HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

HOME MOISTURE

Minnesota Department of Commerce Energy Information Center

Complaints about excessive indoor moisture have become common in Minnesota as older homes are weatherized to reduce heating costs and new homes are built to better energy standards.

Related Guides:
Landscaping
Attic Bypasses
House Diagnostics
Windows & Doors
Caulking & Weatherstripping
Ice Dams
Indoor Ventilation
Basement Insulation
New Homes
Home Insulation

Standard building practices in the cheap fuel era produced extremely drafty houses. So much air leaked into and out of the living space that any moisture leaking into the house or created by cooking, bathing and other activities disappeared quickly.

But now, houses are being made tighter to keep the cold air out and the costly warm air in. One common unwanted result is too much indoor moisture.

Symptoms of excess moisture

Many signs of excess moisture are readily apparent; others are difficult to detect. One moisture symptom can have several causes, while one moisture source could be causing a large number of seemingly unrelated problems. There are a number of symptoms:

Odors. Odors increase in intensity with high relative humidity. Musty smells may signal mold, mildew or rot. Odors from everyday household activities that seem to linger too long may be a signal of too much moisture.

Frost and ice on cold surfaces; fogging windows. Frost or ice on any surface is a possible indication of trouble. Condensation on windows and other smooth surfaces can be a sign of excess moisture, or the need to stop air leaks, insulate, or warm the surface.

Another possibility is a faulty heating plant or other flame-fired appliance, which is causing excess moisture and combustion gases to enter the living space. Physical symptoms include frequent headaches, drowsiness, or other unexplainable illnesses. This possibility should be checked at once.

Damp feeling. The sensation of dampness is common in areas with high humidity.

Discoloration, staining, texture changes. These usually indicate some moisture damage, no matter what the material. These changes may appear as black or dark streaks or lines which border a discoloration. The area may or may not be wet.

Mold and mildew often seen as a discoloration, which may be white, orange, green brown or black. They are surface conditions that may indicate decay and are often noticed as a musty odor.

Water-carrying fungi look like a dirty white, or slightly yellow, fan with vine-like strands. The fungus can spread over moist or dry wood, and can be found under carpets, behind cupboards, on framing between subfloors or on damp concrete foundations.

Deformed wooden surfaces. Wood swells when it becomes wet, and warps, cups and cracks when allowed to dry.

Rot and decay. Wood rot and decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi penetrate the wood and make it soft and weak. Look for any type of rot or mushroom-like growths. (See the sidebar on for more information on detecting wood decay.)

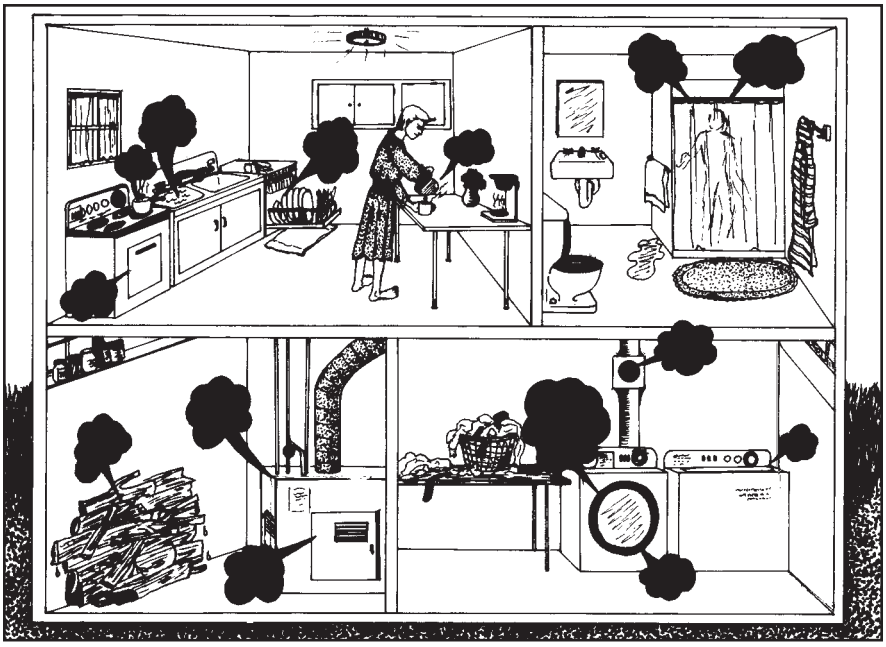


Figure 1
Common indoor moisture sources

Sweating pipes, water leaks and dripping. Water vapor may be condensing on cold pipes, or the pipes may be leaking.

Peeling, blistering, cracking paint. Moisture may be working from outside or inside the home to damage paint. Exposed surfaces between cracks or under blisters are a major signal of moisture-caused paint damage.

Crusty, powdery, chipping concrete and masonry. Concrete or masonry may show signs of deterioration after moisture has moved through it. Freeze thaw cycles speed the process of deterioration, causing chipping and crumbling. A buildup of salt or other powdery substance indicates that water was evaporated.

Indoor Causes

Many sources of excess moisture can lead to high indoor humidity and cause a wide variety of problems (Figure 1). Check each possible moisture source – the problems may have one or more causes – and take the corrective actions outlined in the Table Home Moisture Problems

New construction. Construction materials contain a large volume of water that is gradually released into the house as the materials dry. All new homes should have a mechanical ventilation system that provides a minimum of 0.35 air changes per hour to all rooms.

Basement floor and walls are often the source of excess moisture, particularly for homes in areas with high ground water and poor drainage. (see "Drainage Problems.")

Inadequate interior ventilation. Poor ventilation of high moisture areas such as kitchens and baths commonly leads to damage. If the house has inadequate ventilation overall, moisture problems may be the first clue. Adequate ventilation will usually correct any moisture problems without further steps needed.

Attic moisture problems. Attic bypasses are areas where warm air escapes into you attic: around light fixtures, up walls, etc. Bypasses can allow enormous amounts of warm, moist air to leak into the attic. (Figure 2). Sealing them can save on winter heating expenses while preventing some moisture damage. Call the Energy Information Center and ask for the Home Energy Guide, "Attic Bypasses" for an in-depth discussion.

Too many occupants. People generate moisture. If there is less than 250 square feet of living space per person, there could be a problem.

Wood. Storing large amounts of wood in the house can lead to big problems. Though seemingly dry, wood can contain a great deal of water that will evaporate into the house as the wood dries.

Domestic activities. Cooking without lids, open-flame heating and cooking appliances, baths, showers, and hanging wet clothing and towels inside to dry can produce excessive moisture. Most low-volume shower heads save energy, but generate greater amount of water vapor. In addition, large numbers of house plants can produce a considerable amount of moisture.

Clothes dryer vented into the living space. Clothes dryers are sometimes exhausted into the living space to save the heat. This is a very bad idea for both gas and electric dryers. In addition to the moisture, significant air pollution may result from combustion by-products, lint, and residual detergent fabric softener and bleach products.

Temperature differences, lack of insulation. When warm, moist air hits a cold surface, conden-

sation can sometimes cause water or frost damage and lead to the growth of mold or mildew. Rooms shut off from heating sources or used only intermittently, such as bedrooms or closets, are problem areas, as are areas made cold by drafts or spaces behind furniture on outside walls. Uninsulated walls and windows, and wall, ceiling or floor areas where insulation is missing or has shifted, such as the junction where wall meets ceiling, are other key locations (Figure 3).

Crawl spaces. In the summer, warm humid air can enter into crawl spaces and condense on cool surfaces. If the ground is not covered by an air-vapor barrier, large amounts of water vapor can escape into the crawl space. Eventually, this moisture may cause damage to wood and find its way into the living space. Missing air-vapor barriers are also a problem.

Missing, or poorly installed, air-vapor barriers. Air-vapor barriers–sometimes called air-vapor retarders–have been used for the last several decades. Air-vapor barriers do not stop all air or moisture movement. They only reduce the rate.

Tightly-built homes have a greater need for a durable air-vapor barrier that has been carefully installed on the warm side of the surface to stop moisture and air movement through building materials. If the air-vapor barrier is installed haphazardly, every point subject to air leakage is a place for condensation.

Air-vapor barriers should always be located on the warm side of the insulation (Figure 4). The cold side of the wall must be allowed to breathe, to allow any moisture that does not pass through to escape. An air-vapor barrier should be installed on basement walls, between the interior wall and the insulation.

Improper installation of air-vapor barriers is not uncommon. For example, if a building material that is, in fact, an air-vapor barrier has been installed on the cold side of the wall surface, moisture may be condensing in the walls. If an air-vapor barrier is used on two sides of a wall surface, moisture may build up without an avenue of escape.

Rigid insulation can be an exception to the warm-side, cold-side rule. Although it is still being studied, some researchers say that if the insulation is good enough (R-5 or more), the interior wall temperature will be raised and condensation should not occur under normal humidity levels.

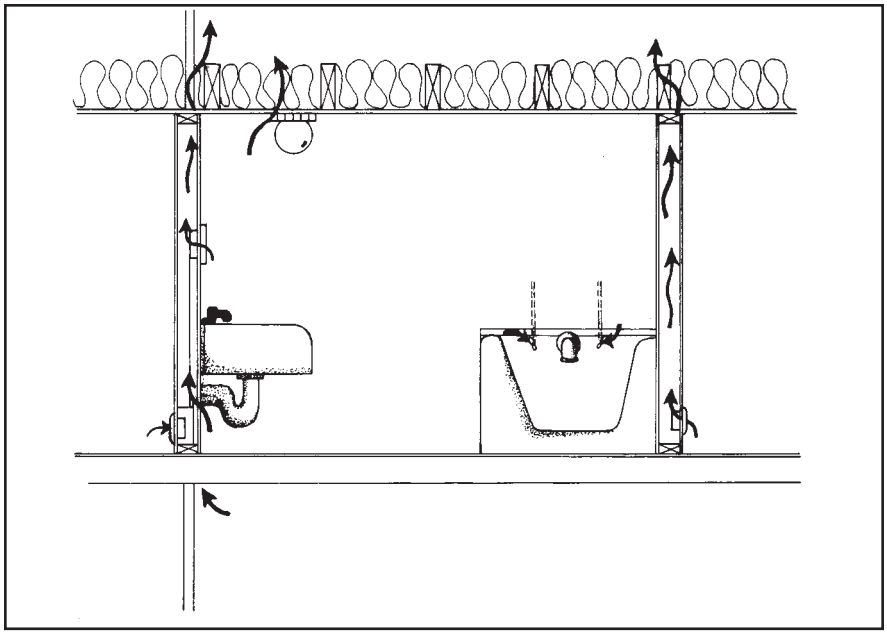


Figure 2
Attic bypasses from the bathroom.

Faulty heating plants. Faulty appliances used for heating, water heating or cooking can be sources of moisture problems. Without adequate combustion air, these appliances can spill water vapor and deadly carbon monoxide gas into the living area. Incomplete combustion is revealed by an excessively yellow or wavy flame and soot in the smoke, and can cause drowsiness, recurring headaches or even death.

Air conditioners, humidifiers. Used in a new or newly retrofitted house, humidifiers only add to construction moisture. Using a humidifier can also cause trouble after a house has been weatherized or tightened to reduce air leaks. In some cases, a humidifier can cause mold and mildew growth in leaky, dry houses. In general, a humidifier should not be necessary in a properly weatherized house.

Most air conditioners turn on and off by sensing temperature, not humidity. As a result, they do a better job of lowering the temperature than of dehumidifying. Over time, humidity can be raised, and if the indoor temperature has dropped enough, moisture can condense on interior sur-

Tip:

Ventilation is a major strategy to control moisture

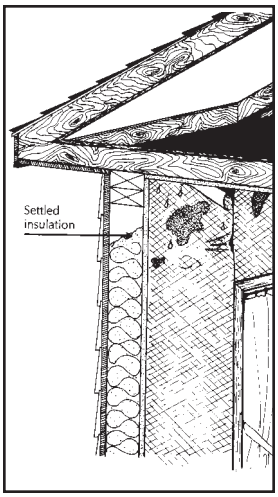


Figure 3

faces. Air conditioners that are too large for the space they are cooling can make the problem worse. Properly designed and sized conditioning systems should cause no problems.

Plumbing leaks. The best way to check the plumbing is to run each part of the system for 10-15 minutes while watching and listening for leaks. Check all accessible connections. Leaking pipes may be buried in a concrete slab floor or hidden in the walls.

Plants. Plants can generate large amounts of airborne moisture. Attached greenhouses can cause moisture problems in the wall they share with the house because of condensation unless properly sealed with an air-vapor barrier. In addition, drainage may be a problem.

Outdoor causes

Poor drainage is the major exterior moisture problem. Proper drainage for foundations is critical. Construction details, such as flat ledges, inadequate drip edges, and bad flashing, can also cause problems.

Precipitation, humidity, soil moisture content, surface water, ground water table and outdoor water use can all change seasonally, creating problems that show only at certain times in the year.

Water in the ground may move through basement floors or walls and then evaporate into the air inside the house. If ground water is a suspect, use the capillary test (See Sidebar) to determine if moisture is wicking up through the ground or coming from the interior space.

High outdoor humidity. Consistently high outdoor humidity can cause a variety of problems, particularly higher cooling costs and constant mold, mildew and decay. Ventilating basements, crawl spaces and interior living spaces with high humidity outside air in the summer can aggravate existing moisture problems or cause new ones.

Blocked exterior air circulation. Foliage close to the dwelling or items stored next to the house, such as firewood, can block air circulation and cause localized areas of high humidity. Roof and soffit vents can become clogged by dust, leaves or tree flowers.

Ventilation

Ventilation is a major moisture control strategy. Passive ventilation is important for crawl spaces, attics and other unconditioned spaces, and mechanical ventilation is needed in kitchens, baths and sometimes other areas of the home. In new homes and extremely tight homes, mechanical whole-house ventilation is a necessity.

Indoor ventilation. The first preventative and corrective action with kitchens and bathrooms is to install fan venting systems that pull moisture out quickly. A minimum of 50 cubic feet per minute (cfm) ventilation in bathrooms and a minimum of 100 cfm in kitchens are recommended.

Ductless kitchen and bath recirculating units simply filter air, not remove it, and are not suitable for removing moisture.

If it is impossible to install the vents in the kitchen and bath, another option is to put an exhaust fan in a central location as close as possible to the humidity source and duct it to the outdoors.

For automatic control of unwanted moisture, any of these vent fans can be successfully connected to a dehumidistat that operates the fan automatically.

There are several methods of exhausting air from bathrooms and kitchens. Each has its strengths and weaknesses. *One rule must always be followed: always vent exhaust fans directly to the outside – do not dump the air into the attic or the soffit areas. Extensive damage can result when the moisture condenses on cold surfaces.*

Installing a fan in the ceiling and running exhaust tubing to a vent on the roof is common. Always seal all cracks and joints in the tubing and insulate it well. Also seal all cracks around the fan itself to reduce the amount of warm air that escapes through the bypass into the attic. Avoid venting a ceiling exhaust fan through the soffits.

In cold weather, roof exhausts will act like chimneys and send a constant stream of warm air out of the house. The roof vents are another potential place for leakage and can become blocked with snow and ice. The stream of warm air can melt the snow on the roof and cause ice dams. If the exhaust pipe is not well insulated, water vapor can condense on the walls of the pipe and leak

back down into the living space.

Running the exhaust pipe down an inside wall and venting the air out through the rim joist works well, but can be difficult to do in existing houses. The fan can be placed at the bottom of the duct and can be quieter than a ceiling unit. Running the exhaust duct down and out also eliminates the chimney effect of a ceiling and attic system (Figure 5).

In kitchen fan systems, use a replaceable or washable filter element that will keep grease from accumulating in the duct work. Clean the filter often.

An occasionally-seen tactic for bathrooms is a to install an overhead infrared heat lamp. These lamps are sometimes combined with a blower to help circulate the warm air. The heat lamps only reduce visible signs of condensation and increase comfort – they do not remove moisture. An exhaust fan is a better solution.

Wall exhaust fans are also available. In general, the wall fan will lose a great deal of energy and cause drafts. It may also become frosted over during cost weather and cause moisture stains on walls when the frost melts.

Attics. Ventilation and eliminating attic insulation bypasses are the main strategies to avoid moisture problems in attics.

Seal around all penetrations into the attic, such as plumbing pipes, chimney chaseway and electrical wiring. Call the Energy Information Center and ask for the Home Energy Guide, "Attic Bypasses," for complete information.

Attics should be ventilated with passive vents that are located to promote good air circulation. Half of the vents should be placed high on the roof, at least three feet higher than the lower vents, which should be as close to the eave as possible (Figure 6). Using a fan for attic ventilation is costly and can draw moisture and heated air into the attic.

The size of the vents depends on four factors: total area to be vented, type of vent opening (screens or louvers), vent location and whether an air-vapor barrier is present.

The general rule is to provide a vent-to-space ratio of 1:300; that is, one square-foot of attic ventilation area is needed for every 300 square feet of space to be vented if a vapor barrier is in place and half of the vent area is located at least three feet above the eave vents. If roof vents are less than three feet above eave vents and there is no vapor barrier, the ratio is 1:150 – one square foot of vent area for each 150 square feet of attic area.

When adding insulation to the attic, take care to keep all vents open. Rigid vent troughs can be installed on the underside of the roof sheathing to

Combustion air caution

Exhausting moist air out of the house with the aid of exhaust fans helps solve home moisture problems. It is important to remember, however, that exhaust fans and clothes dryers reduce the amount of air available for combustion by furnaces, water heaters, and other fuel-burning appliances. A shortage of air for these appliances can result in backdrafting of dangerous gases into the home. To prevent backdrafting caused by a deficiency of air, install a ventilation system that brings fresh air into the home to compensate for the air exhausted out. Another option is to buy "sealed combustion" type appliances, which bring outside air directly to the appliance.

Figure 4
Air-vapor barrier placement

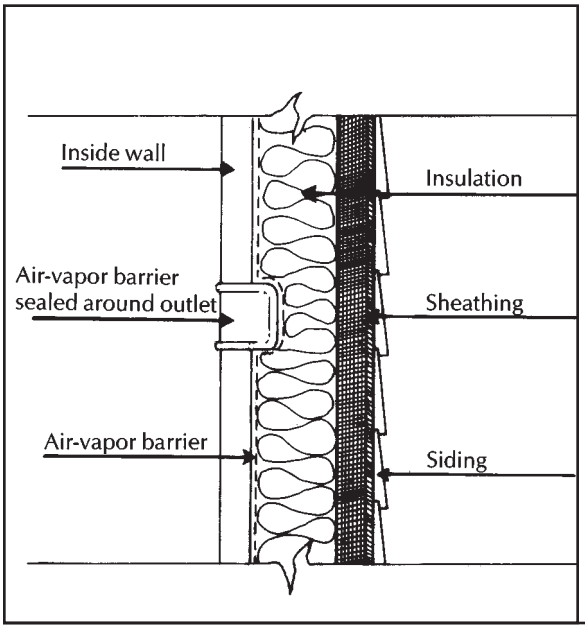
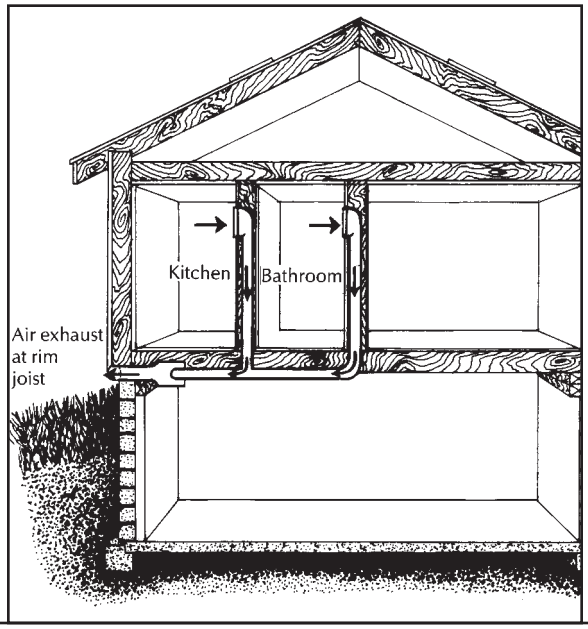


Figure 5
Mechanical ventilation



Tip:

To solve drainage problems, focus first on exterior solutions

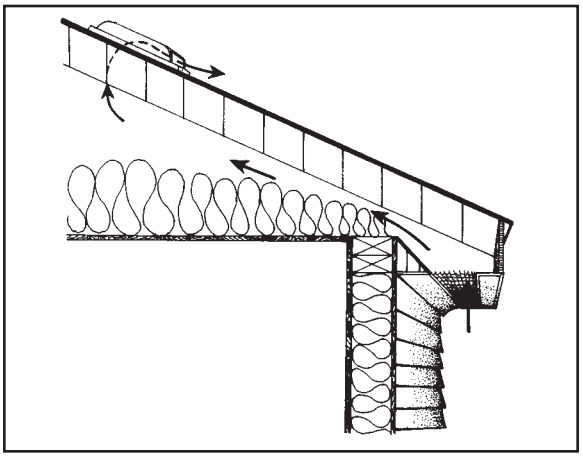


Figure 6

prevent thicker levels of insulation from blocking airflow.

Unfaced insulation is best. If you are installing kraft-backed insulation, the backing can act as an unwanted air-vapor barrier on the cold side of the insulation. Moisture can become trapped behind it, reduce the insulating ability of the insulation, and possibly cause ceiling moisture damage. Cut the backing to allow moisture damage. Cut the backing to allow moisture to escape from the insulation and be carried out of the attic by passive ventilation.

Basements. During warm, humid weather, ventilation with outdoor air can cause condensation in basements and make the indoor moisture problem worse. If the floor or walls are sweating, close basement windows and doors to keep out the humid air. Use a large fan to circulate the air in the basement. If may be necessary to use a dehumidifier to keep the basement dry during the humid months.

Another mechanical method of ventilation is the air-to-air heat exchanger. The air-to-air heat exchanger serves as a heat recovery ventilation system; it extracts heat from outgoing stale air and uses it to warm the fresh, cold air coming into the house. Heat exchangers also need defrosting in very cold climates, and some exchangers have an automatic defrost cycle.

Crawl spaces. The air-vapor barrier is usually a tough, puncture-resistant material (often 6 mil polyethylene) laid over the soil and held in place with weights or bricks. For best protection, overlap the sheets of polyethylene and seal together with contractors' sheathing tape designed to adhere to plastic sheeting. Seal the edges to the walls (Figure 7). Do not use caulk to seal the plastic to polystyrene insulation as caulk may react chemically with the insulation and not adhere to the poly film.

As with basements, ventilation of crawl spaces may cause sweating of concrete or masonry walls below grade because these surfaces stay at a cooler temperature and outdoor air may hold enough moisture to cause condensation. Beyond the routine action of installing a ground cover air-vapor barrier in the drawl space, other actions may be needed to avoid causing this problem.

Drainage problems

Common sources of drainage problems include excess surface and ground water, and clay soils. When combined with poor construction details, drainage problems can quickly cause moisture damage, from roof to basement.

Some drainage improvements are fairly simple, such as adding down spouts and replacing flashing. Others are costly or require a lot of labor for retrofit applications, such as excavating around the basement walls to get at the source of a severe ground water problem.

In some cases, more radical action may be needed, including efforts that are traditionally used to control excess high water tables. These actions include adding drain tile systems, sump pumps, dry wells, floor drains, and laying a new basement floor over a waterproofing layer.

It is best to first tackle the water problem from the outside. Most interior efforts treat the symptoms of the problem, not the causes. In some cases, extensive interior retrofit action, such as a drain tile system below the basement floor, is the only available route, but it may not produce satis-

factory results in severe situations. The wall may become saturated with water.

Even in systems where the foundation is tied into the drain tile system, the block wall may still be wet enough to allow a significant amount of moisture to migrate up into the frame walls.

Exterior solutions. Adding soil around the foundation to achieve a good slope away from the house is a basic treatment. A 6-inch slope over a 5-foot run is recommended. Where cost or lack of space prohibit meeting the recommended slope, slope the soil as much as possible, and try to channel water away (Figure 8).

Use rain gutters on the roof eaves with long extension spots to channel water away from the house. Ground level drains can also be installed at the drip line. Inspect and repair flashing details all around the house.

In new construction and comprehensive retrofits, another basic preventative measure is to install a sloped drain pipe along the footings with use of gravely soil next to the foundation.

If the problem is severe, waterproofing the basement or foundation walls and slab floors is recommended. Waterproofing stops the direct flow of water, and it often consists of several layers of membranes

Waterproof material – at least the equivalent protection of two-ply hot mopped felts, 6-mil polyvinyl or 55 pound rolled roofing – should be carefully applied and sealed at all seams. Waterproofing should extend from the edge of footings to the finished soil line. Waterproof material should also be placed under basement and ground slabs, but in practice this can be very difficult to do.

Heavy rains may cause seasonal back-up of storm sewers, and if soil is heavy, it may retain water for long periods of time even though high ground water isn't a normal problem.

In general, if the soil type is sandy and gravely, and ground water is below the foundation level, drain tiles at the footings are unnecessary because the soil's natural drainage will be adequate. However, seasonal changes and terrain may require some exterior waterproofing, and may make installation of drain tile worthwhile.

Remember that when exterior waterproofing is required, a backfill of crushed gravel should be considered, especially for areas with clay soil.

Interior solutions. Remember that most interior water-stopping action deals with the symptoms of the problem more than the cause. Attempts can be made at controlling the moisture problem with the use of wall coatings, drainage and sump pumps.

Insulating walls

Insulating the walls of older homes usually means blowing in cellulose or similar loose insulation. It is unusual to need an air-vapor barrier in those situations. Condensation problems are rare, and usually localized in an area of high moisture generation, such as the bathroom, and where there is too much air leakage, such as around leaky electrical outlets.

The Energy Information Center recommends using ventilation in those areas and sealing any penetrations into the walls, such as around electrical outlets and switches, with appropriate gaskets. Built-in cabinets, windows, doors and baseboards are other potential areas of condensation because of air leakage.

If the interior wall surfaces are to be removed as part of a remodeling or renovation effort, a 6-mil or thicker air-vapor barrier can be easily installed at that time. Mechanical ventilation and sealing of all penetrations are still recommended.

Water vapor moves into wall cavities both by air movement and diffusion, but air movement is by far the more powerful force. Seal penetrations around windows, doors, where the wall meets the ceiling and floor, and any cracks or holes in wall surfaces.

Windows

A good rule of thumb with older windows is to always tighten the existing prime window first with weather stripping and caulk. If an outer storm window is being added, make sure it has small weep holes at the bottom to allow moisture to escape – exterior storm windows should not be made airtight.

With interior storm windows, make sure that the seal is tight around all edges. The tighter the seal, the less condensation on the prime window.

Capillary test

To determine if moisture is coming through the foundation walls or floor to the inside, or whether moisture is coming from inside the dwelling itself, do the following:

1. Identify the damp interior surface. Testing of multiple locations on the floor or walls may be necessary to locate external sources of moisture.
2. Dry a portion of the damp area approximately 2 feet by 2 feet. (A hair dryer can be used.)
3. Cover the dried area with an air-vapor barrier, preferably polyethylene, firmly attached and sealed with tape around the edges.
4. Check the underside of the air-vapor barrier after a couple of days. If there are beads of moisture under the barrier, there is water seeping or wicking through the surface into the dwelling.

However, if the air-vapor barrier is wet on the room side and dry underneath, the dampness is from another source of moisture. It is possible for both sides to be damp, which indicates both external seepage and internal condensation problems.

This test is sometimes difficult to interpret. Seasonal variations in surface water flow patterns and the ground water table can cause confusion. You may need professional advice.

Home moisture problems

- **Inadequate interior ventilation.**
  Install externally venting fans in kitchens and baths. For localized moisture problems in the home, especially unstoppable condensation, try aiming a small fan at the area to circulate warm air. Provide circulation and ventilation inside the home by opening windows, considering cross-ventilation, and similar strategies. If a significant amount of ventilation is needed, a central exhaust fan or air-to-air heat exchanger could also be considered.

* **Inadequate attic or crawl space ventilation.**
  Install any needed vents in attics, crawl spaces and other areas. Check insulation to see if it is blocking ventilation routes. Seal attic bypasses.

- **Too many occupants; building too small.**
  Step up ventilation. Try to reduce interior moisture sources.

* **Wood.**
  Do not store more than a few days supply of wood in the house.

- **Too many internal sources from domestic activities.**
  Use existing exhaust equipment in kitchens and bathrooms. Install fans if they are not present. Become aware of moisture-generating activity and reduce moisture production. Step up overall ventilation, if necessary, by opening windows, using whole-house or local exhaust fans. Consider installing an air-to-air heat exchanger if appropriate.

- **Clothes dryer vented into the living space.**
  A very bad idea. While there is a small heat gain, there is also a large amount of moisture and other airborne pollutants. Don't do it.

- **Cold surfaces; lack of insulation.**
  Seal the infiltration leaks first, then insulate, employing proper air-vapor barrier techniques. Check existing insulation. Insulate windows with additional glazing or other treatments that seal around all edges. If insulation is impossible, continuous circulation of air with a fan in the problem area will help reduce condensation. For closets or other out-of-the-way places, leave doors open or install louvered doors for better air and heat circulation.

- **Missing or poorly installed air-vapor barrier.**
  Inspect materials on the cold side of the home to determine whether a sheathing or siding may be acting as an unwanted air-vapor barrier. Search for places where the air-vapor barrier may not have been installed, such as the rim joists. Install air-vapor barriers where needed.

- **New construction, retrofit, remodeling.**
  Install mechanical ventilation to provide 0.35 air changes per hour.

- **Unvented heaters, faulty heating plants.**
  Check for blocked furnace vents, a chimney blockage, a chimney that is too short, insufficient combustion air or whether the system is vented at all—do not use an unvented kerosene or gas heater. Make sure your home has an adequate supply of combustion air - call the Energy Information Center and ask for the Home Energy Guide, "Combustion Air." If you suspect the heating plant is faulty in any way, call for help from the local utility or a heating contractor. Don't wait.

- **Air conditioners, humidifiers.**
  Use humidifiers only when needed. Otherwise, avoid them. An unnecessary central humidification system can be disconnected. The main overall action for air conditioners is to keep the thermostat setting at 75ºF or above, to help save cooling dollars and to keep surface temperatures above the point at which condensation will occur. Drain air conditioning condensation to the sewer system or the outdoors, not the crawl space.

- **Plumbing leaks.**
  The best way to check the plumbing is to run each part of the system for 10-15 minutes while watching and listening for leaks. Check all accessible connections. Leaking pipes may be buried in a concrete slab floor or hidden in the house.

- **Plants, attached greenhouses.**
  Provide adequate air circulation and ventilation. Avoid excessive watering. Keep the greenhouse at recommended humidity levels. If the humidity is high, avoid venting into the home. Provide proper exterior drainage away from the house and the greenhouse. Use proper air-vapor barrier and insulation techniques.

- **Long-term air conditioning.**
  Periodically, turn off the air conditioner and ventilate the house when the outside humidity is low.

- **Drainage around house.**
  Slope the ground around the foundation so that water will drain away from the house. Check for blocked downspouts and gutters. Install rain gutters where necessary. Check for cracks in foundations, and install proper perimeter footing drains, if necessary.

- **Ground water.**
  Add an air-vapor barrier and ventilate the crawl space. Fix basement drainage with drain tiles, drain pipe or sump pump. Try fixing cracks in the foundation and use foundation waterproofing. In new construction, lay down a moisture barrier before pouring concrete slab floors.

- **Blocked exterior air circulation.**
  Cut back foliage to allow for circulation. Move stored items away from the house to avoid reducing circulation. Keep vents clean.

Some condensation and light frost on an exterior storm window can be normal. However, if the buildup is heavy and remains on the storm window for an extended period, it can be a sign the prime window should be sealed, or the indoor humidity is too high, or both.

Newer interior window insulation products, such as the popular shrink plastic kits, provide a tight seal around all edges to avoid condensation problems. They add another insulating layer of glazing to the window and are very effective at reducing or eliminating condensation problems on the inside of windows.

They are also very effective in reducing air leakage. Although reduction in air leakage is desirable, a caution should be noted: if steps are not taken to reduce home moisture levels, using these window products may result in moisture problems moving to other, less visible locations.

Traditional drapery and blinds can aggravate window condensation because the window surface gets colder, heat circulation is impeded and the window covering doesn't provide for a tight seal.

A special and hard-to-spot problem can occur with double-hung windows. Warm, moist air can enter the cavities through holes where the pulley-sash cord is located or from the sides of the interior window trim and condense on the cold counterweights. Frost and ice can build up on these weights, and when the ice melts, it can leak into the wall cavity.

Two solutions: either caulk around the interior window trim where it meets the wall and seal the pulley holes, using a sealing device that allows the cords to operate; or remove the weights, seal the cavities, and seal the pulley openings. To keep the window operable with the second option, install low-cost sprint clips. (Note that these clips may not work on extra large windows).

See the Energy Information Center guides "Windows and Doors" and "Caulking and Weatherstripping" for details.

Detecting air leaks

House doctors specialize in home energy use and can help locate air leaks. Among the diagnostic tools they use is the blower door test. Using a fan, a frame-and-panel assembly that fits into an exterior door opening, and some instrumentation, a blower door test tells how tight a house is and helps pinpoint air leaks. Call the Energy Information Center for a list of house doctors.

Window condensation: causes & cures

Condensation is not necessarily an indication that your windows are bad and need to be replaced. Condensation will occur whenever the window surface is cool enough to allow moisture in the air to condense on it, which is why some condensation can be expected in the winter. Condensation should be controlled as much as possible, however, since it can damage the window's components. For instance, moisture on the inside of the storm window indicates that the prime window is allowing air (carrying moisture) to leak out to the storm window where it condenses. Stopping these air leaks with caulking and weatherstripping will stop the condensation and ultimately save your windows. However, it is important to understand that condensation on windows can occur for a number of reasons. Before you replace your windows, call the Energy Information Center for advice.

When window condensation will occur

Outdoor temperature (°F)	30°	20°	10°	0°	-10°
	(Average indoor humidity = 30 to 35%)				
Indoor humidity (%) at which condensation occurs:					
*Insulated glass - double					
Center of glass	57%	50%	44%	39%	35%
Edge of glass	47%	39%	33%	22%	17%
*Insulated glass - double, low-e w/argon					
Center of glass	74%	70%	65%	61%	57%
Edge of glass	50%	43%	36%	30%	26%

(*Assumptions: wood frame, aluminum spacer, 3/8" air space, emissivity of .08)

(From: Patrick Huelman and Timothy Larson, "Performance of Window Systems in Cold Climates;" Building Solutions 1993 EEBA/NESEA Conference, Vol. 1; Energy Efficient Building Association, Minneapolis, MN, 1993)

Wood Deterioration

Decayed wood is more permeable to moisture and more subject to further damage and decay. Recognizing wood decay is a skill that comes with practice, but several symptoms stand out.

White rot is probably the worst form of wood decay, and often it is the most difficult to recognize. Wood infected with white rot appears somewhat whiter than normal, sometimes with dark lines bordering the light discoloration. Because the wood doesn't visibly shrink or collapse, people sometimes miss the fact that wood with white rot is seriously weakened and possibly ready to collapse. In advanced stages, some cracking across the grain occurs with white rot.

In contrast, **brown rot** readily shows as a brown color or brown streaks on the face or end grains. In advanced stages, the wood appears damaged, with cracks across the grain, and the surface shrinking and collapsing. Both white and brown rot are serious forms of wood decay that deserve treatment and/or wood replacement.

Soft rot and **blue stain** are less damaging forms of wood decay that tend to be more active on the surface. Soft rot is recognizable because the wood surface appears soft and profusely cracked, resembling driftwood in color. The soft rot decay is slower acting than white or brown rot. Blue stain indicates somewhat weakened wood, with a blue, brownish black, or steel-gray colored staining. The discoloration actually penetrates the wood cells and is not a surface stain.

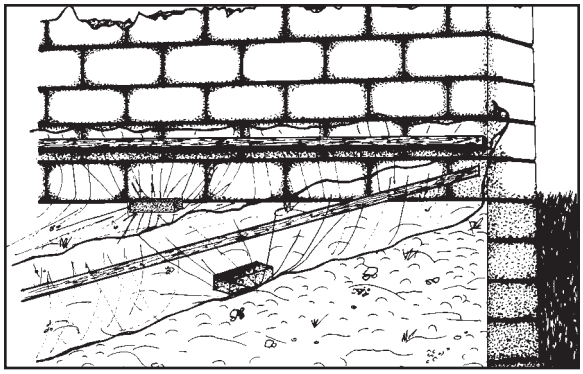


Figure 7
Crawl space air-vapor barrier

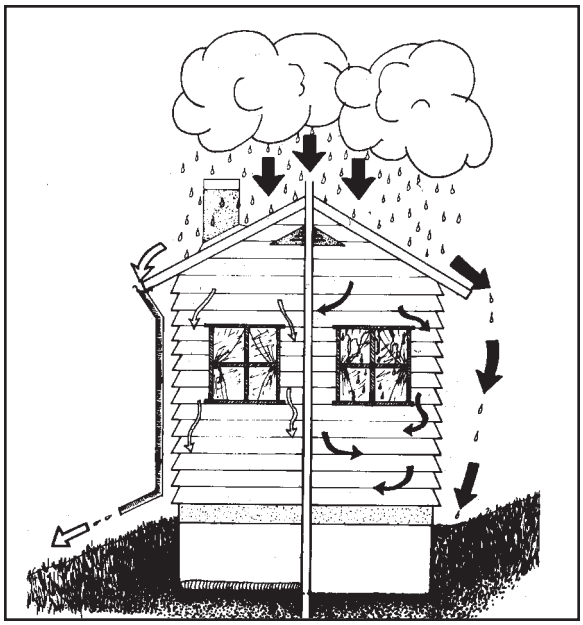


Figure 8
Gutters, a slope away from the house and drainage tile in the foundation keep the left side of this house dry. No gutters, a slope toward the house, and no drainage tile expose the right side to moisture damage.

Dehumidification

When high outdoor humidity is a continuing problem, one option is to dehumidify the air, especially in basements. This can be accomplished by mechanical or chemical methods.

Mechanical dehumidifiers remove moisture by cooling the air. Moist air is pulled past cooling coils, water vapor condenses on the coil, then drips into a collection pan. The dry air is then exhausted back into the house.

At room temperatures of 65° or below, frost or ice will form on the cooling coils, and dehumidification stops until the unit is defrosted. Some units have an automatic defrost cycle, while others must be manually defrosted by shutting the unit down until the ice melts.

For good circulation, place the dehumidifier in the center of the room. For maximum effectiveness, close off the area to be dehumidified. Clean the coil, clean and empty the drainage pan regularly. Stagnant water can grow mold and bacteria, and can be a health hazard.

Chemical dehumidifying agents, known as "desiccants," absorb moisture out of the air. Desiccants are a good option to small, confined places like closet, but they can be dangerous to children and pets. Some desiccants are very corrosive and must be handled with extreme care. Others are reusable and nontoxic, but hands should be washed thoroughly even after handling the nontoxic variety.

Household moisture sources

Moisture source		Estimated amount (pints)
Bathing: tub (excludes towels and spillage)		0.12/standard size bath
	shower (excludes towels and spillage)	0.52/5-minute shower
Clothes washing (Automatic, lid closed, standpipe discharge)		0 +/load (usually nil)
Clothes drying:	vented outdoors	0 +/load (usually nil)
	note vented outdoors or indoor line drying	4.68 to 6.18/load(more if gas dryer)
Combustion - unvented kerosene space heater		7.6/gallon of kerosene burned
Cooking:	breakfast (family of four, average)	0.35 (plus 0.58 if gas cooking)
	lunch (family of four, average)	0.53 (plus 0.68 if gas cooking)
	dinner (family of four, average)	1.22 (plus 1.58 if gas cooking)
	simmer at 203°F., 10 minutes, 6-inch pan (plus gas)	less than 0.01 if covered, 0.13 if uncovered
	boil 10 minutes, 6-inch pan (plus gas)	0.48 if covered, 0.57 if uncovered
Dishwashing:	breakfast (family of four, average)	0.21
	lunch (family of four, average)	0.16
	dinner (family of four, average)	0.68
Firewood storage indoors (cord of green firewood)		400 to 800/6 months
Floor mopping		0.03/square food
Gas range pilot light (each)		0.37 or less/day
House plants (5 to 7 average plants)		0.86 to 0.96/day
Humidifiers		0 to 120 + /day (2.08 average/hour)
Respiration and perspiration (family of four, average)		0.44/hour (family of four, average)
Refrigerator defrost		1.03/day (average
Saunas, steambaths, and whirlpools		0 to 2.7 + /hour
Combustion exhaust gas backdrafting or spillage		0 to 6,720 + /year
Evaporation from materials:		
	seasonal	6.33 to 16.91/average day
	new construction	10 + /average day
Ground moisture migration		0 to 105/day
Seasonal high outdoor humidity		64 to 249 + /day

Source: Minnesota Extension Service, University of Minnesota

Remember that dehumidification, whether mechanical or chemical, is treating the symptom and not the problem. It is only a temporary solution. Dehumidify only if you cannot solve the problem by reducing the amount of moisture in your home.

Paint problems

Exterior paint problems may or may not be caused by excessive interior moisture. Peeling, blistering, or cracking paint can point to a moisture problem, especially if the raw surface or wood is visible. Often, paint problems are severe on outside walls or rooms with high humidify and heavy air leakage.

Some paint problems are not recognized as being caused by interior moisture, and the problem is simply covered up with a new coat of paint or new siding. Of course, some paint problems are caused by poor application, or use of a paint that wasn't meant to do a particular job.