**AE1204** (Revised)

# Keep Your Home Healthy

**Kenneth Hellevang**, Ph.D., P.E.
Agricultural Engineer, NDSU Extension Service

Indoor air quality is important because we breathe about 5,000 gallons of air daily and spend 90 percent of our time indoors.

Everyone's health is affected by indoor air quality, but children and the elderly are at higher risk of adverse effects. Indoor air quality problems, such as exposure to carbon monoxide, can be life-threatening. Exposure to mold can cause respiratory problems and trigger asthma attacks.

## Ventilate to reduce moisture and pollutants

Exchanging inside air with outside air is required to remove pollutants and moisture (when outside air is dry). Ventilation minimizes exposure to human-generated pathogens such as viruses and bacteria that cause illness.

The recommended ventilation rate for homes is about 0.35 air changes per hour (ACH), or 7.5 cubic feet per minute (cfm) per person plus 3 cfm per 100 square feet.

For example, a 1,200-square-foot home with 8-foot walls has an air volume of 9,600 cubic feet. Obtaining an air change of 0.35 per hour requires exchanging 3,360 cubic feet of air per hour (0.35 x 9,600). This is an airflow rate of 56 cubic feet per minute (3,360 ÷ 60 minutes per hour). Using the other recommendation, assuming four people in the home, the home requires a ventilation rate of 66 cubic feet per minute (4 x 7.5 + 3 x12 = 66).

Natural air infiltration through doors and windows provides some air exchange. A heat recovery ventilator (heat exchanger) is an energy-efficient method of obtaining the recommended air exchange while reducing the cost of heating and cooling the ventilation air.

Lingering odors are one indication of inadequate ventilation.

## ▼ Moisture

Many activities in the home produce moisture that needs to be removed. Each person produces about 3 pints of water per day while breathing. About 1 pint of moisture is introduced into a home during a 10-minute shower. Additional moisture is added by towels drying.

A house will produce 6 to 16 pints of moisture per day as materials in it dry during the fall. Moisture coming through a concrete basement floor and walls due to moist soil on the outside may produce as much as 100 pints per day.

Remove moisture by ventilation when outside temperatures are cool and with a dehumidifier or air conditioning when outside temperatures are warm.

## Mold

A major problem with excess moisture in the home is mold. Exposure to mold can cause coldlike symptoms, respiratory problems, nasal and sinus congestion, watery eyes, sore throat, coughing and skin irritations, and can trigger asthma attacks. Children, the elderly and people with existing respiratory sensitivities are at higher risk for adverse health effects from mold.

NDSU EXTENSION SERVICE

June 2013

If you can smell or see mold, you have a mold problem. Because people react to mold whether it is living or dead, the mold must be removed.

Mold can be removed from hard surfaces such as hard plastic, glass, metal and countertops by scrubbing with a soap or detergent. **(Do not mix ammonia and bleach. The fumes are toxic.)**

Completely removing mold from porous surfaces such as paper, Sheetrock (drywall) and carpet padding is impossible. These materials should be removed and discarded.

Scrubbing may not remove mold growth on structural wood, such as wall studs, completely, so it may need to be removed by sanding. Wear personal protective gear and isolate the work area from the rest of the home while sanding.

After the mold is removed from structural wood, sanitize the area using a chlorine (sodium hypochlorite) bleach and water solution or another biocide. Refer to the product's label for recommendations.

It is critical to first clean the surface because chlorine bleach is neutralized by organic material.

The surface must remain wet about 10 minutes for the solution to be effective. Provide adequate ventilation – exchanging inside air with outside air – during sanitizing, and wear rubber gloves. Rapidly dry the surfaces.

## Plumbing leaks

Extensive mold growth occurs in areas that stay moist due to plumbing leaks. Check under sinks, dishwashers and other locations that may have hidden moisture.

## Bathroom exhaust fan

Run the bathroom exhaust fan during and for a few minutes after showers to exhaust the moisture. A timer switch is a convenient method of obtaining the desired fan run time. You should be able to feel air entering the bathroom under the bathroom door while the exhaust fan is running. Keep surfaces dry to prevent mold growth.

## Closets

Closets can be conducive to mold growth. Closets on exterior walls will be higher in humidity than the rest of the house during the heating season.

The relative humidity of the air in a closet may be at a level conducive to mold growth, even when the humidity in the house is low, if the temperature in the closet is cooler than in the house **(Figure 1)**. This typically will occur near the outside wall. Keep the closet warm by storing things away from the outside wall to allow air circulation. Leave closet doors open during very cold weather.

Clothes stored in a basement may become musty, particularly during the summer, if the humidity is above about 70 percent. Stored clothes should be clean and dry.

Boxed articles will stay wet if they become damp, creating an environment conducive to mold growth.

## Furniture

Keep furniture away from outside walls to permit air circulation. Cool areas behind furniture will be high-humidity areas conducive to mold growth.

Periodically vacuum upholstered furniture to remove skin fragments that create an environment conducive to dust mites.

## Basement carpet

Water vapor from moist soil under a concrete basement floor may come through the floor and moisten the carpet. This creates an environment conducive to mold growth.

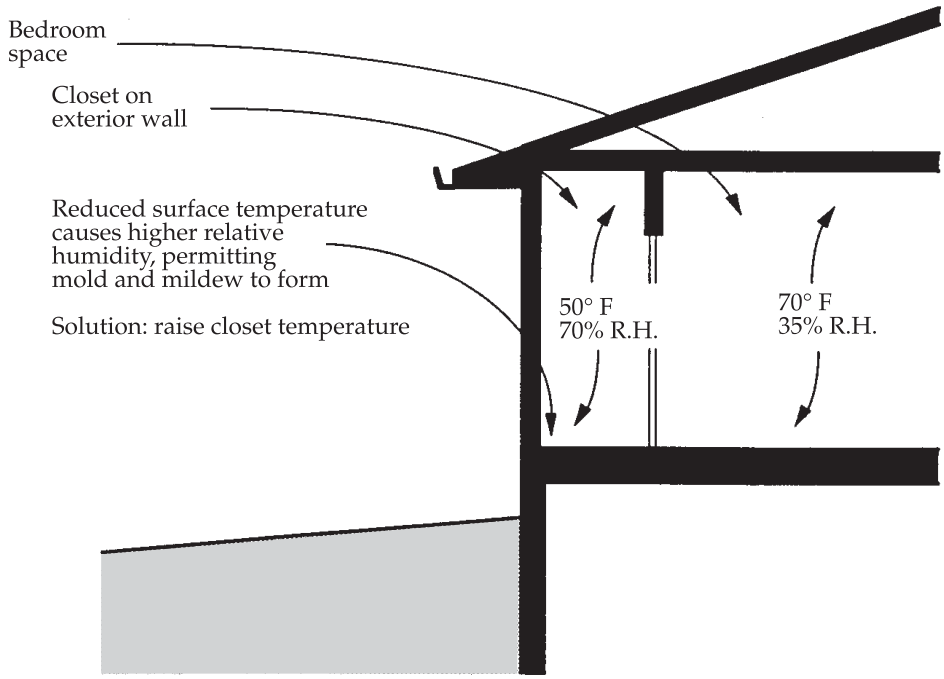



**Figure 1. Closets on exterior house walls may be conducive to mold growth.**

*Adapted from Moisture Control Handbook: Principles and Practices for Residential and Small Commercial Buildings by Lstiburek and Carmody.*

A carpet pad shouldn't be used on a basement floor with a potential for moisture because the pad holds the moisture. Generally mold growth occurs on the back side of the carpet and is not visible unless the carpet is lifted.

## Clothes dryer

Vent a clothes dryer outdoors. About 5 pints of water are removed per load of clothes. This amount of moisture could cause severe moisture problems, such as mold growth, if vented into the house.

## Wet materials

Mold will grow on wet materials in 24 to 48 hours. Expose the wet materials to dry airflow to promote rapid drying. Wall cavities and other closed areas, such as flooring layers, need to be opened to permit drying before mold growth occurs.

## Window condensation

Moisture condenses on windows because the window surface temperature is below the dew point of the air in the house. This moisture can damage the window and wall around the window and lead to mold growth.

Condensation can be minimized by reducing the humidity level or warming the window surface **(Figure 2)**. Keep the inside humidity level below about 40 percent in the winter in cold climates to reduce condensation potential.

Lower the humidity level by increasing ventilation when outside air is cooler than inside air. Dehumidifiers generally lower the humidity level to only about 50 percent, so they normally are not adequate for limiting condensation during the winter.

The window surface can be warmed by adding additional layers, such as plastic.

## Indoor humidity

The recommended humidity level in the winter is 30 to 40 percent in cold climates. A relative humidity above about 40 percent increases the potential for condensation on windows and other cool surfaces.

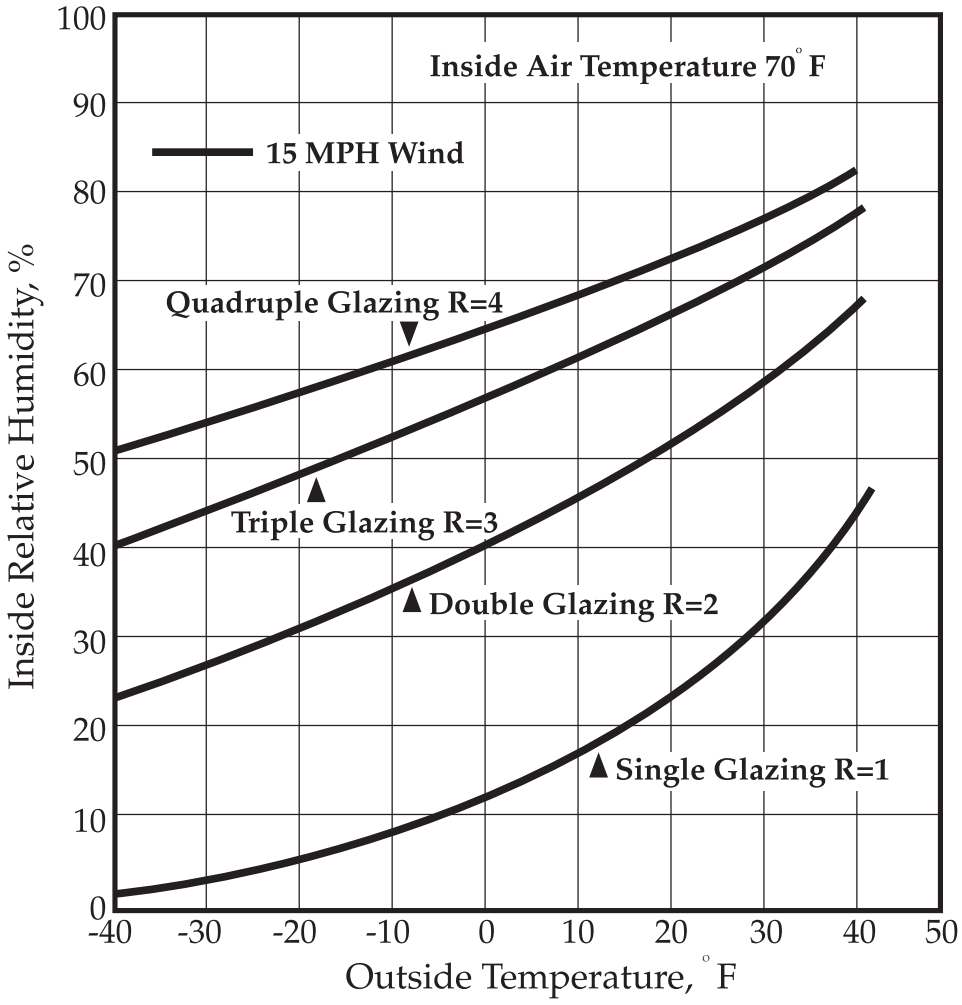



**Figure 2. Condensation on window surfaces as affected by outside temperature, inside relative humidity and window type.**

Humidity levels below about 30 percent lead to dry skin and nasal passages, increasing the potential for respiratory illnesses. Overly dry air can inflame the symptoms of sinusitis, lead to laryngitis and get in the way of a good night's sleep. Also, low humidity levels cause problems in furniture and pianos due to wood shrinkage and increase the incidence of static electricity shocks.

During the summer, indoor humidity levels should be kept below about 65 percent to minimize the potential for mold growth and below about 50 percent to minimize dust mites.

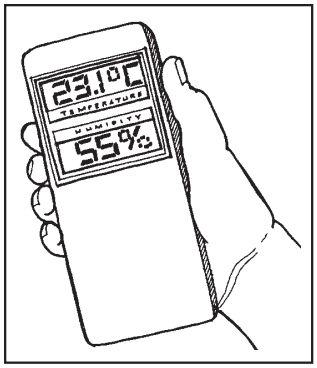
Hygrometers (relative humidity gauges) may not be accurate. Hygrometers are frequently in error by more than 20 percent when purchased.

Calibrate your hygrometer by sealing it in a plastic bag along with a cup containing ½ cup of water and ¼ cup of table salt **(Figure 3, Page 4)**. After at least 12 hours at room temperature, the meter should read 75 percent relative humidity.

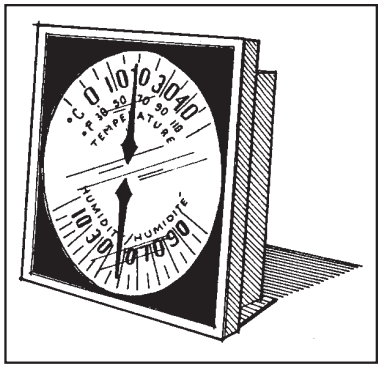
## Dehumidifying

A dehumidifier works best at removing moisture from warm, humid environments. Many units are rated at 80 F and 60 percent relative humidity.

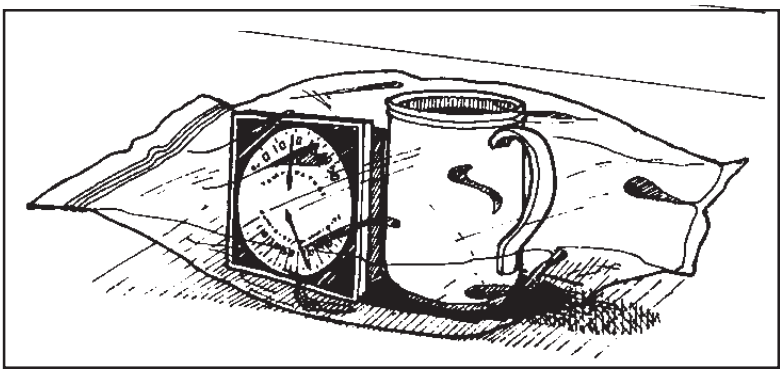
A 10-degree reduction in temperature will reduce the capacity by about




Electronic hygrometer




Mechanical hygrometer



¼ cup table salt • ½ cup water • 5 qt. ziplock bag
After 12 hours 75% humidity

**Figure 3. Calibrate a hygrometer to assure its accuracy.**

40 percent. Therefore, a dehumidifier rated at 30 pints per day at 80 F is expected to remove only about 18 to 20 pints at 70 F.

A 10-percent increase in relative humidity is expected to increase the capacity by about 25 percent.

Therefore, a dehumidifier rated at 20 pints per day at 60 percent relative humidity would be expected to remove about 25 pints at 70 percent relative humidity.

Coils should be cleaned periodically to maintain the dehumidifier's efficiency.

Basement humidity should be kept at or below about 65 percent during the summer. A dehumidifier or air conditioning should be used to remove the moisture.

Ventilation with outside air during the summer may add moisture to the basement. Outside air at 80 F and 50 percent relative humidity will be at almost 70 percent relative humidity when cooled to 70 F in the basement.

## Attic ventilation

Adequate attic ventilation is required to prevent moisture problems in the attic, including moist insulation and moisture that can soak through the ceiling.

For natural ventilation, provide 1 square foot of vent area for each 300 square feet of attic area with a vapor retarder (plastic) in the ceiling and 1 square foot of vent area for each 150 square feet of attic area without a vapor retarder. Place half of the vent area near the roof peak and half at the eaves.

Provide air chutes or use other methods to assure that eave vents are not blocked by insulation and that wind does not enter the insulation, reducing its insulating value **(Figure 4)**.

## Ice dams

Ice dams occur when escaping heat melts snow on the roof and the water freezes when it reaches the cooler surface near the eave. Water from ice dams can enter wall cavities, causing insulation to be ineffective, leading to rotting of structural wood, staining wall coverings and creating conditions conducive for mold growth.

Reduce the potential for ice dams by sealing any air leaks from the living space to the attic and providing adequate attic insulation and ventilation to keep the roof cold **(Figure 5)**.

## Crawl space

A vapor retarder must be placed on the soil and sealed to the foundation to limit moisture from moving into the crawl space. Moisture in the crawl space will lead to mold growth, which can affect the health of building occupants **(Figure 6, Page 6)**.

The crawl space should have vents to permit ventilation to remove moisture if needed, but the vents normally are closed.

Warm outdoor air entering a cool crawl space adds moisture, creating a damp environment that may be conducive to mold growth.

The soil on the house exterior should be sloped to carry water away from the foundation. The crawl space should have drainage similar to a basement.

## Home drainage

Install at least 6 inches of gravel underneath the basement concrete floor. This forms a water drainage layer and radon removal layer. Place a vapor retarder between the concrete floor and granular layer to minimize radon and moisture entry into the house.

Place 4-inch drainage pipe along the inside and outside of the concrete footing. The top of the drainage pipe should be below the top of the footing. Install a coarse gravel envelope around the outside drainage pipe. Place filter fabric around the coarse gravel to prevent soil particles from clogging the coarse gravel **(Figure 7, Page 7)**.

Place gravel or a drainage mat next to the concrete foundation wall (basement wall) to allow water to drain to the drainage pipe and to keep wet soil

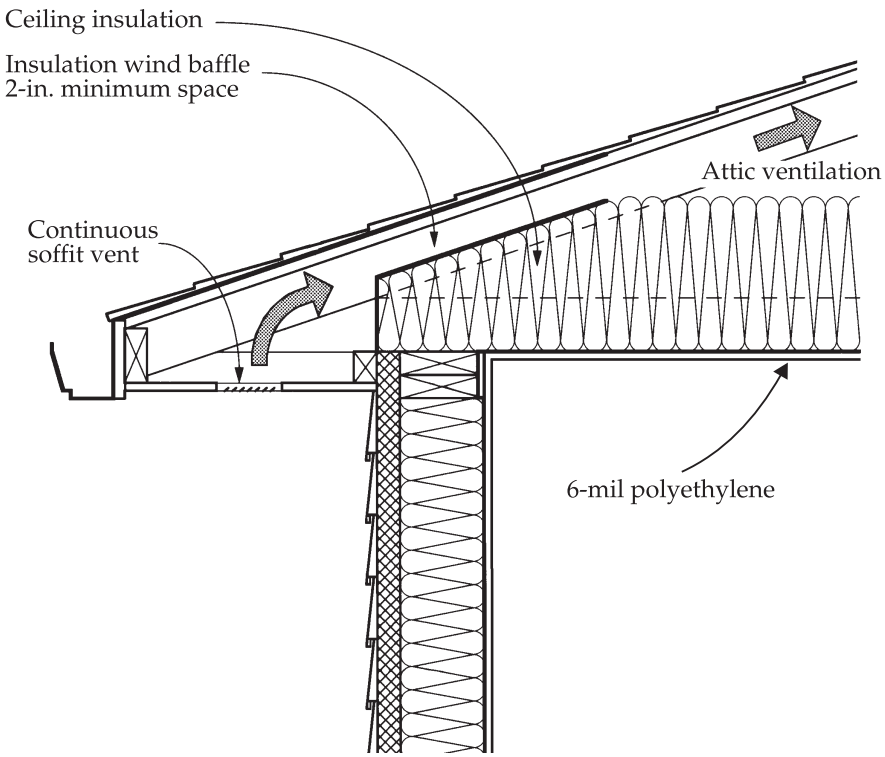



**Figure 4. Air enters for attic ventilation at the eave and exhausts near the roof peak.**

*Adapted from Moisture Control Handbook: Principles and Practices for Residential and Small Commercial Buildings by Lstiburek and Carmody.*

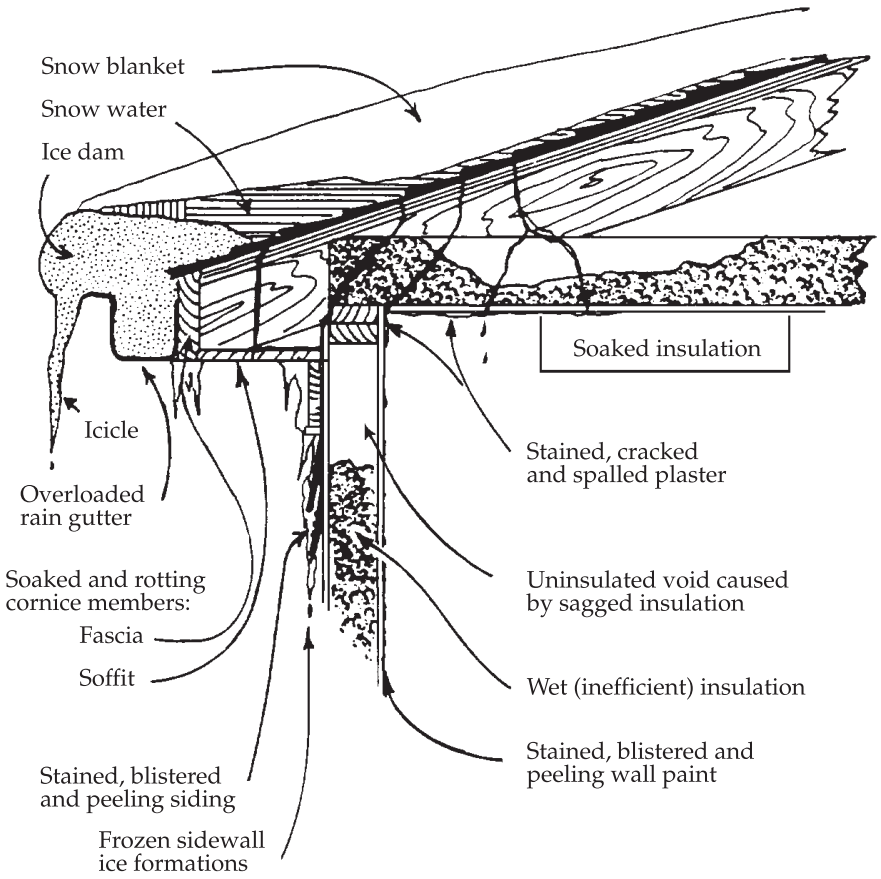



**Figure 5. Problems caused by ice dams.**

away from the wall. Place a layer of low-permeability soil, such as clay, near the surface to limit the amount of water soaking into the ground next to the wall.

Slope the ground about 1 inch per foot away from the house. Extend down spouts several feet away from the house. One inch of rain on a 1,000-square-foot roof is equal to about 625 gallons of water.

### Dust mites

Dust mites are tiny creatures (too small to see) that feed on human skin cells that we shed each day. Mites may cause symptoms such as a runny nose or watery, itchy eyes in allergic people.

Dust mites prefer moist environments and soft textiles, including sheets and bedding, upholstery fabrics and carpeting.

Keep humidity levels less than 50 percent and provide ventilation to minimize dust mites. Wash sheets weekly in water that is 130 F or warmer. Mattress pads and other bedding also should be washed in hot water, but probably do not need to be washed as frequently as sheets.

Periodically vacuum the mattress to remove skin fragments that create an environment conducive to dust mites. Special pillow and mattress covers can minimize dust mite exposure. Replace pillows about every five years.

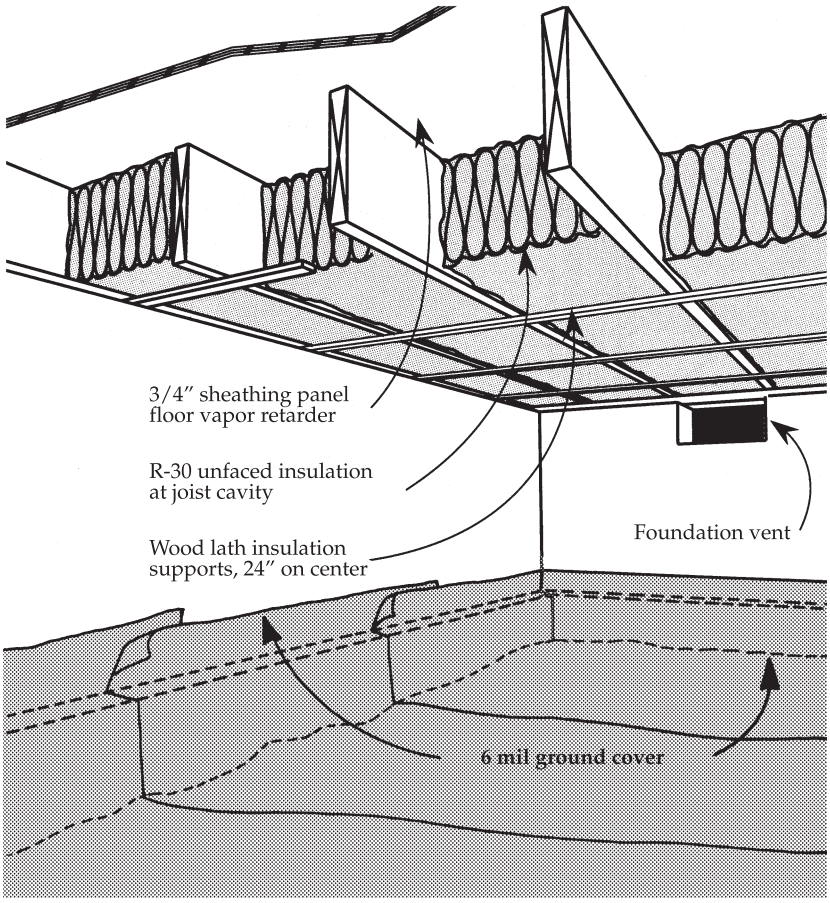
Dust mites normally do not live in the dry environment of a furnace or air-conditioning duct.

## ▼ Pollutants

### Humidifiers

Studies by the Environmental Protection Agency and Consumer Product Safety Commission have shown that cool-mist humidifiers (ultrasonic and impeller) can disperse microorganisms and minerals into the air.

**UNHEATED crawl space**




**HEATED crawl space**

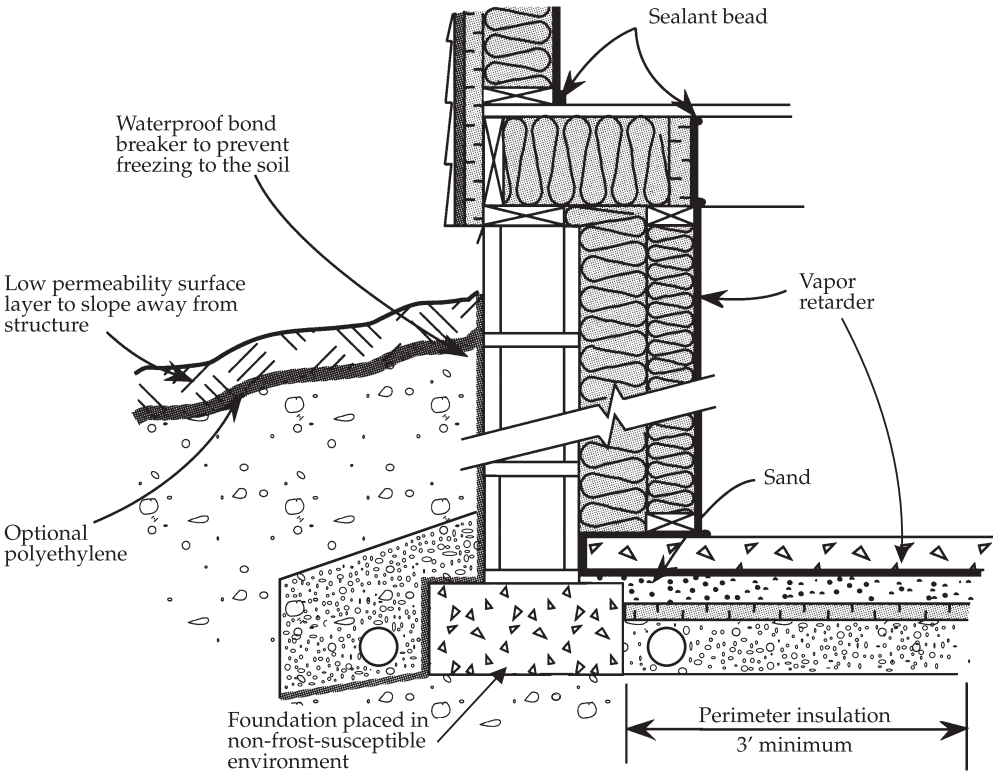



**Figure 6. A vapor retarder must cover the ground of a crawl space to limit moisture accumulation and the potential for mold growth.**

*Adapted from Northern Comfort: Advanced Cold Climate Home Building Techniques.*

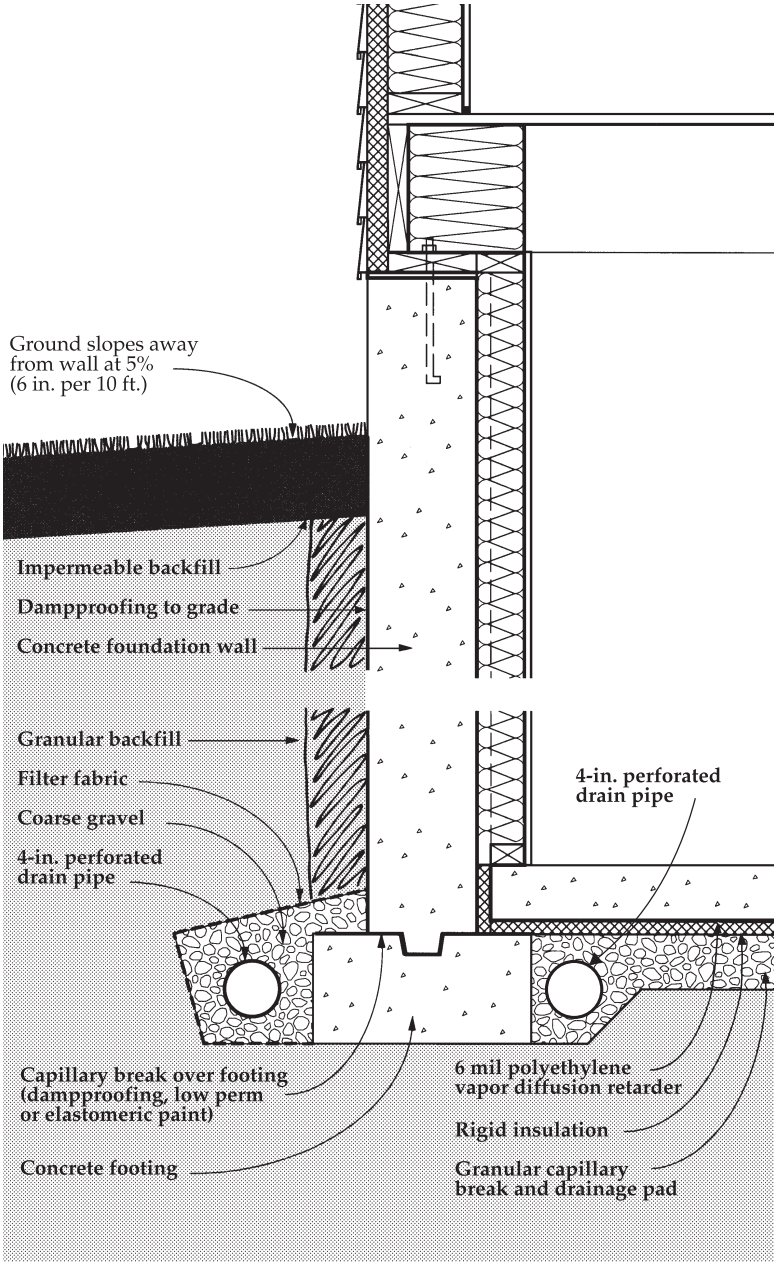



**Figure 7. Foundation drainage system.**

*Adapted from Moisture Control Handbook: Principles and Practices for Residential and Small Commercial Buildings by Lstiburek and Carmody.*

Proper care and cleaning of humidifiers are important for reducing the potential for exposure to these microorganisms. Microorganisms often grow in humidifiers equipped with tanks containing standing water. Follow the manufacturer's recommendation for cleaning and changing water in the humidifier.

Do not permit the area around the humidifier to stay wet.

## Space heaters

Combustion-type space heaters produce carbon monoxide, water (almost ½ gallon per gallon of fuel) and many harmful pollutants during the combustion of the fuel. These combustion gasses must be vented outdoors. Carbon monoxide is a colorless, odorless gas that can be fatal.

## Vehicles in attached garages

Vehicles should not idle in an attached garage because they produce large amounts of carbon monoxide and other pollutants that can enter the house.

## Smoke detectors

Place smoke detectors near or in bedrooms and on every floor of your home. Test smoke detectors at least every three months and replace batteries as recommended.

## Radon

Radon is a colorless, odorless, tasteless radioactive gas that increases the potential for lung cancer. Radon has been found at elevated levels in homes across the country.

Test your home for radon. The testing device, normally a charcoal canister kit, is set in the lowest habitable space (usually the basement during the heating season when the house is kept closed) for a few days and then sent in for analysis.

If the reading exceeds the recommended level of 4 picocuries per liter of air, further testing will be needed to determine if sufficient radon is in the living space to require action to reduce the level.

Test kits are available from some hardware stores, your local public health district or the American Lung Association.

Reducing radon levels requires a combination of subslab suction using a fan, a sand or gravel layer under the concrete floor and basement floor crack sealing. Consult the Extension Service or other publications for more information.

## Furnace

A furnace should be serviced by a technician every one or two years. This service should include maintenance and a check for proper operation, such as proper combustion

and exhausting of combustion gasses. Combustion gasses contain many pollutants, and for a furnace with a chimney flue exhaust, they can be drawn back into the house if a vacuum is created in the house by an operating fireplace or large exhaust fan.

The furnace filter needs to be changed routinely to permit adequate airflow through the furnace or air conditioner. The more porous furnace filters are designed to protect the furnace and have little ability to remove household pollutants.

Common pleated filters generally capture particles larger than about 1 micron, which will remove most dust and many allergens. Choosing an air filter with a MERV rating between 8 and 11 generally is recommended for most residential furnace and A/C units to adequately remove airborne contaminants. MERV, or Minimum Efficiency Reporting Values, is an industry-created standard that evaluates the efficiency of air filters.

## Carbon monoxide

Carbon monoxide is produced during combustion. It is colorless and odorless, and may be lethal.

Symptoms of carbon monoxide poisoning include headaches, dizziness, nausea and fatigue.

Carbon monoxide detectors should be placed on every level of your home and near bedrooms.

## Air filters

The most effective and usually the least costly methods to limit indoor pollutants are source control and ventilation. Air cleaners may reduce the levels of certain pollutants, but air cleaning alone cannot remove all the pollutants adequately in a typical indoor air environment.

Because particles float in the air, they are difficult to live with and control. Air movement from a person walking around, or the furnace or air conditioner, and the natural convection of warm air rising and cold air sinking causes particles to swirl about. Some of the particles float in the air and some settle on surfaces. Natural settling may be so rapid that air cleaners contribute little additional effect.

The effectiveness of air cleaners in removing pollutants from the air is a function of the efficiency of the device (the percentage of the pollutant removed as it goes through the device) and the amount of air handled by the device. A product of these two factors for a given pollutant is expressed as the unit's clean air delivery rate (CADR).

Filters are the most common particle removal method. The filters are rated based on the size of particles removed. Other methods include electrostatic and ion generators.

Particles entering an electrostatic air cleaner receive an intense positive electrical charge and adhere to plates, which have to be removed and washed. Ion generators charge the particles in a room so they are attracted to each other or to surfaces in the house. Independent tests of ion generators have shown no reduction in dust concentration in the air.

Ozone can be a byproduct of electrostatic cleaners, particularly if the units become loaded with material, and of ion generators. Ozone is a lung irritant and should not be used in an occupied space.

Machines that purposely produce ozone as an indoor cleansing agent are available. These should not be used in occupied areas. Ozone, which is an oxidizing agent, is a potent lung irritant that can cause respiratory distress.

Although residential ozone-generating machines are promoted as air cleaners, independent studies have shown that the machines do not destroy microbes or mold effectively, remove odor sources or reduce indoor pollutants sufficiently to provide any health benefits. See *www.epa.gov/iaq/pubs/ozonegen.html*.

Keep your home healthy through proper home construction, maintenance and operation.

**For more information on this and other topics, see www.ag.ndsu.edu**



County Commissions, NDSU and U.S. Department of Agriculture Cooperating.
This publication will be made available in alternative formats for people with disabilities upon request, (701) 231-7881.

500-6-13