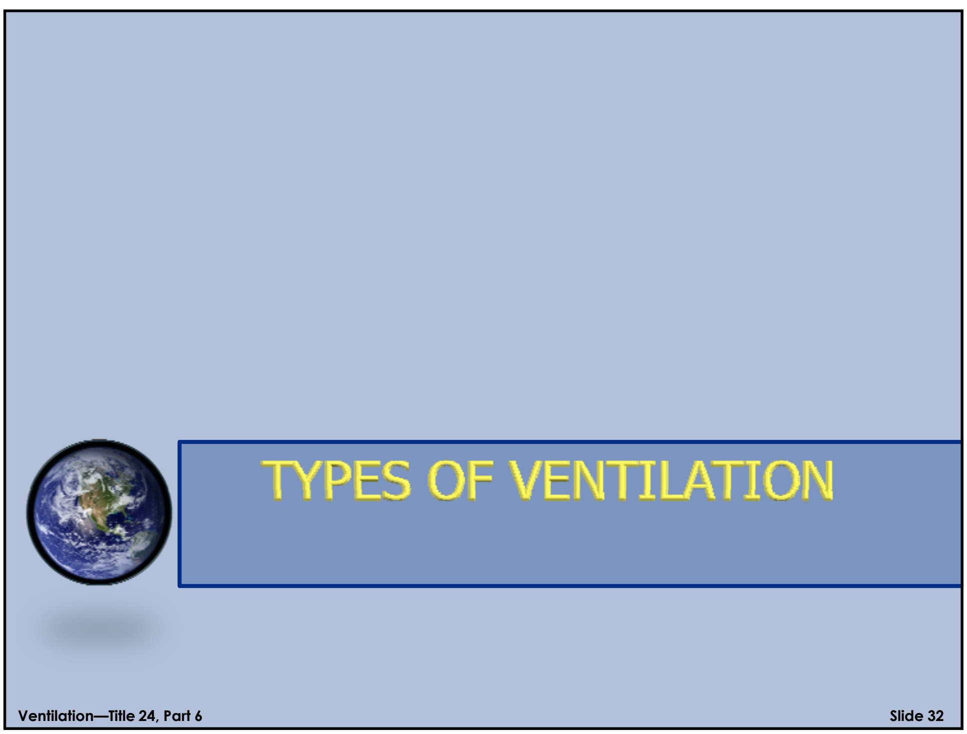
TYPES OF VENTILATION
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Types of Ventilation
Passive

Open Windows:

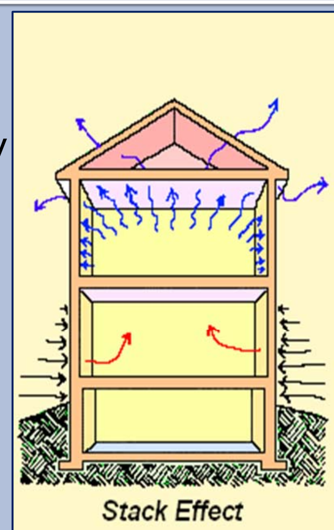
If it is cool or breezy enough outside, opening windows may induce enough fresh air into the house, forcing stale air out.

Types of Ventilation

House Fans:

In a typical multi-story house during most of the year, air moves naturally upwards as it warms and rises.

In mild climates, a fan placed in the ceiling or open attic will exaggerate or induce this "stack effect" when you open the windows, providing fresh air and cooling.



Types of Ventilation

Intermittent Fans:

If there isn't a breeze and the air flow between inside and outside is static, operating a 100 cfm fan would continuously provide adequate ventilation for a 1,500 ft^2 house with 8-foot ceilings.

Exhaust-ventilation depends on uncontrolled infiltration to provide fresh air.

If hot and humid air is drawn into the building for an extended period, condensation, mold, and damage are likely to develop.

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Types of Ventilation Supply

Supply ventilation systems draw clean outside air into the interior living space, usually through a supply vent that feeds into the return duct of a forced air system.

Aside from allowing incoming air to be carefully controlled and filtered, supply-only strategies tend to "pressurize" the house, which keeps moisture out in hot, humid climates but may induce drafts in cold climates as warm air escapes to the outside.

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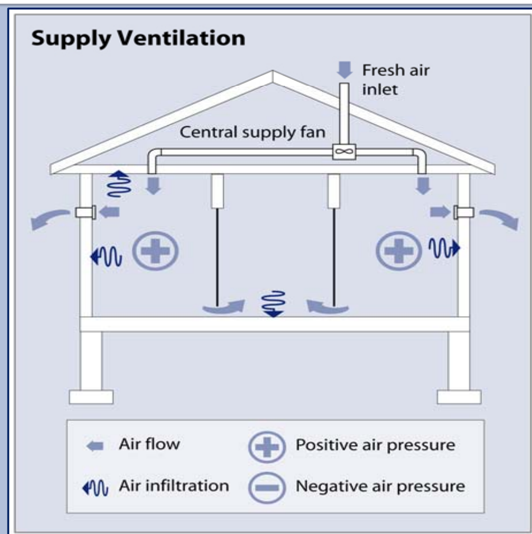
Supply Ventilation

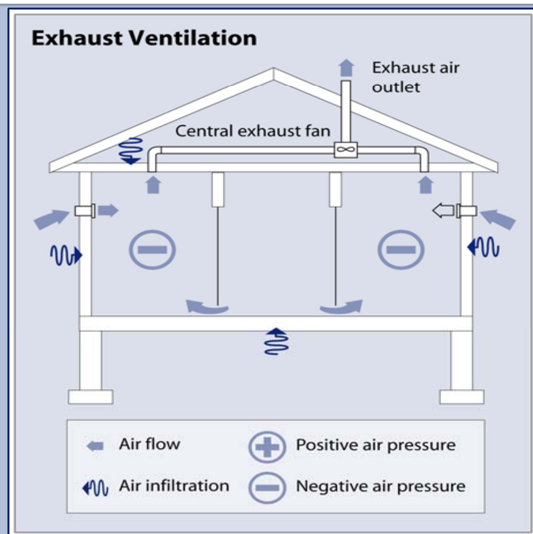


Types of Ventilation
Exhaust

Exhaust ventilation systems work by depressurizing the building. By reducing the inside air pressure below the outdoor air pressure, they extract indoor air from a house while make-up air infiltrates through leaks in the building shell and through intentional, passive vents.

Exhaust ventilation systems are relatively simple and inexpensive to install. Typically, an exhaust ventilation system is composed of a single fan connected to a centrally located, single exhaust point in the house.

Exhaust Ventilation



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Exhaust Ventilation

One concern with exhaust ventilation systems is that they may draw pollutants, along with fresh air, into the house. In addition to drawing in fresh outdoor air, they may draw in:

Radon and molds from a crawl space

Fumes from an attached garage

Flue gases from a fireplace or fossil-fuel-fired water heater and furnace.

Dust from an attic

This can cause serious concern when bath fans, range fans, and clothes dryers (which also depressurize the home while they operate) are run all at the same time.

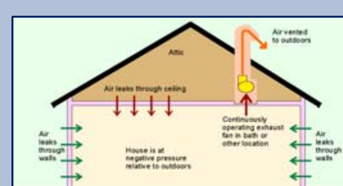

Figure 4-20 – Exhaust Ventilation Example

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Bathroom Fans

Many high quality bath fans are available in the 30 to 150 cfm size range and are quiet enough to be used continuously. One or more fans of this size will meet the requirements of most homes.

The exhaust fan can be a dedicated IAQ fan or it can be a more typical bath fan that is used for both whole building ventilation and local ventilation.




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Balanced Ventilation Systems

Balanced ventilation systems, if properly designed and installed, neither pressurize nor depressurize a house.

A balanced ventilation system usually has two fans and two duct systems.

A typical balanced ventilation system is designed to supply fresh air to bedrooms and living rooms.

They exhaust air from rooms where moisture and pollutants are most often generated (kitchen, bathrooms).

The supply air is often filtered, to remove dust and pollen from incoming airstream before introducing it into the house.

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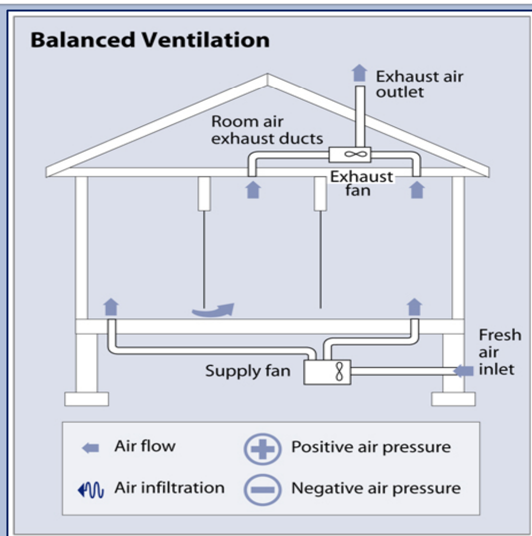
Balanced Ventilation



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Energy Recovery Ventilation Systems Similarities between ERV's and HRV's

Energy recovery ventilation systems provide a controlled way of ventilating a home while minimizing energy loss.

They reduce the costs of heating ventilated air in the winter by transferring heat from the warm inside air being exhausted to the fresh (but cold) supply air.

In the summer, the inside air cools the warmer supply air to reduce ventilation cooling costs.

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Energy Recovery Ventilation Systems

There are two types of energy-recovery systems:

Heat-recovery ventilators (HRV)

Energy-recovery ventilators (ERV) (enthalpy-recovery)

Both types include:

Heat exchanger,

Fan(s) to move air,

Controls.

There are some small wall- or window-mounted models, but the majority are central, whole-house ventilation systems with their own duct system or shared ductwork.

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Energy Recovery Ventilation Systems

The main difference between a Heat Recovery and an Energy Recovery Ventilator is the way the heat exchanger works.

With an Energy Recovery Ventilator, the heat exchanger transfers a certain amount of water vapor along with heat energy, while a heat-recovery ventilator only transfers heat.

The Energy Recovery Ventilator transfers some of the moisture from the exhaust air to the usually less humid incoming winter air, the humidity of the house air stays more constant. This also keeps the heat exchanger core warmer, minimizing problems with freezing.

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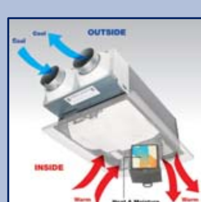
Energy Recovery Ventilation Systems

Most Energy Recovery Ventilator systems can recover about 70%–80% of the energy in the exiting air and deliver that energy to the incoming air.

Energy Recovery Ventilators are most cost effective in climates with extreme winters or summers, and where fuel costs are high. In mild climates, the cost of the additional electricity consumed by the system fans may exceed the energy savings.

Energy Recovery Ventilation Systems Installation and Maintenance

Energy recovery ventilation systems require more maintenance than other ventilation systems. They need to be cleaned regularly to prevent deterioration of ventilation rates and heat recovery, and to prevent mold and bacteria on heat exchanger surfaces.





Ventilate indoor moisture

The materials used in building a new 2,000 ft^2 home contain about six tons of water that must escape during the first year.

Occupants generate moisture when they cook, shower, and do laundry. Just by breathing and perspiring, a typical family adds about three gallons of water per day to their indoor air.

If a clothes dryer is not vented outside, or if the outdoor vent is closed off or clogged, all that moisture will enter the living space, too.

Ventilate indoor moisture

Kitchen and bathroom vents must lead directly outside and should never be vented into the attic, where moisture can cause serious problems and pose potential health problems.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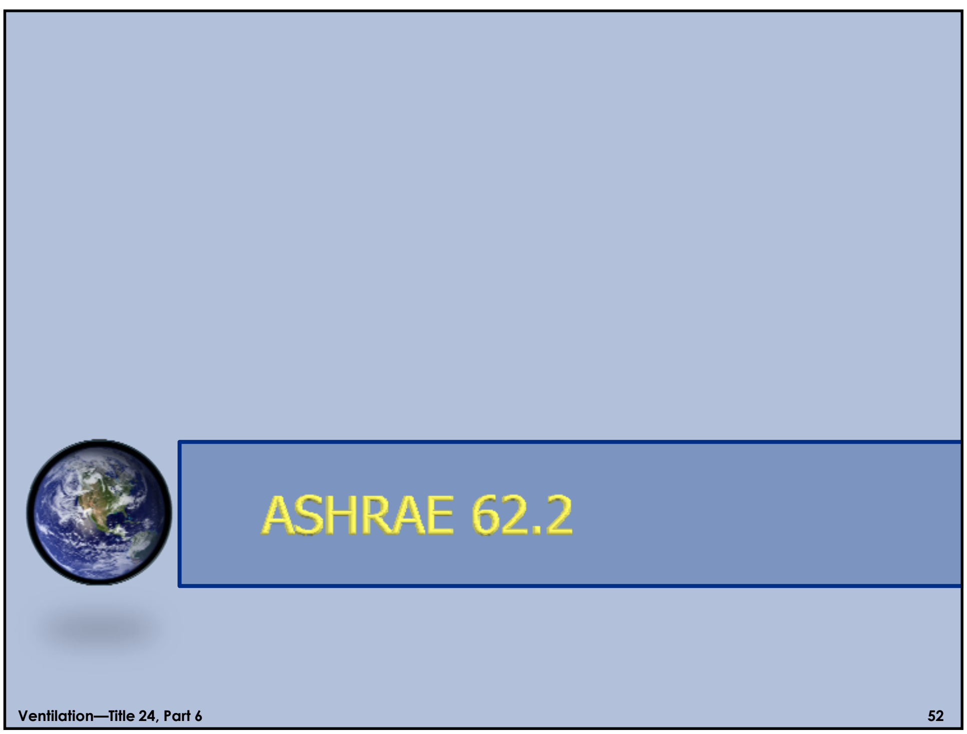
ASHRAE 62.2
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3.5.2 Mandatory Measures Ventilation Opening Area

ASHRAE Standard 62.2 requires ventilation openings in habitable spaces, toilets and utility rooms. **Ventilation openings usually will mean operable windows,** although a dedicated non-window opening for ventilation is acceptable. Spaces that meet the local exhaust requirements are exempted from this requirement so **a complying exhaust system can be substituted for a ventilation opening** (see Section 4.6.6).

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House Ventilation Rates

Spot Ventilation

Bathrooms: 50 cfm

Kitchens: 100 CFM or 5 ACH

Whole house:

Mechanical Ventilation Requirements

Flow Rate = Occupant Rate + Residence Rate

Occupant Rate:

(Bedrooms + 1) x 7.5 cfm = Occupant Rate

Residence Rate:

CFA * .01 cfm = Residence Rate

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Joints and Other Openings §117, Part 1

The following openings in the building envelope must be caulked, gasketed, weatherstripped or otherwise sealed:

1. Exterior joints around window and door frames, including doors between the house and garage, between interior HVAC closets and conditioned space, between attic access and conditioned space, and between wall sole plates, floors, exterior panels and all siding materials.
2. Openings for plumbing, electricity, and gas lines in exterior walls, ceilings and floors;

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Joints and Other Openings §117, Part 2

3. Openings in the attic floor (such as where ceiling panels meet interior and exterior walls and masonry fireplaces);
4. Openings around exhaust ducts such as those for clothes dryers; and
5. All other such openings in the building envelope.

Note also that range hoods must have dampers.

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4.6.1 Typical Solutions for Whole-Building Ventilation, Part 1

There are three generic solutions to meeting the outside air ventilation requirement:

1. Exhaust ventilation,
2. Supply ventilation,
3. Combination of supply and exhaust ventilation. If the supply and exhaust flows are within 10 percent of each other this is called a balanced ventilation system.

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4.6.1 Typical Solutions for Whole-Building Ventilation, Part 2

Whole-building ventilation may be achieved through a single fan or a system of fans that are dedicated to this ventilation only. Or it may be carried out by fans that also provide local exhaust or distribute heating and cooling.

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4.6.2 Whole-building Ventilation Flow Rate (Section 4 of ASHRAE 62.2)

The whole-building ventilation system may operate continuously or intermittently.

The whole-building ventilation rate is determined for continuous ventilation, and if the system is operated intermittently, an adjustment is made.

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Equation 4-1 Continuous Ventilation

Ventilation (cfm) = CFA / 100 + 7.5 × (Bedrooms + 1)

Instead of the equation above, Table 4-7 may be used to determine the required ventilation.

This table allows the user to find the required ventilation rate directly if they know the floor area and number of bedrooms.

The size of the fan must be greater than or equal to the required capacity.

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Table 4-7 Continuous Whole-building Ventilation Rate (cfm)

Conditioned 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

Equation 4-2 Intermittent Ventilation

Qf = Qr / (e x f)

Where:

Qf = fan flow rate

Qr = ventilation air requirement (continuous)

e = ventilation effectiveness, (from Table 4-8 below)

f = fractional on-time.

Table 4-8 – Ventilation Effectiveness for Intermittent Fans

Daily Fractional On time, f	Ventilation Effectiveness, e
f ≤= 35%	0.33
35% <= f < 60%	0.50
60% ≤= f < 80%	0.75
80% ≤= f	1.0
Fan runs at least once every three hours	1.0

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Key requirements for most residences.

1. A whole-building mechanical ventilation system shall be provided.
2. Kitchens and bathrooms shall have local exhaust systems vented to the outdoors.
3. Clothes dryers shall be vented to the outdoors.

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Miscellaneous indoor air quality design requirements apply, including, 1-4:

1. Ventilation air shall come from the out of doors and shall not be transferred from adjacent dwelling units, garages or crawlspaces.
2. Ventilation system controls shall be labeled and the home owner shall be provided with instructions on how to operate the system.
3. Combustion appliances shall be properly vented and air systems shall be designed to prevent back drafting.
4. The wall and openings between the house and the garage shall be sealed.

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Miscellaneous indoor air quality design requirements apply, including, 5-7:

5. Habitable rooms shall have windows with a ventilation area of at least 4 percent of the floor area.
6. Mechanical systems including heating and air conditioning systems that supply air to habitable spaces shall have MERV 6 filters or better.
7. Air inlets (not exhaust) shall be located away from known contaminants.

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Airflow and Sone

8. Air moving equipment used to meet either the whole-building ventilation requirement or the local ventilation exhaust requirement shall be rated in terms of airflow and sound.

a. All continuously operating fans shall be rated at a maximum of 1.0 sone.

b. Intermittently operated whole-building ventilation fans shall be rated at a maximum of 1.0 sone.

c. Intermittently operated local exhaust fans shall be rated at a maximum of 3.0 sone.

d. Remotely located air-moving equipment (mounted outside of habitable spaces) need not meet sound requirements if there is at least 4 feet of ductwork between the fan and the intake grill.

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Ventilation Rate for Intermittent Local Exhaust

A minimum intermittent ventilation airflow of 100 cfm is required for the kitchen range hood and a minimum intermittent ventilation airflow of 50 cfm is required for the bath fan.

The kitchen exhaust requirement can also be met with either a ceiling or wall-mounted exhaust fan or with a ducted fan or ducted ventilation system that provides at least 5 air changes of the kitchen volume per hour.

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Ventilation Rate for Intermittent Local Exhaust

Recirculating range hoods that do not exhaust pollutants to the outside cannot be used to meet the requirements of the ASHRAE Standard 62.2.

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Clothes Dryers ASHRAE 62.2-2007

6.3 Clothes Dryers—Clothes dryers shall be exhausted directly to the outdoors.

All laundry rooms must be built with a duct to the outdoors, designed to be connected to the dryer.

Devices which allow the exhaust air to be diverted into the indoor space to provide extra heating are not permitted.

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Loose Fill Insulation

Loose fill insulation must be blown in evenly, and insulation levels must be documented on the Installation Certificate (CF-6R). The insulation level can be verified by checking that the depth of insulation conforms to the manufacturer's coverage chart for achieving the required R-value. The insulation must also meet the manufacturer's specified minimum weight per ft^2 for the corresponding R-value.

When installing loose fill insulation, the following guidelines should be followed:

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Loose Fill Insulation

1. For wood trusses that provide a flat ceiling and a sloped roof, the slope of the roof should be at about 4:12 or greater in order to provide adequate access for installing the insulation. Insulation thickness near the edge of the attic will be reduced with all standard trusses, but this is acceptable as long as the average thickness is adequate to meet the minimum insulation requirement.
2. If the ceiling is sloped (for instance, with scissor trusses), loose fill insulation can be used as long as the slope of the ceiling is no more than 4:12. If the ceiling slope is greater than 4:12, loose fill should be used only if the insulation manufacturer will certify the installation for the slope of the ceiling.
3. At the apex of the truss, a clearance of at least 30 inch should be provided to facilitate installation and inspection.

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Notes

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FILTRATION

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Filter Particulates

The Filter for the HVAC system needs to be regularly cleaned or replaced, usually monthly.

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Filtration—Mechanical Filtration

Mechanical air filters, such as high efficiency particulate air (HEPA) filters, remove particles by capturing them on filter materials. Most mechanical air filters are good at capturing larger airborne particles—such as dust, pollen, some mold spores, and animal dander—and particles that contain dust mite and cockroach allergens.

Filters that remove finer particles cost more and have higher resistance to airflow, which requires more fan energy.

Mechanical Filtration

Mechanical air filters will capture some biological pollutants, but some will bypass the filter along with the airstream, and many small microorganisms can pass through lower efficiency filter media.

Microorganisms such as bacteria and molds also can enter the HVAC system by the following mechanisms.

They may grow through the filter media when conditions are favorable, for example when moisture is present and temperatures are high.

They can be introduced into the system during routine maintenance, for example a filter change.

Mold spores on the filters can be released back to the airstream when the air velocity suddenly increases, for example during HVAC system startup or off-and-on operation.

Filtration—HEPA Filters

High Efficiency Particulate Air (HEPA) are usually made of submicron glass fibers and have a texture similar to blotter paper. They also have a larger surface area and remove respirable particles more efficiently than pleated filters.

Filtration—Electronic Filtration

Electronic air cleaners, such as electrostatic precipitators, use a process called electrostatic attraction to trap particles.

Some electronic air cleaners can produce ozone, a lung irritant.

Filtration—Electronic Filtration

Electrostatic filters attract particles passing through the filter by electric charge. These are typically better than mechanical filters because they can trap very small particles without hindering air flow.

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Filtration—Pleated Filters

Pleated or extended surface filters are generally more efficient than flat filters in capturing respirable particles.

Pleated filters increase surface area, reduces air velocity, without a large drop in airflow rate.

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MERV—Minimum Efficiency Report Value

A measurement scale designed in 1987 by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) to rate the effectiveness of air filters.

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MINIMUM EFFICIENCY REPORTING VALUE (MERV)

ASHRAE Standard 52.2				ASHRAE Standard 52.1	Application Guidelines		
MERV	Particle Size Removal Efficiency, Percent in Particle Size Range, µm			Dust-Spot Efficiency Percent	Particle Size and Typical Controlled Contaminant	Typical Applications	Typical Air Filter/Cleaner Type
	0.3 to 1	1 to 3	3 to 10				
20	≥ 99.999	in 0.1 – 0.2 µm particle size		—	**< 0.3 µm** Virus (unattached) Carbon dust, Sea salt, All combustion smoke	Electronics manufacturing, Pharmaceutical manufacturing, Carcinogenic materials	HEPA/ULPA Filters*
19	≥ 99.999	in 0.3 µm particle size					
18	≥ 99.99	in 0.3 µm particle size					
17	≥ 99.97	in 0.3 µm particle size					
16	> 95	> 95	> 95	—	**0.3-1 µm** All bacteria, Droplet nuclei (sneeze), Cooking oil, Most smoke, Insecticide dust, Most face powder, Most paint pigments	Superior Commercial Buildings, Hospital Inpatient Care, General Surgery	**Bag Filters–** Nonsupported (flexible) microfine fiberglass or synthetic media, 12 to 36 inches deep. **Box Filters–** Rigid style cartridge, 6 to 12 inches deep.
15	85-95	> 90	> 90	> 95			
14	75-85	> 90	> 90	90-95			
13	< 75	> 90	> 90	80-90			

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MINIMUM EFFICIENCY REPORTING VALUE (MERV)

ASHRAE Standard 52.2				ASHRAE Standard 52.1	Application Guidelines		
MERV	Particle Size Removal Efficiency, Percent in Particle Size Range, µm			Dust-Spot Efficiency Percent	Particle Size and Typical Controlled Contaminant	Typical Applications	Typical Air Filter/Cleaner Type
	0.3 to 1	1 to 3	3 to 10				
12	—	> 80	> 90	70-75	**1-3 µm** Legionella, Humidifier, Dust, Lead Dust, Milled Flour, Auto Emission Particles, Nebulizer Drops	Superior Residential Better Commercial Buildings Hospital Laboratories	**Pleated filters–** Extended Surface with cotton or polyester media or both, 1 to 6 inches thick. **Box Filters–** Rigid style cartridge, 6 to 12 inches deep.
11	—	65-80	> 85	60-65			
10	—	50-65	> 85	50-55			
9	—	< 50	> 85	40-45			
8	—	> 95	> 95	—	**3-10 µm** Mold Spores, Dust Mite body parts and Droppings, Cat and Dog Dander, Hair spray, Fabric protector, Dusting aids, Pudding Mix, Powdered Milk	Superior Commercial Buildings, Hospital Inpatient Care, General Surgery	**Pleated filters–** Extended surface with cotton or polyester media or both, 1 to 6 inches thick. **Cartridge filters–** Viscous cube or pocket filters **Throwaway–**Synthetic media panel filters
7	—	> 90	> 90	> 95			
6**	—	> 90	> 90	90-95			
5	—	> 90	> 90	80-90			

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MINIMUM EFFICIENCY REPORTING VALUE (MERV)

ASHRAE Standard 52.2				ASHRAE Standard 52.1	Application Guidelines		
MERV	Particle Size Removal Efficiency, Percent in Particle Size Range, µm			Dust-Spot Efficiency Percent	Particle Size and Typical Controlled Contaminant	Typical Applications	Typical Air Filter/Cleaner Type
	0.3 to 1	1 to 3	3 to 10				
4	—	—	<20	<20	**> 10 µm** Pollen, Dust mites Cockroach body parts and droppings, Spanish moss Sanding dust Spray paint dust Textile fibers Carpet fibers	Minimum filtration Residential window air conditioners	**Throwaway–** Fiberglass or synthetic media panel, 1 inch thick. **Washable–** Aluminum mesh, foam rubber panel **Electrostatic–** Self-charging (passive) woven polycarbonate panel
3	—	—	<20	<20			
2	—	—	<20	<20			
1	—	—	<20	<20			

This table is adapted from ANSI/ASHRAE Standard 52.2-2007.

*The last four MERV values of 17 to 20 are not part of the official standard test, but have been added by ASHRAE for comparison purposes. Ultra Low Penetration Air filters (ULPA) have a minimum efficiency of 99.999 percent in removing 0.3 µm particles, based on the IEST test method. MERVs between 17 and 19 are rated for 0.3µm particles, whereas a MERV of 20 is rated for 0.1 to 0.2 µm particles.

** For residential applications, the ANSI/ASHRAE Standard 62.2-200716 requires a filter with a designated minimum efficiency of MERV 6 or better.

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Interesting Report prepared by Davis Energy Building America 2009 Annual Report Consortium for Advanced Residential Buildings

Table 6-1: Filters Selected for Testing

Filter Make & Model	Thickness	MERV
3M Filtrete 1000	1"	11
3M Filtrete 1085	1"	11
3M Filtrete 1550	4"	12
3M Filtrete 1700	1"	12
3M Filtrete 6		8
Ace 30 day		2
Ace Micropa		11
Ace Pleated		8
Aeolus Synt		13
American Fi		6
Flanders Na		8
Flanders Pr		8
WEB Lifetim		8

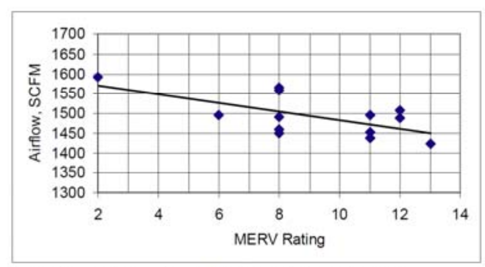

Figure 6-4: Airflow rate vs. MERV rating using a PSC motor

Interesting Report prepared by Davis Energy Building America 2009 Annual Report Consortium for

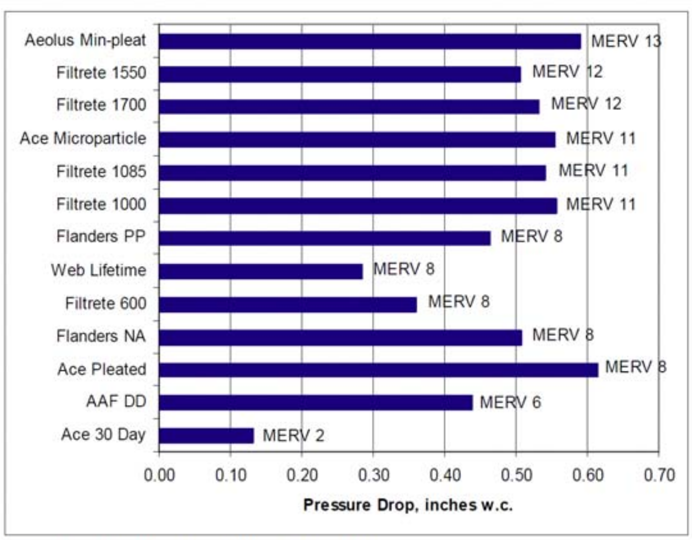

Figure 6-5: Filter Pressure Drop at 492 FPM

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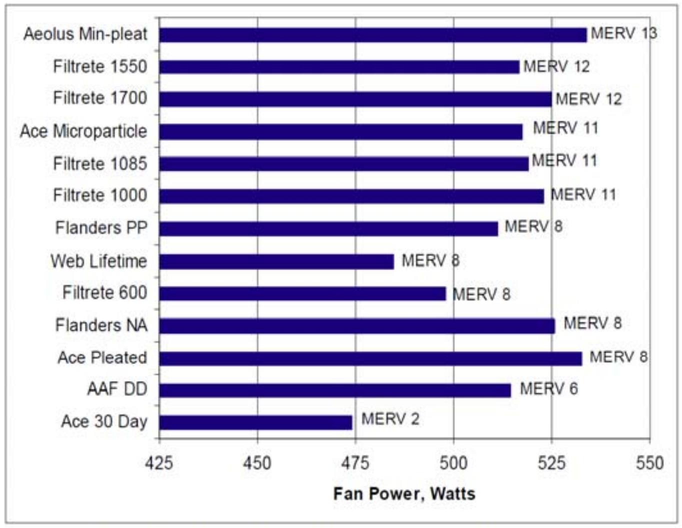

Figure 6-6: Fan Motor Power for ECM Motor at 492 FPM

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The best strategy for reducing filter pressure drop (other than using low-loss filters) is to decrease the face velocity by increasing the size of the filter. Figure 6-8 shows the pressure drop vs. face velocity curve measured for the Filtrete 600. At the standard 492 FPM face velocity the static pressure is about 0.32" w.c. Increasing the filter size by 25% decreases the static pressure to 0.20", and doubling the size of the filter will reduce it to about 0.07".

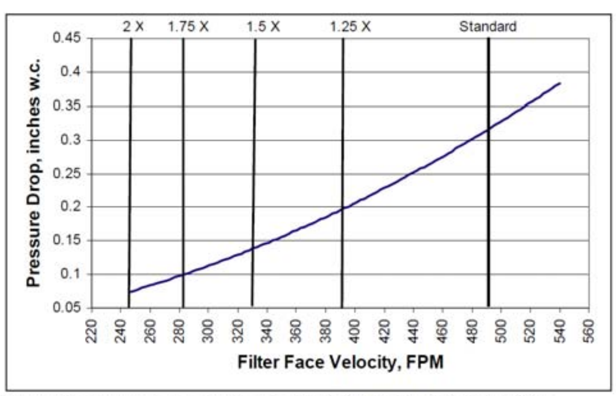

Figure 6-8: Pressure drop vs. filter face velocity for the Filtrete 600 filter

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Air Filtration

Mechanical systems that supply air to an occupiable space through **ductwork exceeding 10' in length** and **through a thermal conditioning component,** except evaporative coolers, **shall be provided with air filter devices** in accordance with the following:

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System Design and Installation

i. The system shall be designed to ensure that **all recirculated air and all outdoor air supplied to the occupiable space is filtered** before passing through the system's thermal conditioning components.

ii. The system shall be designed to **accommodate the clean-filter pressure drop imposed by the system air filter device(s).** The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter device shall be determined.

iii. **All system air filter devices shall be located and installed in such a manner as to allow access and regular service** by the system owner.

iv. All system air filter device locations **shall be labeled to disclose the applicable design airflow rate and the maximum allowable clean-filter pressure drop** as determined according to subsection ii above. **The labels shall be permanently affixed to the air filter device readily legible, and visible to a person replacing the air filter media.**

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Air Filter Media Efficiency

The system shall be provided with air filter media having a designated efficiency equal to or greater than **MERV 6** when tested in accordance **with ASHRAE Standard 52.2**, or a particle size efficiency rating equal to or greater than 50 percent in the 3.0–10 μm range when tested in accordance with AHRI Standard 680.

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Air Filter Media Pressure Drop

The system shall be provided with air filter media that conforms to the maximum allowable clean-filter pressure drop determined according to Section 150.0(m)12Aii, as rated using AHRI Standard 680, for the applicable design airflow rate(s) for the system air filter device(s). If the alternative to 150.0(m)13B is utilized for compliance, **the design clean-filter pressure drop for the system air filter media shall conform to the requirements given in TABLE 150.0-C or 150.0-D.**

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Table 150.0-C

Table 150.0-C: Return Duct Sizing for Single Return Duct Systems		
Return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.		
Return grille devices shall be labeled in accordance with the requirements in section 150.0(m)12A to disclose the grille's design airflow rate and a ***maximum allowable clean-filter pressure drop of 12.5 Pa (0.05 inches water)*** for the air filter media as rated in accordance with **AHRI Standard 680** for the design airflow rate for the return grille.		
System Nominal Cooling Capacity (Ton)*	**Minimum Return Duct Diameter (inch)**	**Minimum Total Return Filter Grille Gross Area (inch2)**
1.5	16	500
2.0	18	600
2.5	20	800
*Not applicable to systems with nominal cooling capacity greater than 2.5 tons or less than 1.5 ton		

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Table 150.0-D

TABLE 150.0-D: Return Duct Sizing for Multiple Return Duct Systems			
Return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow. Return grille devices shall be labeled in accordance with the requirements in section 150.0(m)12A to disclose the grille's design airflow rate and a ***maximum allowable clean-filter pressure drop of 12.5 Pa (0.05 inches water)*** for the air filter media as rated in accordance with **AHRI Standard 680** for the design airflow rate for the return grille.			
System Nominal Cooling Capacity (Ton)*	Return Duct 1 Minimum Diameter (inch)	Return Duct 2 Minimum Diameter (inch)	Minimum Total Return Filter Grille Gross Area ($inch^2$)
1.5	12	10	500
2.0	14	12	600
2.5	14	14	800
3.0	16	14	900
3.5	16	16	1000
4 .0	18	18	1200
5.0	20	20	1500
*Not applicable to systems with nominal cooling capacity greater than 5.0 tons or less than 1.5 tons.			

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Duct System Sizing and Air Filter Grille Sizing

Space conditioning systems that utilize forced air ducts to supply cooling to an occupiable space shall:

A. **Have a hole for the placement of a static pressure probe (HSPP),** or a permanently installed static pressure probe (PSPP) in the supply plenum downstream of the air conditioning evaporator coil. **The size, location, and labeling of the HSPP or PSPP shall conform to the requirements specified in RA3.3.1.1** as confirmed by field verification and diagnostic testing; **and**

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Duct System Sizing and Air Filter Grille Sizing

B. Demonstrate, in every control mode, **airflow greater than 350 CFM per ton of nominal** cooling capacity through the return grilles, **and an air-handling unit fan efficacy less than or equal to 0.58 W/CFM** as **confirmed by field verification and diagnostic testing** in accordance with the procedures given in RA3.3.

EXCEPTION to 150.0(m)13B: Multi-speed compressor systems or variable speed compressor systems shall verify air flow (cfm/ton) and fan efficacy (Watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

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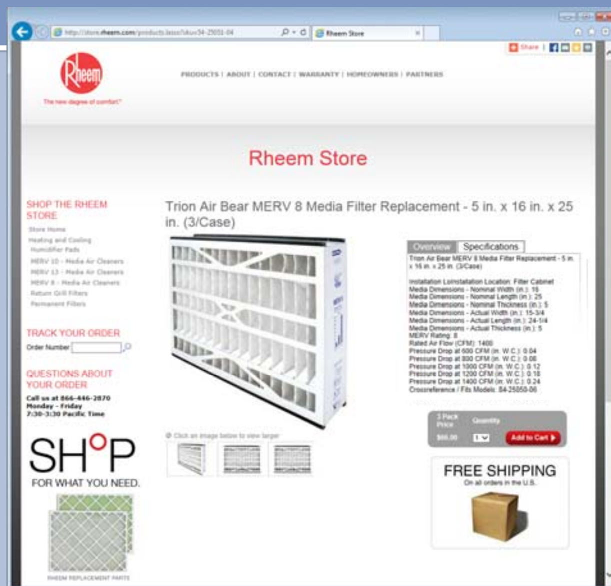
Filter



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Filter

Overview | Specifications

17 inch Replacement Filter for RXHF-E17AM13

Installation Location: Filter Cabinet
Media Dimensions - Nominal Width (in.): 17-1/2
Media Dimensions - Nominal Length (in.): 21
Media Dimensions - Nominal Thickness (in.): 4-1/2
Media Dimensions - Actual Width (in.): 17-1/4
Media Dimensions - Actual Length (in.): 20-3/4
Media Dimensions - Actual Thickness (in.): 4-3/8
MERV Rating: 13
Rated Air Flow (CFM): 1400
Pressure Drop at 600 CFM (in. W.C.): 0.098
Pressure Drop at 800 CFM (in. W.C.): 0.145
Pressure Drop at 1000 CFM (in. W.C.): 0.203
Pressure Drop at 1200 CFM (in. W.C.): 0.273
Pressure Drop at 1400 CFM (in. W.C.): 0.347
Crossreference / Fits Models: RXHF-E17AM13

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Notes

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Definitions—ASHRAE 62.2.2010

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]).

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.

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.

Definitions—ASHRAE 62.2.2010

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-hour 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.

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.

Definitions—ASHRAE 62.2.2010

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.

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.