Version 2.2

April 23, 2009

These are steps to reduce household hazards. People are not born knowing that they must brush their teeth to prevent decay, they must learn it. So with household hazards, they must learn how to take care of themselves. Occupants know things about the building and themselves that can be learned nowhere else. Start with the people.

The second step is to keep the household in a certain condition:

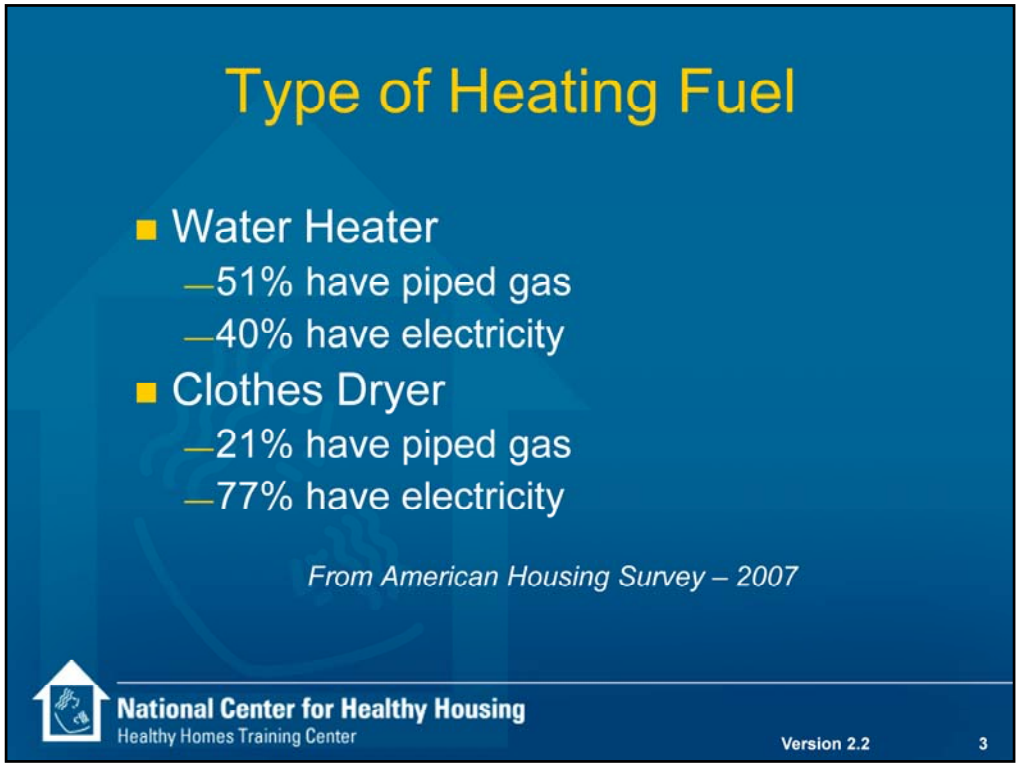
- limit moisture related problems,
- limit dust and allergens,
- limit pest borne disease,
- provide local exhaust ventilation and general dilution ventilation to control unavoidable air contaminants,
- provide a comfortable space by limiting hazards like slips, falls, electric shock, drowning and poisons.

Third, limit sources of contaminants like lead, asbestos, combustion fumes, VOCs (Volatile organic compounds) and radon.

Fourth, maintain the house so it continues to provide dry, clean, comfortable and safe conditions.

Why Well Ventilated?

- Pollutants can be found in concentrations 2-5 times higher indoors than outdoors.
- Proper ventilation can reduce hazards of:
  - Volatile organic compounds
  - Moisture
  - Environmental tobacco smoke
  - Particulate matter
  - Allergens
  - Mold
  - Carbon monoxide
  - Formaldehyde



See page 17 of 29 in Reference Tab Connections Section

Primary Heating Equipment

- 63% have warm air furnace
- 12% have steam or hot water system
- 12% have electric heat pump

But . . .

- 1.3 million homes (1.2%) have room heaters without flue
- 900,000 homes (0.8%) rely on stoves
- 120,000 homes (0.1%) rely on cooking stove

For their Primary Source of Heat!

Heating Problems

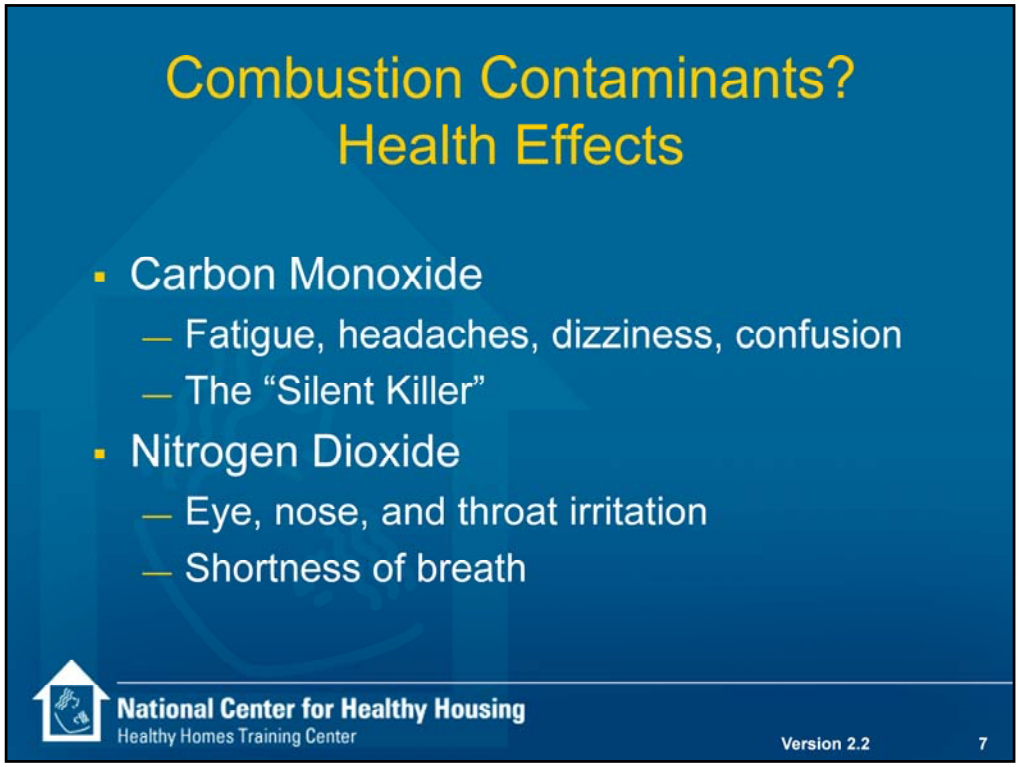
- 7% were uncomfortably cold for more than 24 hours
  - 11% for renters
- 1% had inadequate heating capacity
  - 2% for renters and residents below poverty level
- 0.8% had inadequate insulation
  - 1.6% for renters
  - 1.4% for residents below poverty level

Combustion contaminants are not uncommon problem. This problem is popping up all over the country, mostly in new homes. Usually families notice a fine layer of soot appears on plastic surfaces, such as TV and computer screens, inside refrigerators and freezers, on walls and ceiling, on carpets, particularly under doors and at baseboards.

Unvented kerosene or gas heaters

Burning fuel without ventilation can produce nitrogen dioxide, carbon monoxide, and nitrogen oxide, as well as particles. Unvented combustion devices should not be used in occupied spaces. [1]

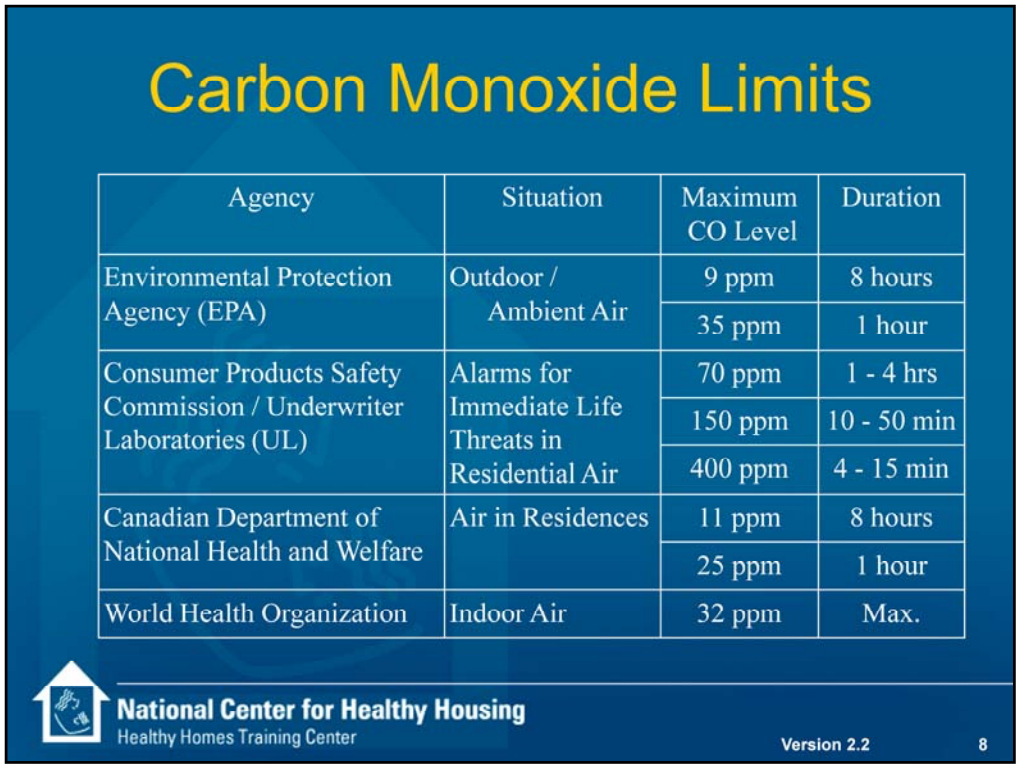
The kerosene heater in this home was used to provide supplemental heat, but the odor of the combustion products was so annoying that the door behind the heater was cracked open while the heater was in use.



There are two major pollutants associated with combustion products.

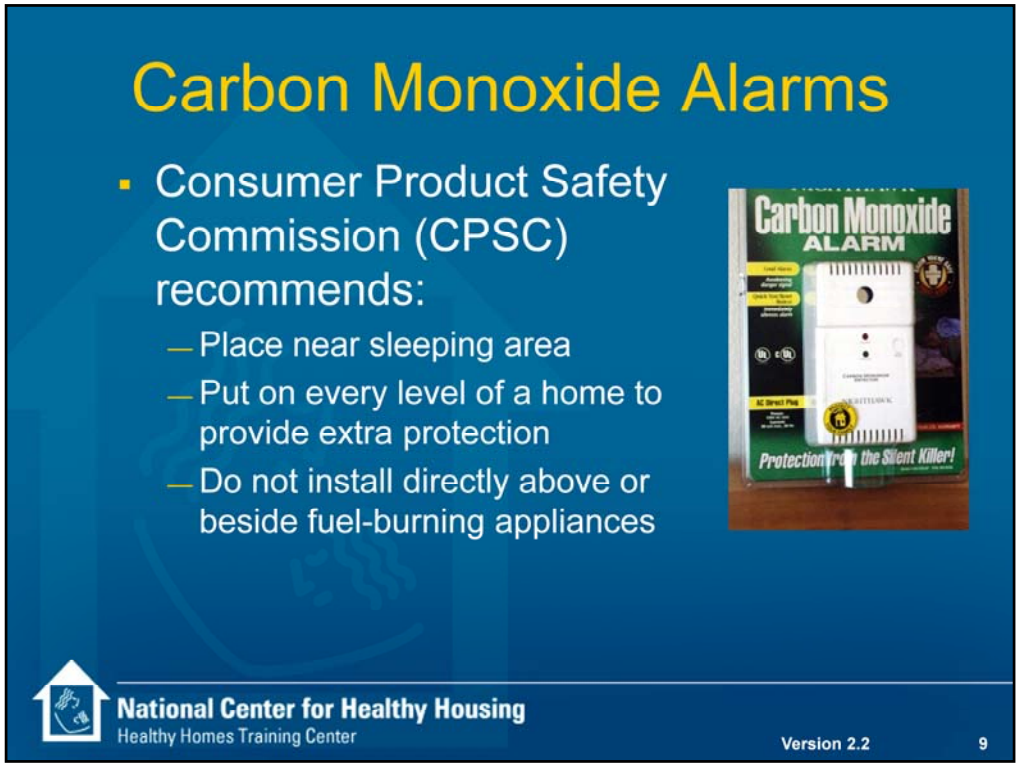
At relatively low levels of carbon monoxide a healthy person may feel fatigued. As levels increase a person may complain of headaches, dizziness, weakness or confusion. It is important to realize that CO is often referred to as the "Silent Killer" because it is colorless and odorless and death can occur without the person being aware that high levels exist. CDC reports that over 15,000 people each year are treated in emergency rooms for non-fire related carbon monoxide exposures. And an average of about 500 people die each year from non-fire related carbon monoxide exposures.

If a flame is yellow, it is not burning hot enough and it will produce more carbon monoxide. The hotter the flame, the most nitrogen dioxides produced.



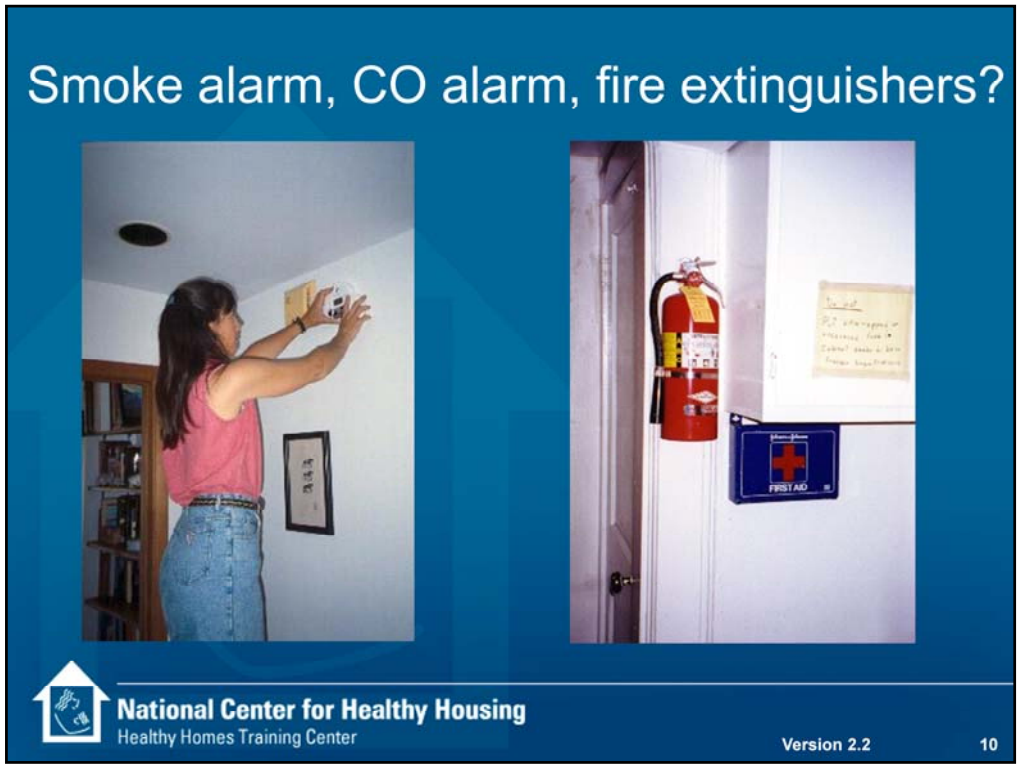
From CEHRC Carbon Monoxide Background Document.[3] See www.cehrc.org/tools/carbon/cobacmat.cfm.

These are exposure limits for people at work for 8 hours a day or for **outside** air. What about people who are in their home virtually all the time?



Proper placement of a carbon monoxide detector is important. If you are installing only one carbon monoxide detector, the Consumer Product Safety Commission (CPSC) recommends it be located near the sleeping area, where it can wake you if you are asleep. Additional detectors on every level and in every bedroom of a home provides extra protection.

Homeowners should remember not to install carbon monoxide detectors directly above or beside fuel-burning appliances, as appliances may emit a small amount of carbon monoxide upon start-up. A detector should not be placed within fifteen feet of heating or cooking appliances or in or near very humid areas such as bathrooms.

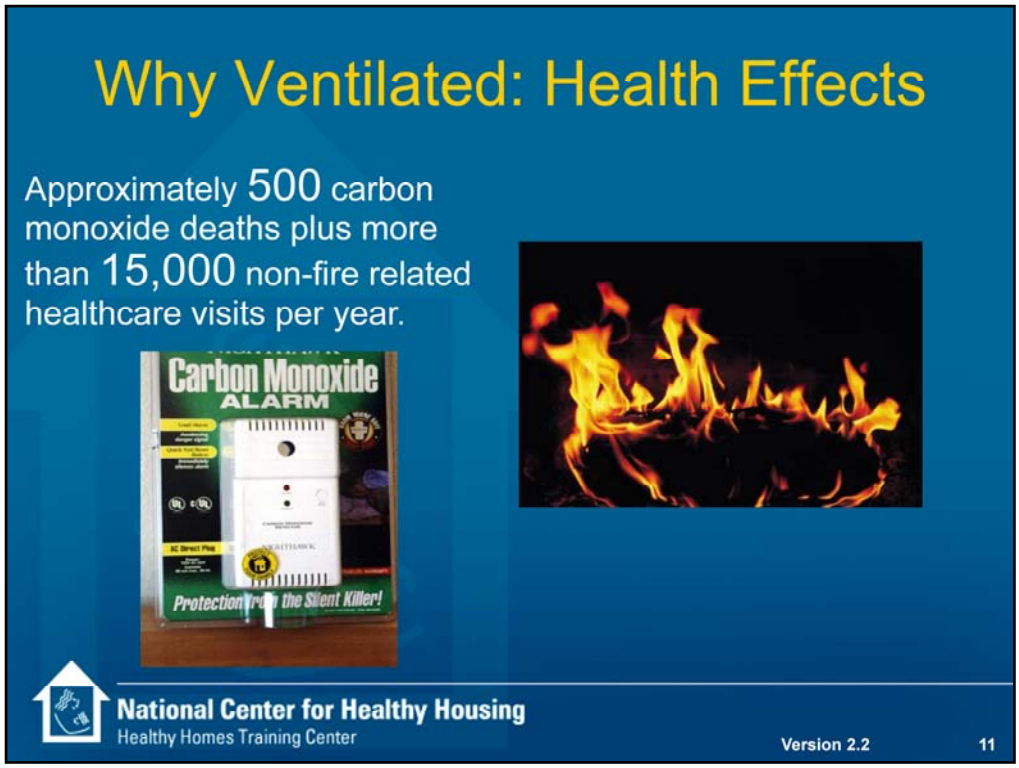


Placing and maintaining a smoke and fire detector.

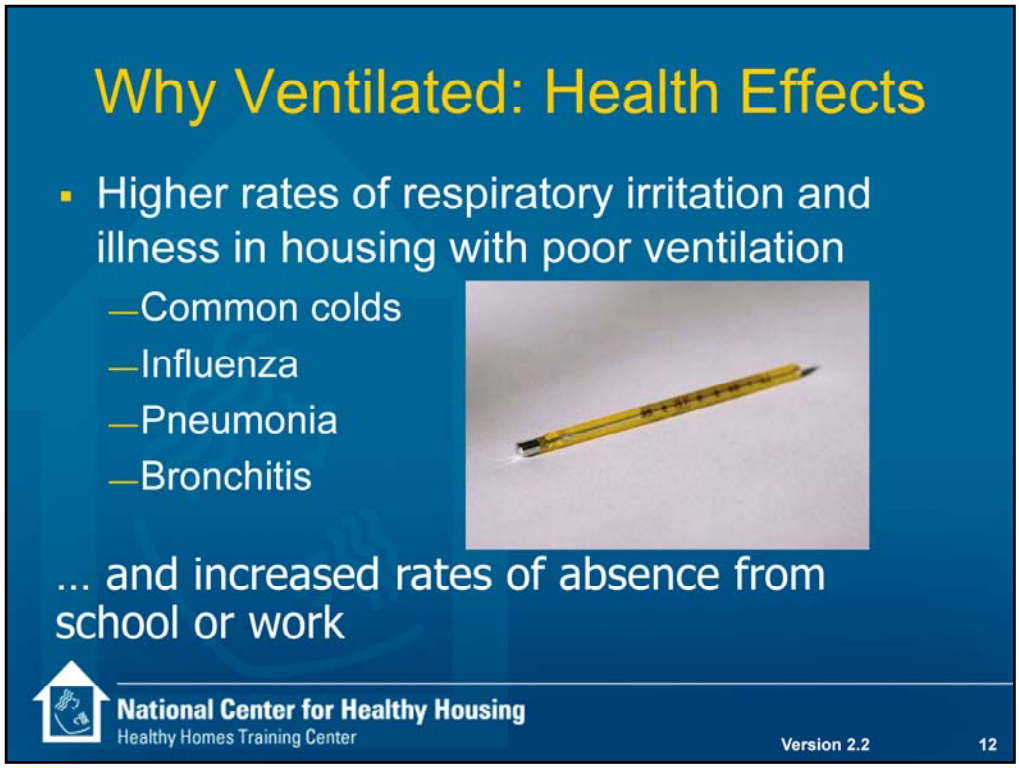
Smoke and fire alarms are needed to sound an alarm. Place them where hot air from a potential fire will collect so they will sound the alarm at the beginning of a fire, when moments are precious. Regulations vary on whether the alarms must be hard-wired, battery powered or both.

In this photo, a smoke and fire alarm are placed next to a CO alarm in the hallway outside of a frequently-occupied bedroom.

During the review, these devices should be tested by pressing the TEST button. A common cause of failure is weak or missing batteries, which should be replaced routinely.



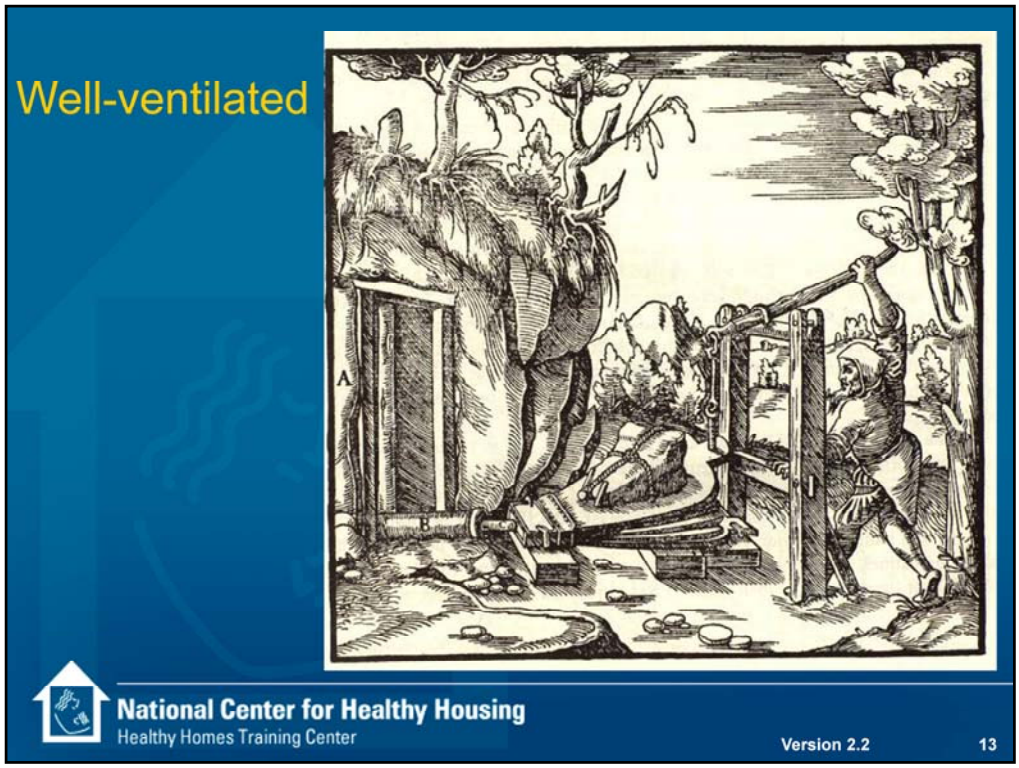
Here are some surprising statistics regarding ventilation in the home that are supplied by the Homes Safety Council. [4]



Ventilation plays an important role in maintaining health. Poor ventilation can result in higher rates of respiratory irritation, common colds, influenza, pneumonia, and bronchitis.

A recent study stated the following[5]:

- a 70% higher respiratory illness in fan-ventilated classrooms compared to window ventilated rooms;
- Nursing homes had much lower (76%) influenza rates in buildings with 100% supplied outside air
- With improved ventilation in housing and buildings, illnesses could decrease in incidence by 18% and costs to the US economy could be decreased by $6-14 billion.

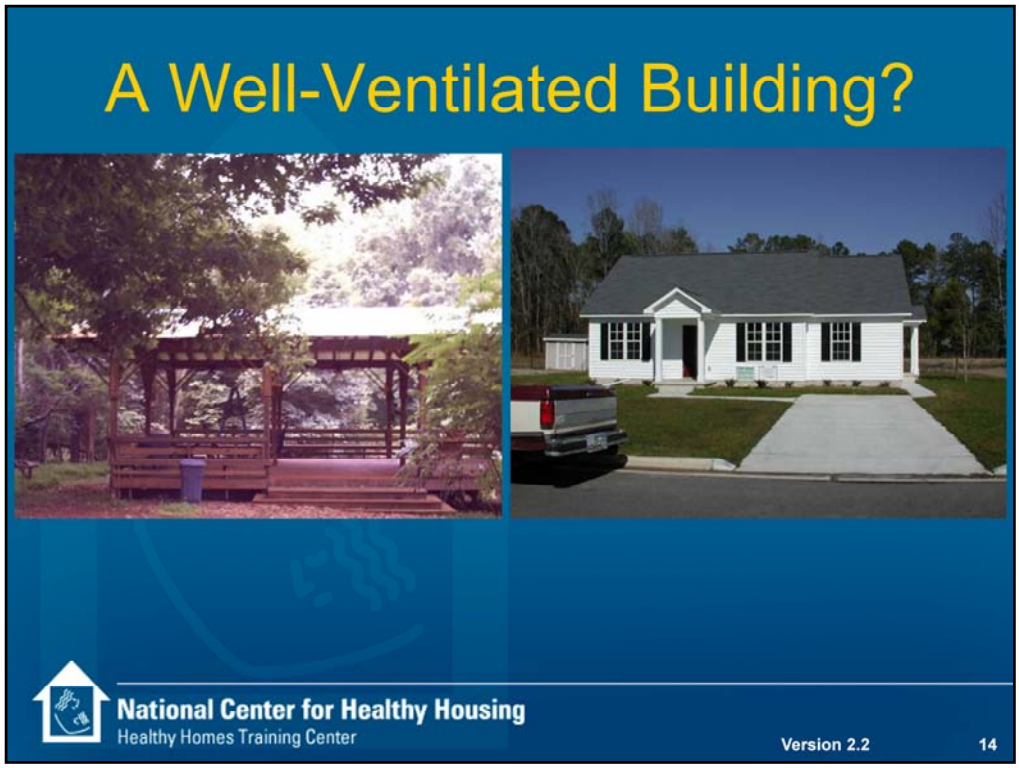


Ventilation equipment is the visible evidence of a long history of indoor air quality, heat, and moisture problems. Why else would we have invented it?

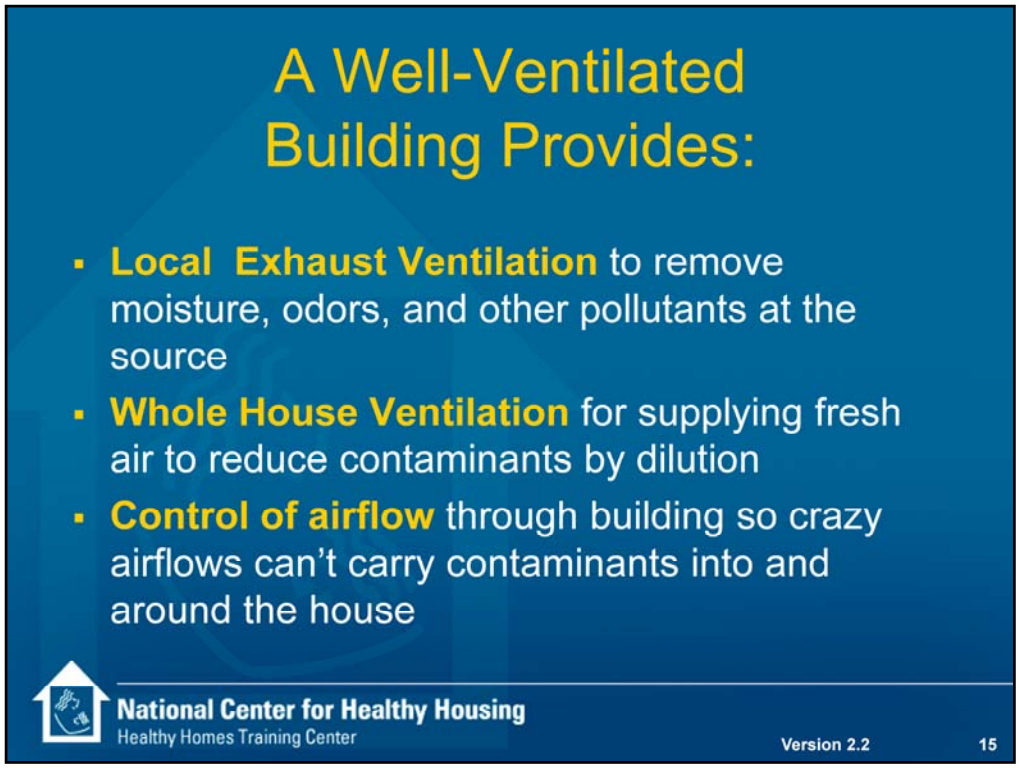
This is a photo of a woodcut showing a worker pumping air into a mine shaft to provide ventilation for his fellow workers. The woodcut is from *De Re Metallica,* a text on mining and metallurgy written in 1556 by Georgius Agricola. Agricola describes many of the ailments suffered by miners and the solutions for them, among which is "stagnant air…which… produces a difficulty in breathing; the remedies for this evil are the ventilating machines."

The chapter on ventilation shows three types of ventilators – scoops to divert wind into the mine, fans resembling radial blowers powered by men, water turbines or wind mills, and bellows powered by men or horses.

Indoor air quality problems are not new and the benefit of ventilation has long been understood.



Is there a difference between a building with plenty of air flow and one that is well-ventilated?



Ventilation reduces air contaminant levels in two different ways:

- If contaminants are released from a point source, a local exhaust system can be used to collect the contaminants before they spread throughout the building (e.g. chimneys, toilet exhaust, dryers and range hoods)
- Outdoor air with low air contaminant levels can be drawn or blown into the building and mixed with the indoor air through a whole house ventilation system, lowering the concentration by dilution. The contaminant leaves the building in the exhaust air.

By using ventilation or conditioning air to manage pressure differences, the airflow through a building can be planned to minimize exposures in the most efficient way.

Local exhaust ventilation is more efficient than dilution ventilation because it collects the contaminant near the source and intervenes in the transport mechanism. This is why we use local exhaust ventilation for radon removal.

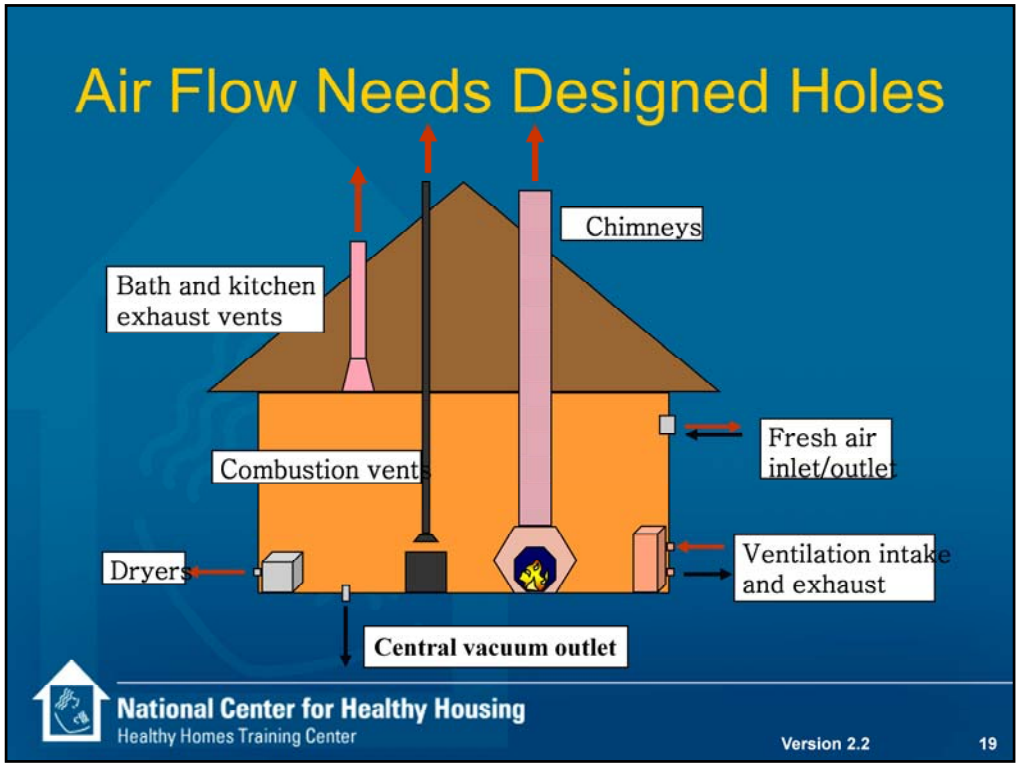
Key Concepts

- If any portion of air leaves a house the same amount must enter
- Air like water seeks the path of least resistance
- When heated air rises
- When cooled air falls
- Air can be hot, cold, wet, dry, or polluted when it enters or exits a house

Air moves through buildings, because a force creates differences in air pressure. The source of the force is most frequently some combination of fans, air temperature differences, and wind. It is easy to understand how fans and wind ventilate and cause air to move through buildings.

Air Flow in Homes

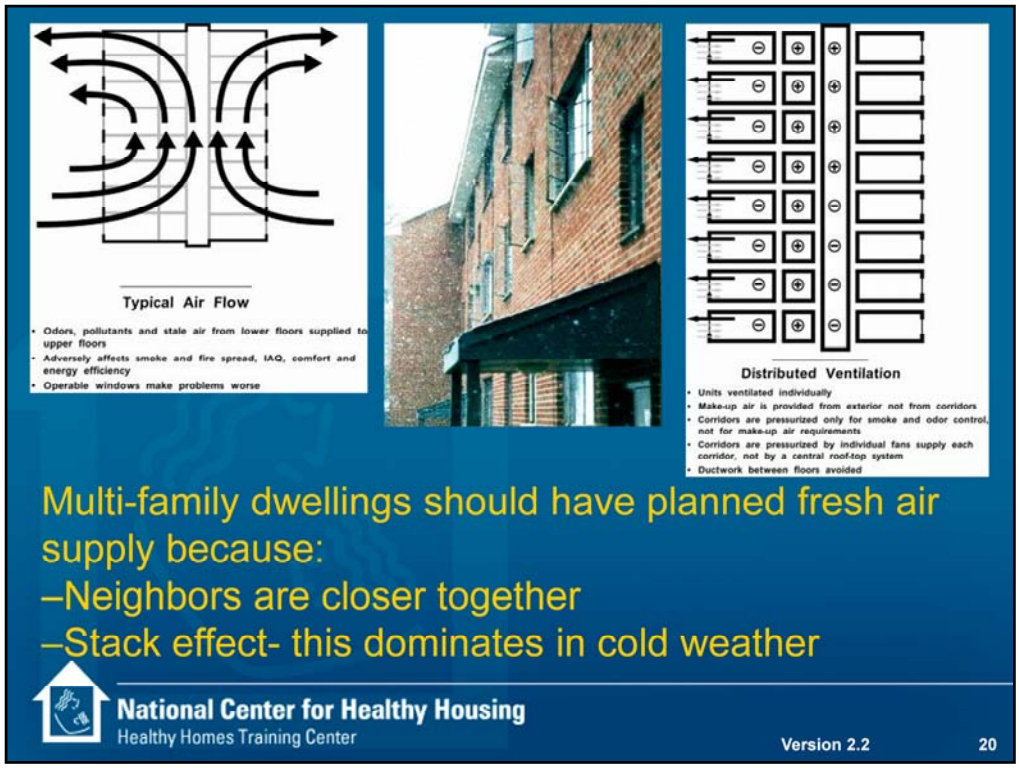
- Typical homes do not have a planned supply of fresh air.
- We depend on leakage such as windows, doors, and cracks.
- This is usually not adequate.



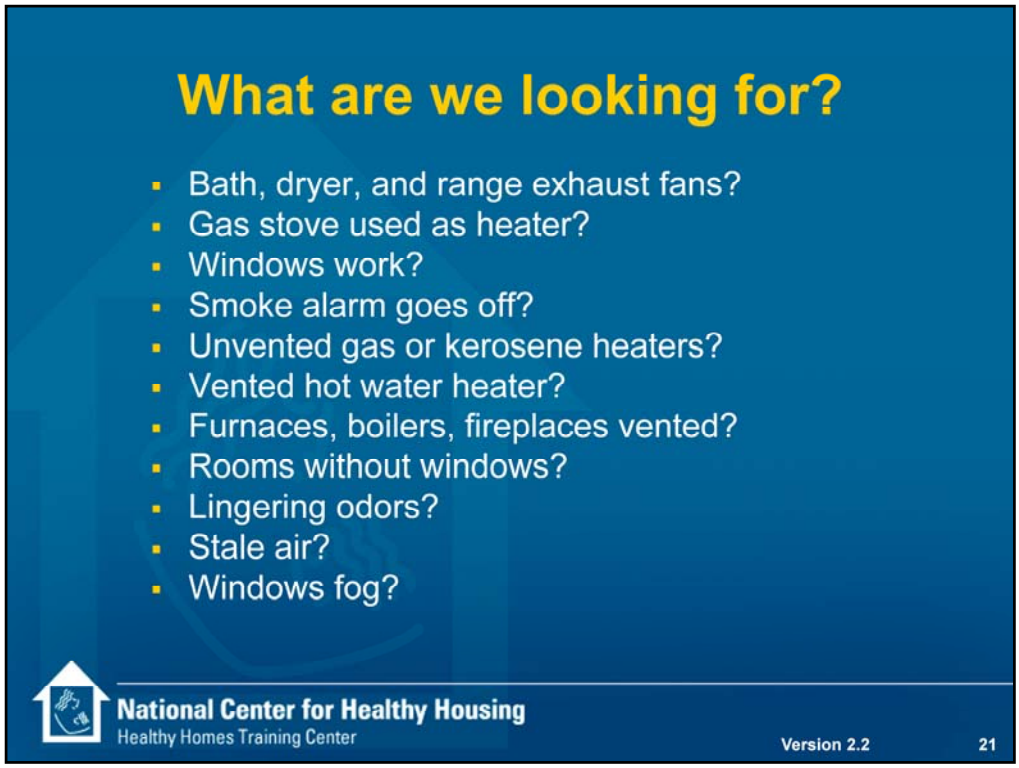
Courtesy of Arnie Katz at Advanced Energy.

Key points:

- Never block, restrict or seal designed holes
- Never reverse the direction of designed flow



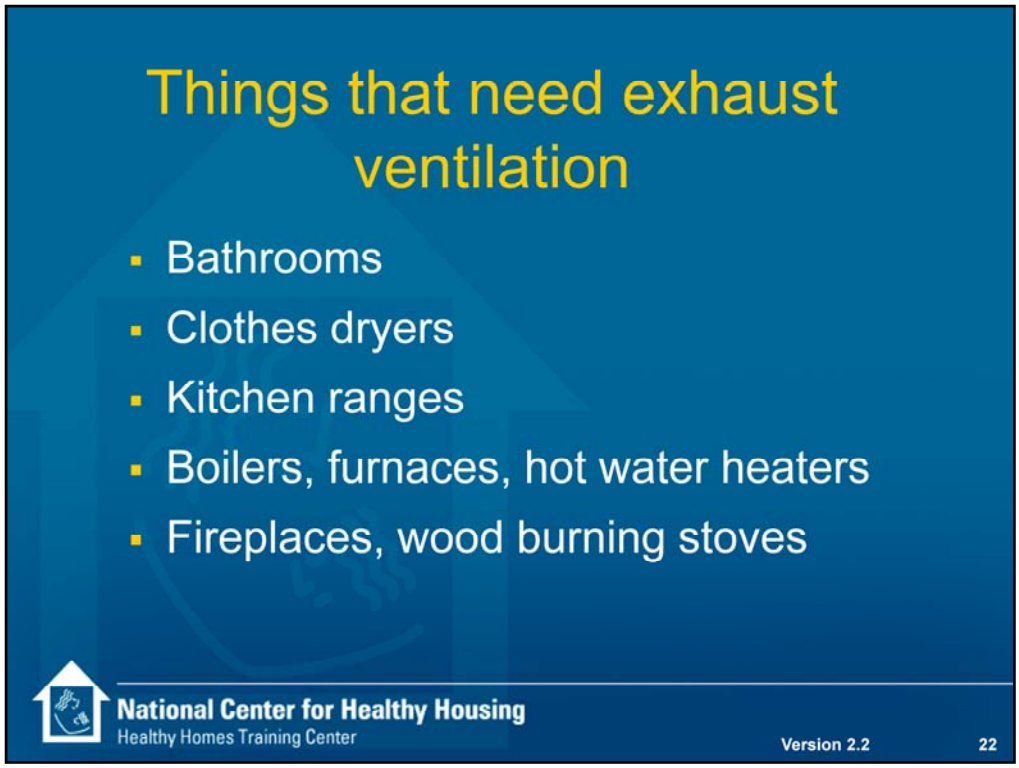
In cold weather, air passes through multi-story buildings from bottom to top. Notice the photo in the center. Cold air drawn in at the bottom of the building chills the lower floors; warm air rising through the building overheats the upper floors and people open their windows in an effort to cool off. The upper floors have no outdoor air during this time – only air that has passed through the floors below.



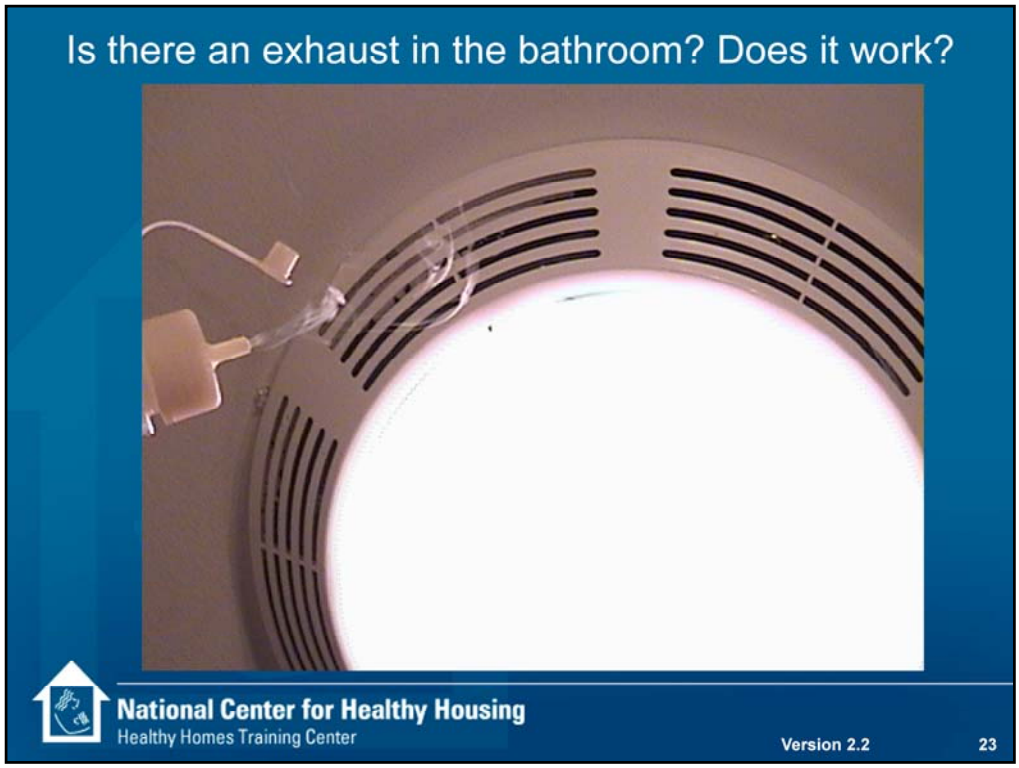
When assessing a house for ventilation, check to see if the important stationary sources have effective exhaust ventilation and whether there is enough general dilution ventilation.

Local exhausts are easy enough to check – are they there, do they work? Because most residential buildings assume that operation of the local exhausts, wind and stack driven air flows, and operable windows provide enough general ventilation, it is more difficult to assess general ventilation. The simplest way to get an idea is to ask the occupant whether odors linger, windows fog during cold weather, or does the air seem stale?

To go beyond this level requires a fair amount of knowledge and less common test equipment (e.g. blower doors).



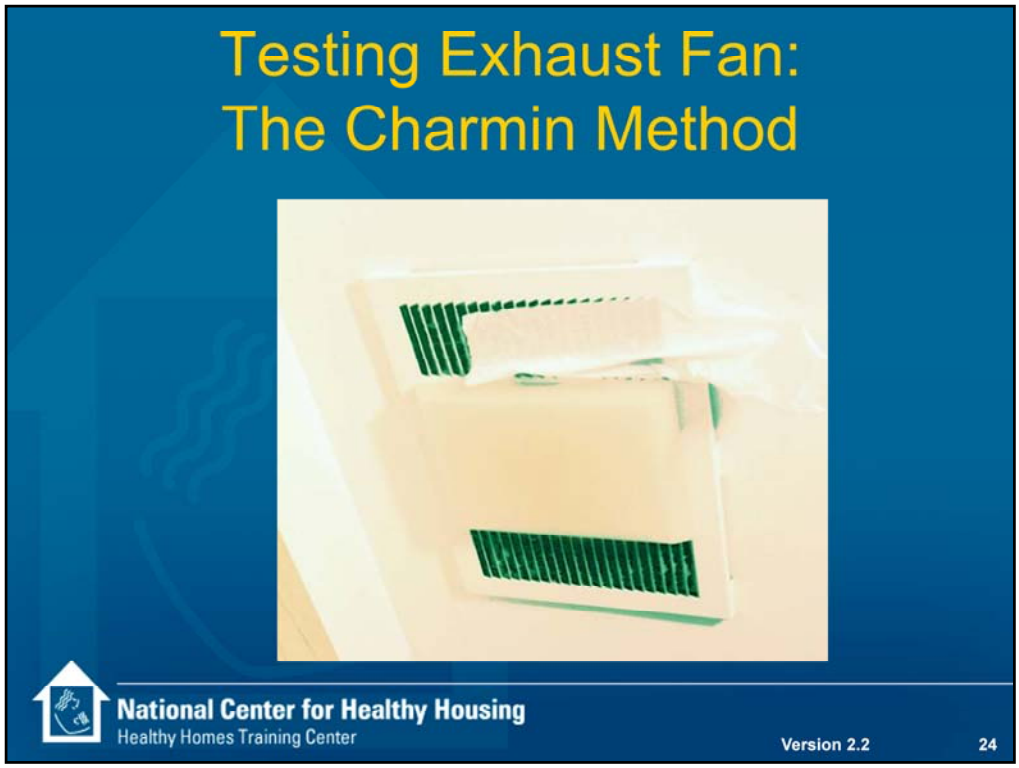
Here is a list of rooms and appliances in a home that need exhaust ventilation.



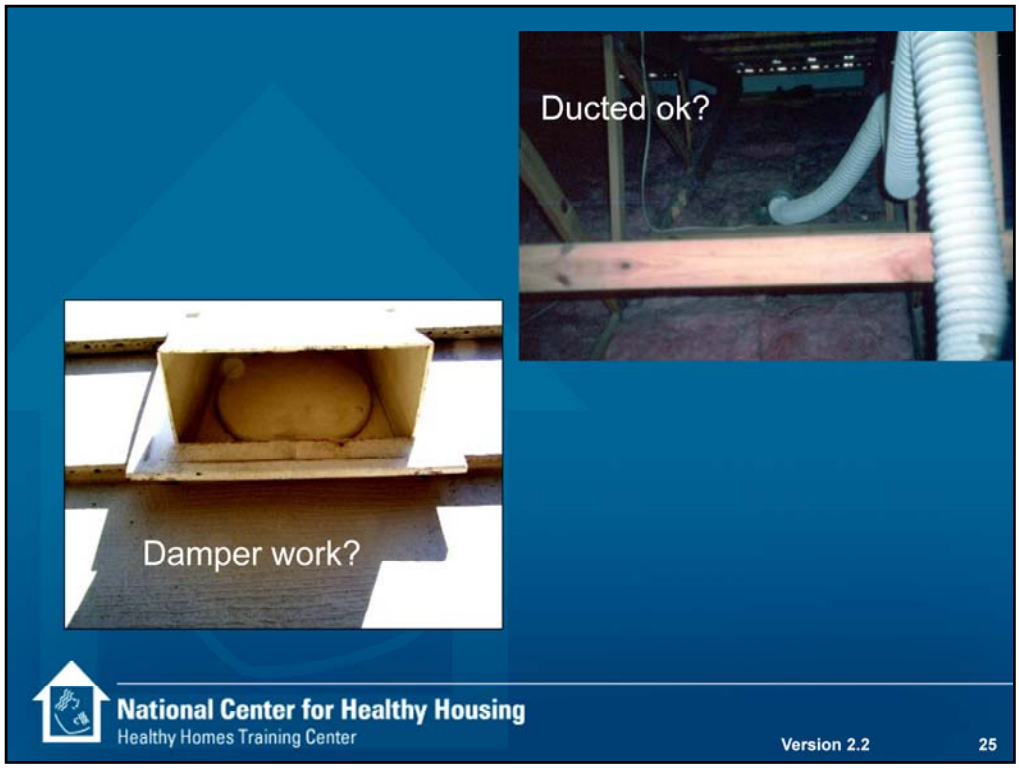
Bathrooms are sources of moisture and odors. An exhaust vent should be located in each one. A single fan ducted to the bathrooms is a simple way of doing this.

A chemical smoke bottle can quickly answer the question: is it moving air the right way?

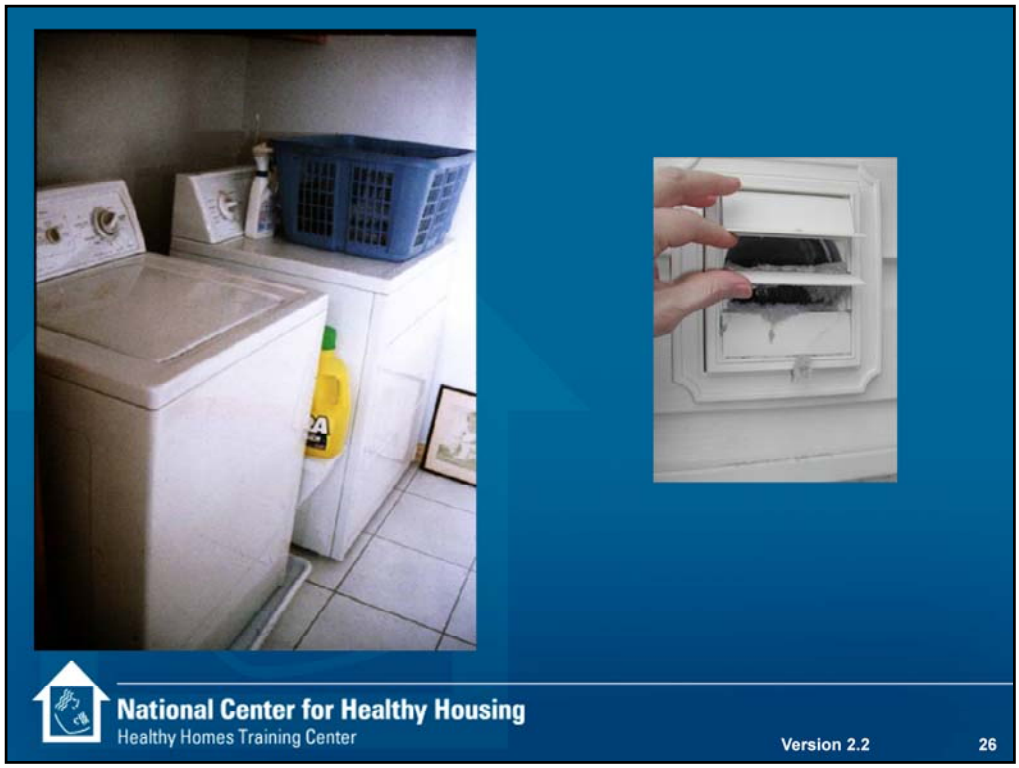
Chemical smoke allows you to quickly understand how air is moving around a building. It is one of the most powerful tools for solving indoor air quality, condensation and comfort problems. Chemical smoke is a strong irritant and should be used carefully. Do not let people in the home keep it.



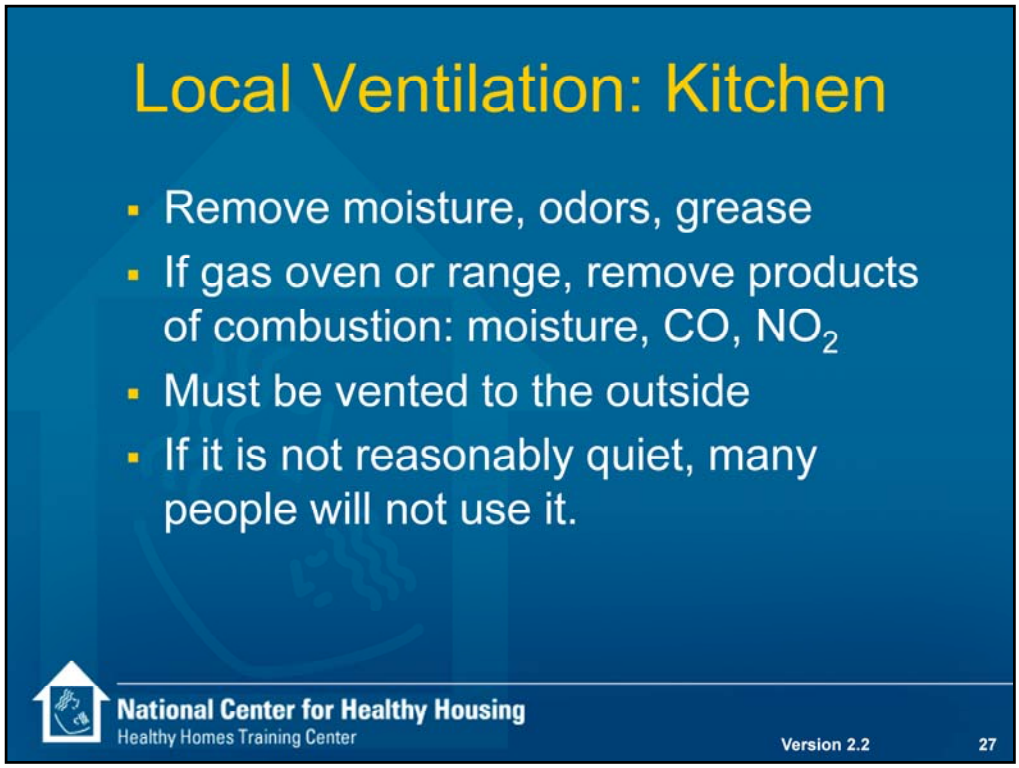
Placing toilet paper over the fan only tells you if the fan is actually pulling some air. A large percentage of installed fans don't even pass this test!



Why bother testing exhaust fans? A recent program, in which exhaust fans were tested in over 300 new homes, found about 20% were pulling less than 15 cfm, despite being properly sized (most were 70 cfm fans) and properly ducted. The problem was that the backdraft dampers, either on the unit itself or on the termination or both, were taped shut to avoid damage while shipping and the installer didn't remove the tape.



Although most people do not think of them in this way, dryers are exhaust vented devices. Dryer exhausts use from 75 to 150 cfm of air to remove heat, lint, the perfumes from fabric softeners and in the case of gas fired dryers, combustion fumes. The amount of air exhausted by a dryer depends on how heavily it's loaded, the amount of lint on the filter and the resistance of the flex duct used to exhaust the air.



Kitchen ranges and ovens are the source of many contaminants. [1,8]

Since grease tends to collect on kitchen exhaust fans, they need to be cleaned frequently. A buildup of grease can attract cockroaches.

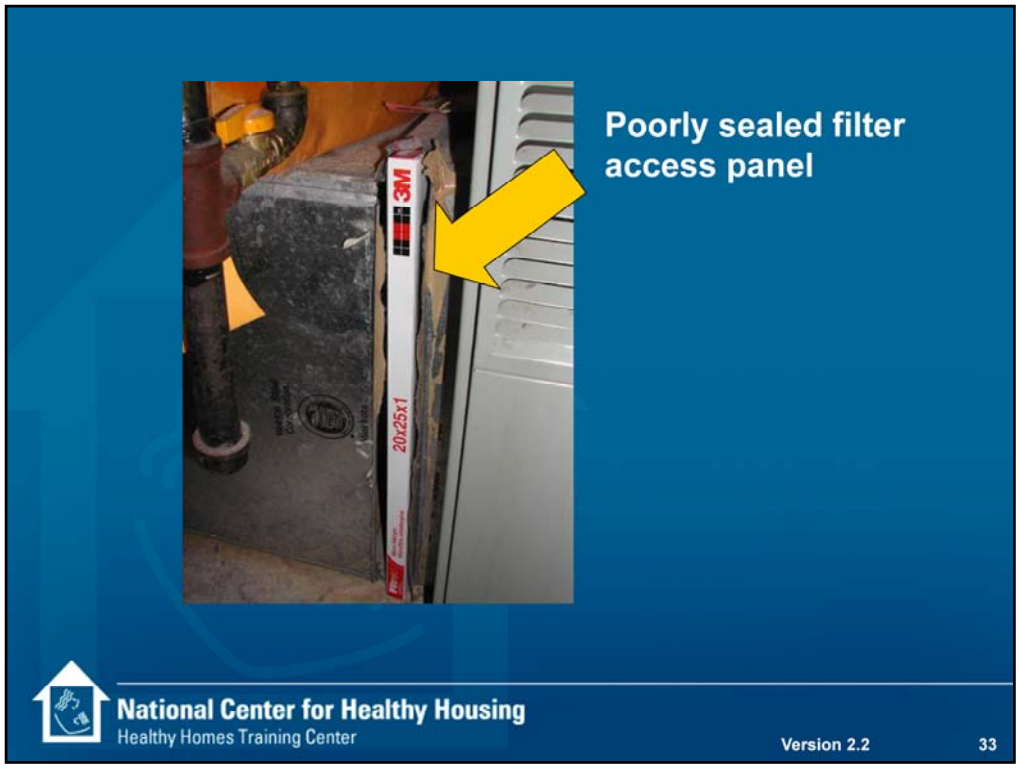
On the left is a vented range hood. Notice the duct in cabinet. On the right is a recirculating range hood (not vented) that has no duct in cabinet but has a grille on upper surface of hood – this is not ideal.

Rooftop fans provide exhaust ventilation for a six story multi-family building. Vertical ducts connect all the floors. Air may pass from one apartment through the ductwork and into another if the fans are not running, there is a problem with fan flow, the ducts are leaky or the stack effect overwhelms the system.

An atmospherically vented gas fired hot water heater, vented through a B-vent (double wall-steel flue). In a tug of war for make-up air between the gas fired hot water heater and an exhaust fan, it may be the exhaust fan that wins. Atmospherically vented combustion devices can be tested for spillage using ASHRAE guidance.

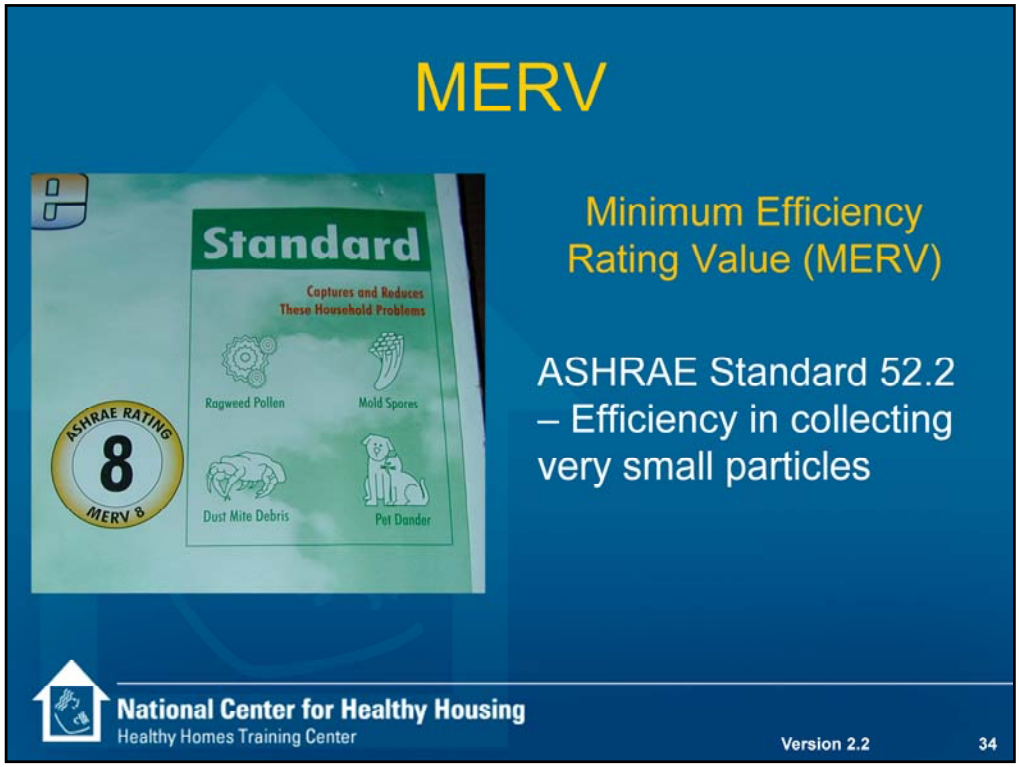
Soot filtered from the air passing beneath the door when it is closed. This is an example of a pressure differential.

Leaks in ductwork can also create pressure difference problems. The leaks in the return side of an air handler can "mine" contaminated air from anywhere the leaks draw air (e.g. crawlspaces, attics, basements). The two photos show poorly constructed ducts on the right and well-sealed (using mastic and mesh) on the left. Duct tape does not last.

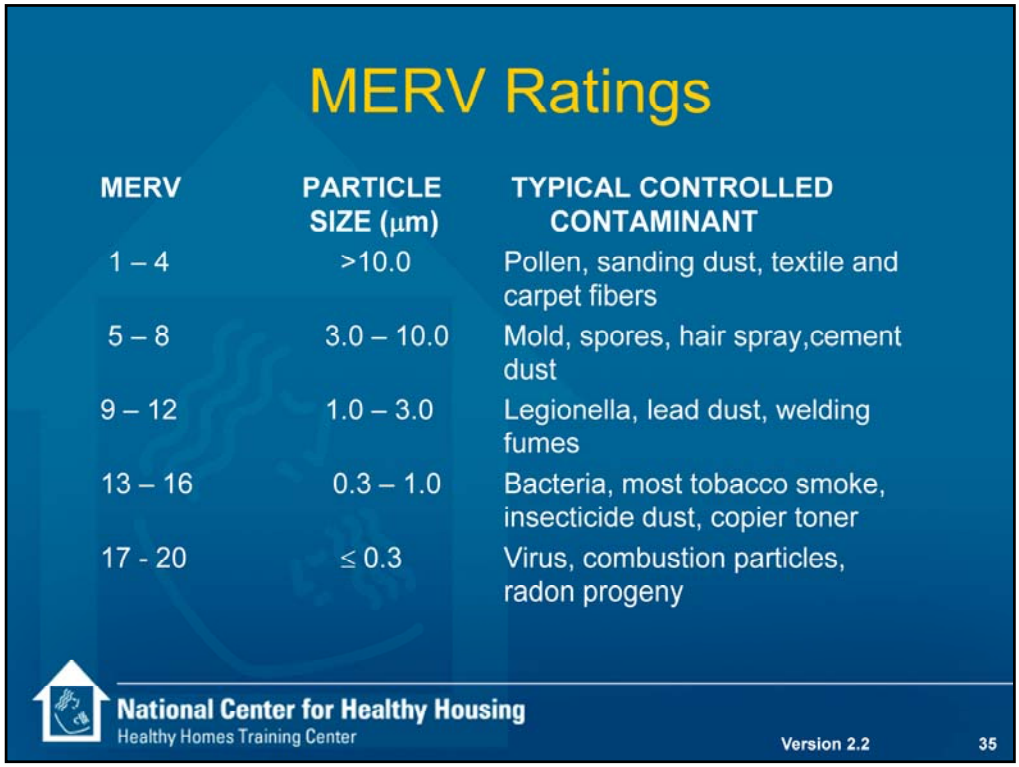


Filtration serves a number of purposes:

- It protects coils from clogging with dust;
- At high enough efficiencies it protects coils and ductwork from collecting deposits of fine particles that could support fungal growth if wetted (25% dust spot efficiency); and
- And at high enough efficiencies it begins to collect fine enough particles and is a benefit to the lungs of the occupants (25% dust spot efficiency).

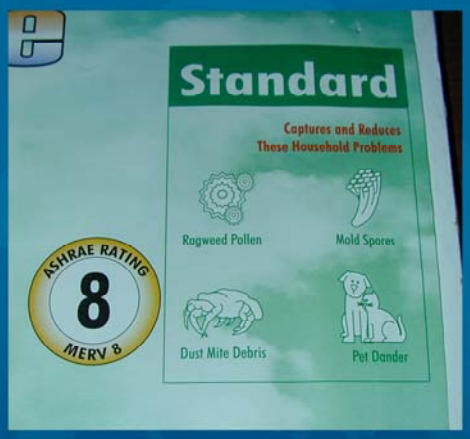


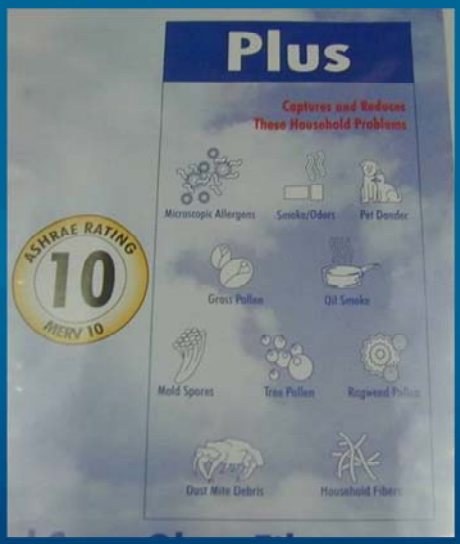
MERV, the Minimum Efficiency Reporting Value, is a new method of rating air cleaning devices. [5] It is based on the removal efficiency for particles of different sizes. Remember the size of the particle plays a role in whether or not it can be taken into the lungs.



MERV is intended to help simplify the air cleaner selection process for users. It is derived by combining the cleaner's average efficiency at removing three particle size fields. If a high MERV filter is used with a fan designed for something lower there may be inadequate airflow.

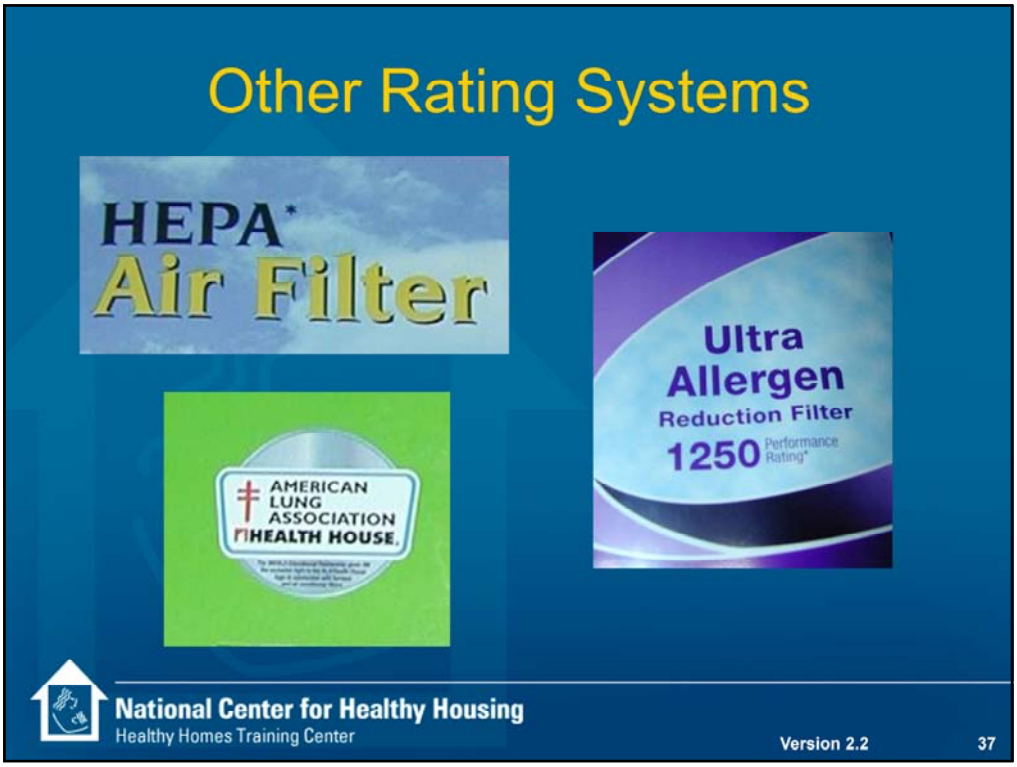
MERV 8 v. 10





National Center for Healthy Housing
Healthy Homes Training Center

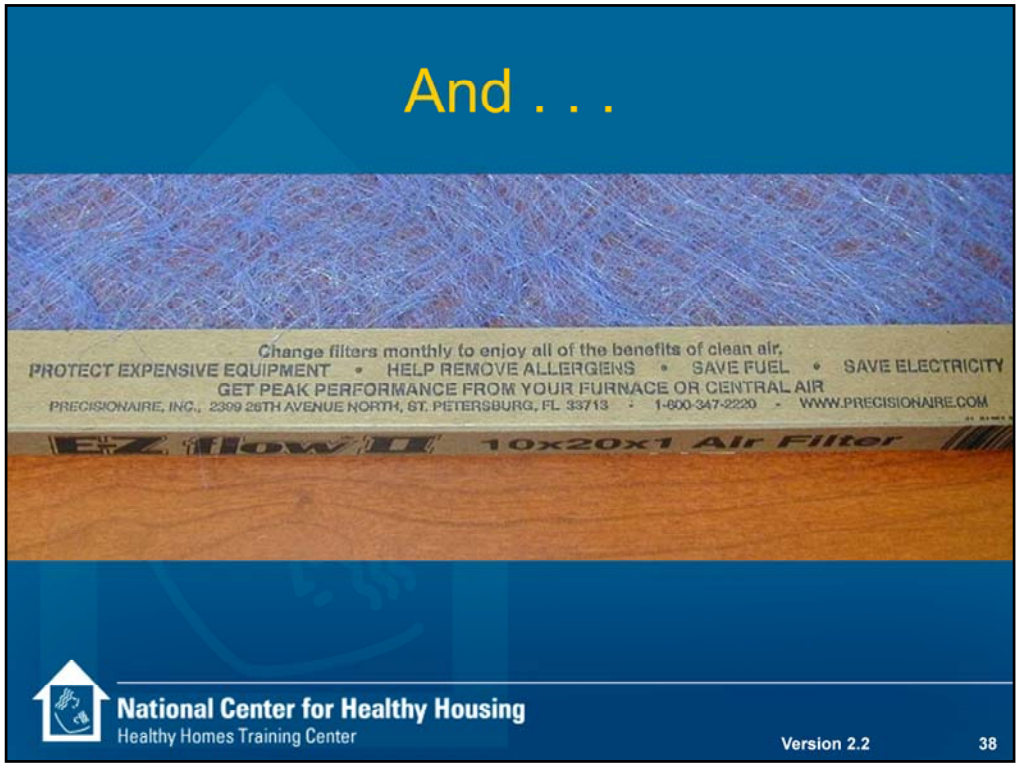
Version 2.2 36



The **High Efficiency Particulate Air** (HEPA) filter is designed to capture airborne particulates (solids) down to 0.3 microns in size. The HEPA media looks like blotting paper. It is made of very thin glass fibers fashioned into a sheet much the same way as wood fibers are used to make paper. Air passing through the media must continually change direction in order to pass around the thin glass fibers. Large particles can not make these sharp turns without colliding into and becoming captured by the HEPA media. To qualify as a HEPA filter, the filter must collect 99.97% of a specific particulate that measures 0.30 microns,

Please note that “HEPA-type” filters and filters labeled for allergen control have not been certified that they meet the standard.

The MERV (Minimum Efficiency Reporting Value) rating of a filter describes the size of the holes in the filter that allow air to pass through. The higher the MERV rating, the smaller the holes in the filter, and the higher the efficiency. MERV 8 filter media should not promote the growth of bacteria, mold, mildew, or fungi in normal operating environments, and are not chemically treated.



Discuss these claims. This filter is probably only a MERV 4.

Code Requirements Related to Ventilation

- **403.1 Habitable spaces.**
  - Every habitable space shall have at least one openable window.
  - The total openable area of the window in every room shall be equal to at least 45 percent of the minimum glazed area required in Section 402.1.
- **403.2 Bathrooms and toilet rooms.**
  - Every bathroom and toilet room shall comply with the ventilation requirements for habitable spaces as required by Section 403.1, except that a window shall not be required in such spaces equipped with a mechanical ventilation system.
  - Air exhausted by a mechanical ventilation system from a bathroom or toilet room shall discharge to the outdoors and shall not be recirculated.

Code Requirements Related to Ventilation

- **302.6 Exhaust vents.** Pipes, ducts, conductors, fans or blowers shall not discharge gases, steam, vapor, hot air, grease, smoke, odors or other gaseous or particulate wastes directly upon abutting or adjacent public or private property or that of another tenant.
- **403.4 Process ventilation.** Where injurious, toxic, irritating or noxious fumes, gases, dusts or mists are generated, a local exhaust ventilation system shall be provided to remove the contaminating agent at the source. Air shall be exhausted to the exterior and not be recirculated to any space.
- **403.5 Clothes dryer exhaust.** Clothes dryer exhaust systems shall be independent of all other systems and shall be exhausted in accordance with the manufacturer's instructions.
- **603.2 Removal of combustion products.** All fuel-burning equipment and appliances shall be connected to an approved chimney or vent.
  - **Exception:** Fuel-burning equipment and appliances which are labeled for unvented operation.

Code Requirements Related to Ventilation

- **607.1 General.** Duct systems shall be maintained free of obstructions and shall be capable of performing the required function.
- **505.4 Water heating facilities.**
  - Water heating facilities shall be properly installed, maintained and capable of providing an adequate amount of water to be drawn at every required sink, lavatory, bathtub, shower and laundry facility at a temperature of not less than 110ºF (43ºC).
  - A gas-burning water heater shall not be located in any bathroom, toilet room, bedroom or other occupied room normally kept closed, unless adequate combustion air is provided.
  - An approved combination temperature and pressure-relief valve and relief valve discharge pipe shall be properly installed and maintained on water heaters.
- **603.5 Combustion air.** A supply of air for complete combustion of the fuel and for ventilation of the space containing the fuel-burning equipment shall be provided for the fuel-burning equipment.

Key Messages

- Ventilation plays an important role in maintaining health.
- Ventilation is necessary to remove humidity and dilute or remove contaminants.
- Local exhaust ventilation removes contaminants from a point source, while whole house ventilation uses fresh air to dilute contaminants.

Learning Objectives

- Name five unhealthful conditions associated with poor ventilation.
- List five things (e.g. a room, appliance, mechanical system) in a household that need ventilation.
- Name three things that power airflow in a building.
- List three household contaminants that can be removed by ventilation.
- Describe two ways ventilation reduces air contaminant levels.