HOME ENERGY GUIDE

TECHNIQUES TACTICS & TIPS

HOME MOISTURE

Minnesota Department of Commerce Energy Information Center

Solving moisture problems can be complicated. The problems are usually created by an assortment of causes and often require a combination of efforts to eliminate. It's a matter of achieving a balance between adequate ventilation and adequate moisture input to create a healthy living environment.

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Indoor Ventilation
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Symptoms of excess moisture

Many signs of excess moisture are readily apparent; others are difficult to detect. One moisture symptom can have several sources, and one moisture source can create a number of seemingly unrelated moisture symptoms.

There are a number of symptoms:

Odors. Odors increase in intensity with high relative humidity. Musty smells likely signal mold, mildew, or, in the worst cases, 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 an indication of trouble. Condensation on windows and other smooth surfaces can be a sign of excess moisture and the need to stop air leaks, add insulation, or otherwise warm the surface.

Another possible cause of condensation 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 immediately. Keep in mind the need for annual maintenance of all combustion appliances such as water heaters, furnaces and boilers. Equip your home with a carbon monoxide detector or alarm.

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, 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. Wood swells when it becomes wet and warps, cups or cracks when allowed to dry.

Rot and decay. Wood rot and decay indicate advanced moisture damage. Wood-decay fungi penetrate the wood and make it soft and weak. Look for any type of rot or mushroom-like growths. (See Wood Deterioration page 10).

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

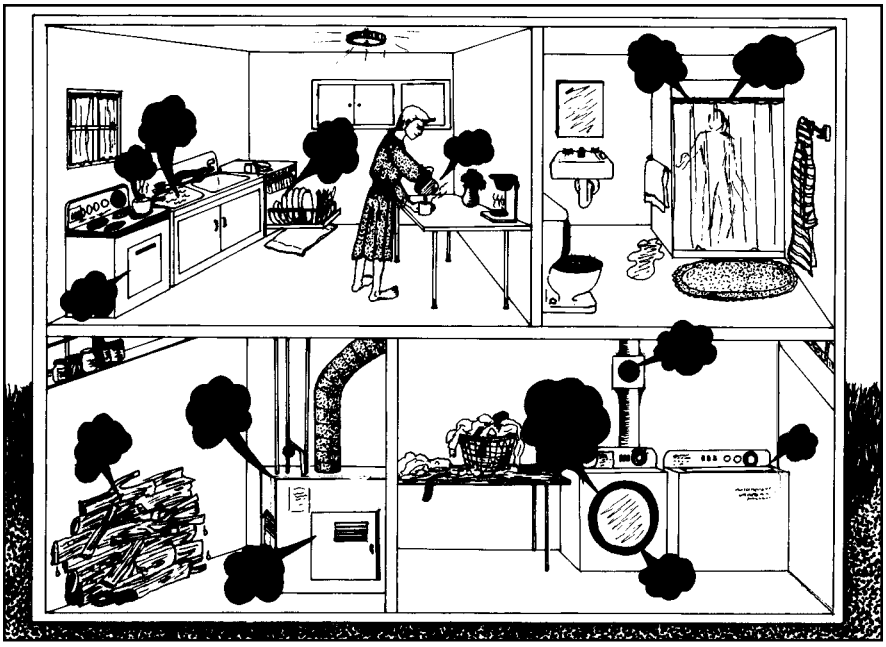


Figure 1
Common indoor moisture sources

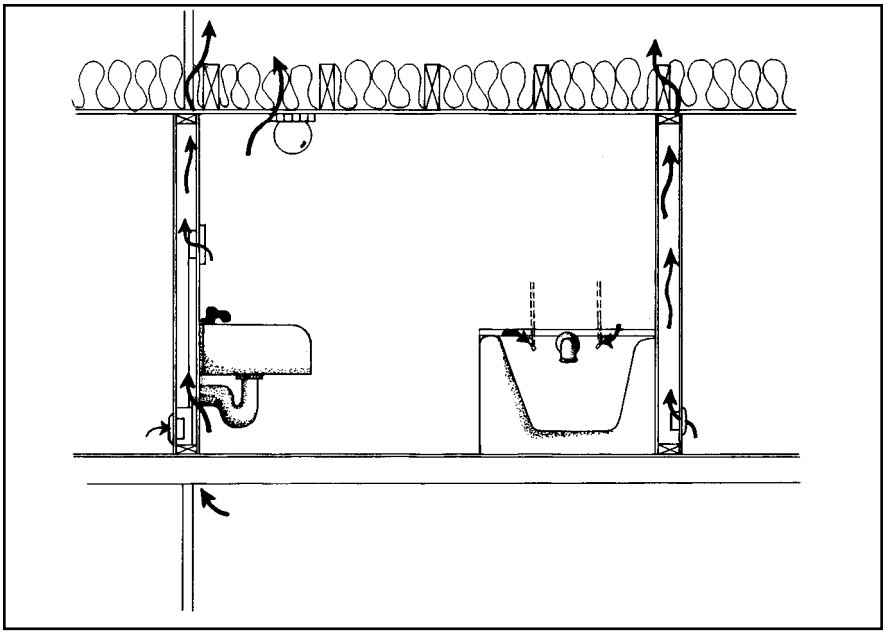


Figure 2
Attic bypasses from the bathroom.

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.

Outdoor causes

Poor drainage is a major exterior moisture problem. Proper drainage for foundations is critical. Construction details, such as flat ledges, inadequate drip edges or bad flashing, can also cause problems. Lack of maintenance can and does lead to water intrusion through siding, windows, doors, exterior light fixtures and other penetrations.

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 moves through basement floors and walls. This water then evaporates into the air inside the house. If ground water is a suspect, use the capillary test (See Capillary test, page 4) to determine if large amounts of 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 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. Typical foundation construction materials are very permeable to water vapor migration. This permeability allows high humidity to migrate inwards from outdoor air on hot summer days.

Blocked exterior air circulation. Closely planted foliage or items stored next to the house, such as firewood, can block air circulation and cause localized areas of high humidity.

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 Home Moisture Problems table on page 8.

New construction. Construction materials contain a large volume of water that is gradually released into the house as the materials dry. All new homes need a mechanical ventilation system that can provide a minimum of 0.35 air changes per

hour to all rooms. The mechanical ventilation system should be set to operate whenever the house is closed, especially during the summer and winter months. Proper maintenance of the system is essential for optimum performance.

Basements and foundations are often the major 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.

Attic moisture problems. Attic bypasses are areas where warm air escapes into your 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.

High building occupancy. People generate moisture. If there is less than 250 square feet of living space per person, there could be a problem.

Wood. Storing 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, appliances, baths, showers, houseplants, and hanging wet clothing inside to dry can produce excessive moisture. Most low-volume showerheads save energy, but generate greater amounts of water vapor. In addition, large numbers of houseplants can produce a considerable amount of moisture.

Clothes dryer vented into the living space. Do not vent gas or electric clothes dryers into your house. The exhaust emits large amounts of water vapor in a short period of time. In addition to the excessive 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, condensation can occur causing water or frost damage, which leads to the growth of mold or mildew. Rooms shut off from heating sources or used only intermittently, such as bedrooms or closets, can be problem areas, as can 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).

Figure 3

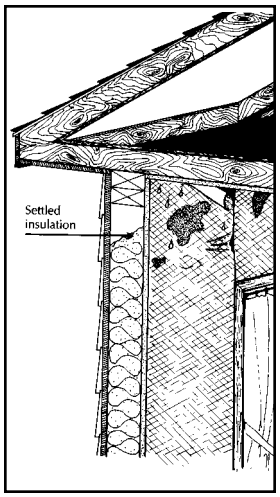
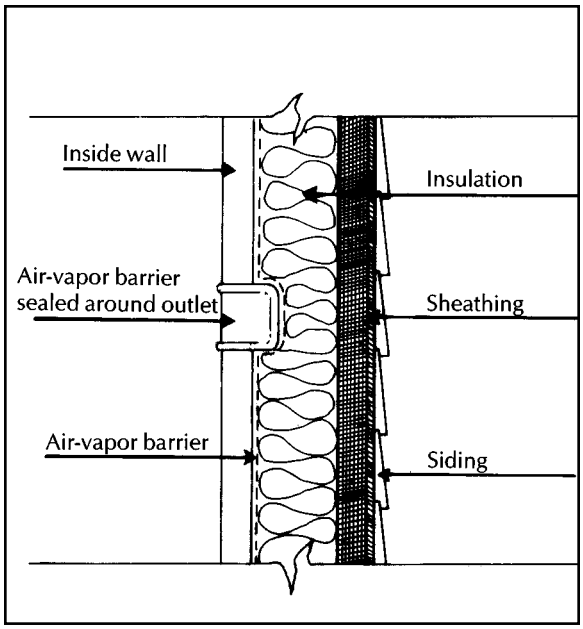


Figure 4
Air-vapor barrier placement



Missing, or poorly installed, air-vapor barriers. Air-vapor barriers–sometimes called air-vapor retarders–do not stop all air or moisture movement. They only reduce the rate and amount of air movement.

Cold climate homes like ours in Minnesota 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. When an air-vapor barrier is installed haphazardly, every point subject to air leakage is a potential 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 moisture that does pass through to escape. Proper installation of air-vapor barriers is important. *Rigid insulation can be an exception to the*

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.

warm-side, cold-side rule. Although it is still being studied, research indicates that if the insulation is R-5 or higher, the interior wall temperature remains warm enough to avoid condensation at normal indoor humidity levels.

Faulty heating systems. Faulty appliances used for heating, water heating or cooking can be sources of moisture problems. Without adequate combustion air or in a "negative pressure" environment, these appliances can spill water vapor and deadly carbon monoxide gas into the living area. Carbon monoxide can cause drowsiness, recurring headaches or even death.

Humidifiers. When operated in a new or newly retrofitted house, improper use of humidifiers only adds to moisture problems. Improper use of a humidifier can cause trouble in any house. Humidifier use should be limited to avoid condensation on windows. As a general rule humidifiers are needed when homes have over-ventilated living space.

Plumbing leaks. The best way to check the plumbing is to run each part of the system for 10 to 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.

Summertime moisture problems

Some common moisture problems occur only during the humid summer months and need special mention.

Air conditioners. Most air conditioners turn on and off by sensing temperature, not humidity. If not properly sized, they may lower the temperature more than dehumidify the air. Over time, humidity can be raised, and if the indoor temperature has dropped enough, moisture can condense on interior surfaces such as ducts moving chilled air. Air conditioners that are too large for the space they are cooling can make the problem worse. Properly designed, sized, and maintained air conditioning systems should cause no problems.

Condensation on cold water supply pipes. Best step to take here is to wrap with closed cell foam pipe insulation and bind the insulation to permanently fasten it in place.

Ventilation

Ventilation is a major moisture control strategy. Passive ventilation is important for attics. Mechanical ventilation is needed in kitchens, baths and sometimes other areas of the home. In newer and renovated homes, mechanical whole-house ventilation is a necessity. As we weatherize, update and remodel older existing homes the ventilation becomes a necessity also.

Indoor ventilation. The first preventative and corrective action with kitchens and bathrooms is to install a fan to pull moisture out quickly. Ductless kitchen and bath recirculating units simply filter air, not remove it, and do not remove moisture. Because the addition of a fan could cause a combustion appliance to malfunction, a carbon monoxide detector or alarm should be installed BEFORE you install any ventilation improvement. If it is impossible to install the vent fans 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. Additional information about ventilation strategies is available in our Indoor Ventilation Home Energy Guide. 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. Ducting that runs through cold spaces must be insulated to avoid condensation from forming and leaking back into the home.

In cold weather, roof exhausts will act like chimneys and send a constant stream of warm air out of the house. If the exhaust pipe is not well insu-

lated, 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. 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 penetration of ceiling and roof surface, further protecting the home from water intrusion. (Figure 5).

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

Attics. Eliminating attic bypasses is the main strategy 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. Power attic ventilators should generally be avoided.

The size of the passive 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. Several coats of oil-based paint will serve the function of a vapor barrier.

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 prevent thicker levels of insulation from blocking airflow.

If you are installing kraft-backed insulation over existing insulation, cut the backing to allow moisture to escape from the insulation and be carried out of the attic by passive ventilation.

Basements and Crawlspaces. During warm, humid weather, ventilation with outdoor air causes condensation in basements and crawlspaces making indoor moisture problems worse. If the

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 5
Mechanical ventilation

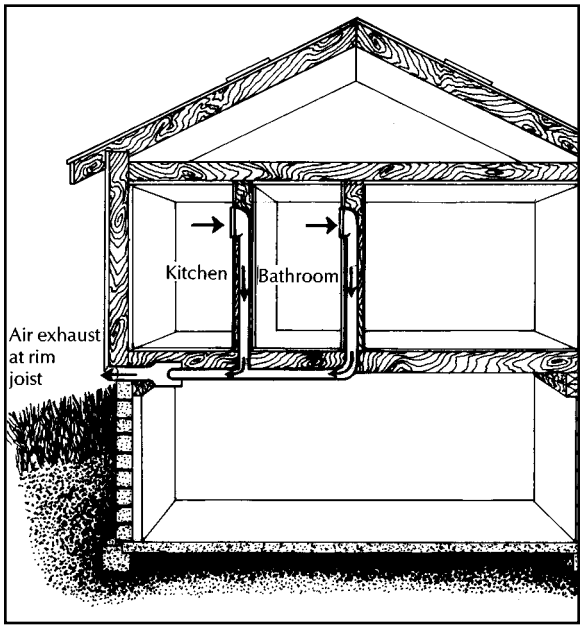
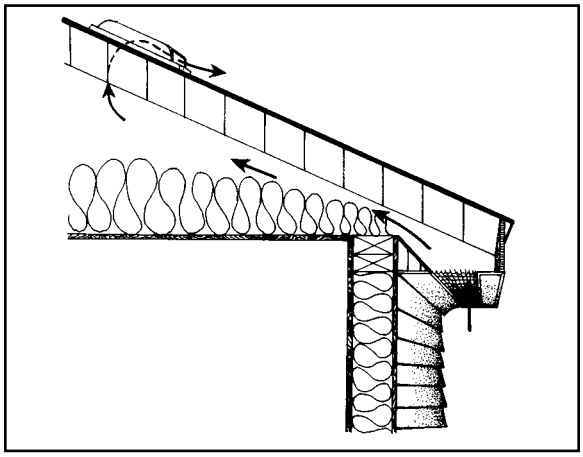


Figure 6



Tip:

To solve drainage problems, focus first on exterior solutions

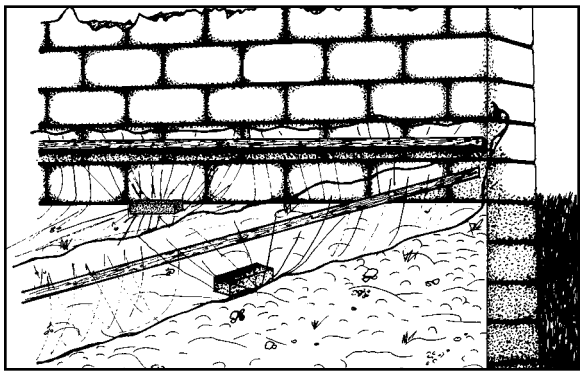


Figure 7
Crawl space air-vapor barrier

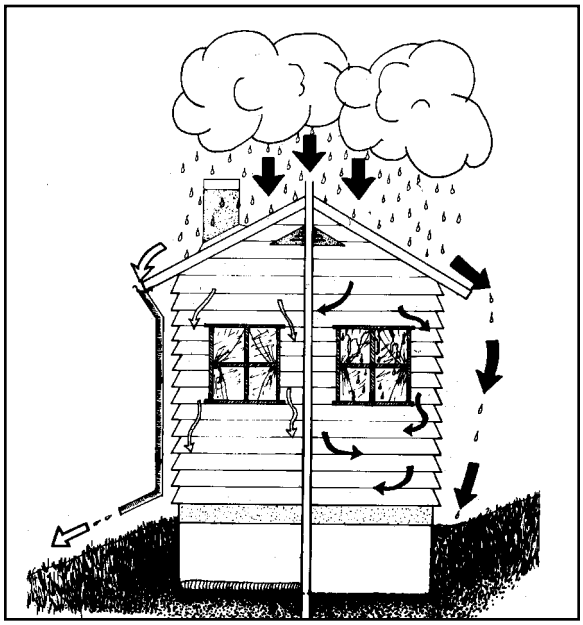


Figure 8
Gutters, a slope away from the house and drainage tile in the foundation keep the left side of this house dry. No gutters, a slope toward the house, and no drainage tile expose the right side to moisture damage.

floor or walls are sweating, close basement windows and doors to keep out the humid air. To dry the space, use a large fan to circulate the air in the basement or crawlspace. It may be necessary to use a dehumidifier to keep the basement dry during the humid months.

Crawl spaces. Crawl spaces need an air-vapor barrier applied to the floor and the parts of the crawl space wall located below grade. A tough, puncture-resistant material (often 6-mil polyethylene) is laid over the soil and continues up the exterior wall until it is at a point above grade. It should be held in place with caulk or anchored in place with a wooden strip. Overlap the sheets of polyethylene and seal them 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 causes sweating of concrete or masonry walls below grade. These surfaces stay at a cooler temperature and, at some times in the year, the outdoor air holds enough moisture to cause condensation. Beyond the routine action of installing a groundcover air-vapor barrier in the crawl space, you may want to consider not ventilating the crawl space.

Drainage problems

Common sources of drainage problems include excess surface and ground water and clay-based 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, and improving the slope of the surrounding earth to rapidly drain water away from the foundation.

Some situations may require a more significant investment, such as adding a drain tile system with floor drain and sump pump. This investment can bring the added benefit of turning uninhabitable space into additional living areas. When possible, it is best to first tackle the water problem from the outside. Most interior efforts treat the problem after the water has entered the foundation wall. In some cases extensive interior retrofit action, such as a drain tile system below the basement floor, is the best available answer.

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 lack of space prohibits meeting the recommended slope, slope the soil as much as possible and try to channel water away (Figure 8). Rain gutters on the roof eaves with long extension spouts will help channel water away from the house. Ground level drains installed at the drip line channel water away. Routinely inspect and repair flashing details all around the house.

In new construction and comprehensive home updates, a basic preventative measure is to install a true foundation waterproofing system. The best system includes a sloped drainpipe along the footings, gravelly soil next to the foundation, and a membrane against the foundation. Waterproofing the basement or foundation walls and slab floors is always recommended.

Waterproofing techniques often consist of several layers of membranes. Waterproofing materials 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. Heavy, seasonal rains may cause soil to retain water for long periods of time, even though high ground water isn't a normal problem. Exterior waterproofing is most desirable, and a backfill of crushed gravel should be considered, especially for areas with clay soil.

Insulating walls

Insulating the walls of older homes usually means blowing loose insulation into the stud wall cavities. It is still desirable to have an air-vapor barrier in those situations. The first coats of oil-based paint in older homes will serve this purpose. Condensation problems are rare. The control of air leakage, such as around leaky electrical outlets and plumbing penetrations, is important.

The Energy Information Center recommends sealing any penetrations into the walls and ceilings, such as around electrical outlets and switches, with appropriate gaskets. Built-in cabinets, windows, doors and baseboards are other potential areas of air leakage need to be addressed–see our "Attic Bypass" guide. The control of air leakage is a critical first step in preventing moisture problems within walls and attic spaces. Densely packed insulation materials can control air leakage. For more information see our "Home Insulation" guide.

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 always 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. Exterior storm windows should not be made airtight.

Make sure all storms have a weep hole or opening at the bottom to allow moisture to escape. 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.

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. Inspect window frames annually to avoid hidden damage.

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. Although they are also very effective in reducing air leakage, there are two general cautions. First, 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. Second, shrink kits can alter the air leakage of the house enough to cause combustion appliances to backdraft (see Combustion air caution, page 5).

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 migrate to condense on the storm window. There are two solutions. The first is to caulk around the interior window trim

Window condensation: causes & cures

Condensation is not necessarily an indication that your windows are bad and need to be replaced. Condensation on windows depends upon a number of factors: type of glazing, frame and sash materials, glazing spacer material, depth of glazing into sash, and other construction details. 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. The chart and accompanying text on page 9 describes the relationship between outdoor temperature, indoor relative humidity and the conductivity of window materials. Condensation should be controlled as much as possible by stopping air leakage. 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. Caulking and weatherstripping to stop the air leaks will help stop the condensation and ultimately save your windows. Before you replace your windows, call the Energy Information Center for 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.

where it meets the wall and seal the pulley holes, using a sealing device that allows the cords to operate. The second is to replace the window using a more efficient replacement window resistant to condensation, or remove the weights, and seal the cavities. See the Energy Information Center guides "Windows and Doors" and "Caulking and Weatherstripping" for details.

Dehumidification

When high outdoor summertime 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.

As room temperatures drop and approach 65 degrees, frost or ice may form on the cooling coils and dehumidification decreases until the unit is defrosted. In some cases frost accumulates because of a low charge of refrigerant. 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. Close off the area to be dehumidified from outside air, as much as possible. Clean dehumidifier coils and clean and empty the drainage pan regularly.

Chemical dehumidifying agents, known as "desiccants," absorb moisture out of the air. Desiccants are options for small, confined places like closets, 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. Remember that dehumidification is the method of dealing with summertime moisture problems.

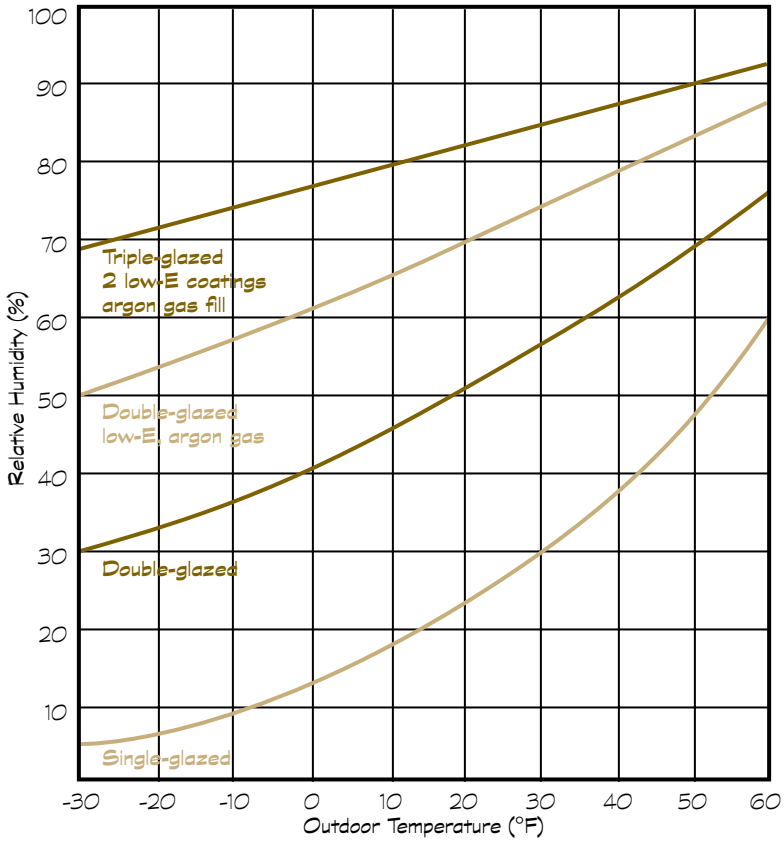
The "right" humidity level

What is the right indoor humidity for winter? Health professionals usually recommend a range of 35 to 65 percent relative humidity. However, typical buildings cannot sustain those wintertime humidity levels. We recommend that you do what you can to avoid condensation on vulnerable surfaces. This will reduce the chance of mold growth and the resulting damage to the building. As you update your home by improving windows and doors and adding a mechanical ventilation system, you will be able to increase indoor humidity levels and avoid damaging the building.

Impact of Temperature, Humidity and Glass Choice on Center-of-Glass Condensation

This graph shows condensation potential on the center of glass area (the area at least 2.5" from the frame/glass edge) at various outdoor temperature and indoor relative humidity conditions. Condensation can occur at any points that fall on or above the curves. Note that the thermal conductivity at the edge of a window is general higher than at the center of the glass. For example, insulated glass with a low-e coating and argon gas may tolerate 61 percent humidity at 0 degrees, but the edge may show signs of condensation at only 26 percent humidity. When buying new windows, look for a low "U" value, and buy an ENERGY STAR window.

Source: Lawrence Berkeley National Laboratory.



U- Factors
(Approximates from National Fenestration Rating Council)

Description	Approx. U-factor
Triple-glazed, 2 low-E coatings, argon gas fill	0.32
Double-glazed, low-E, argon gas	0.37
Double-glazed	0.52
Single-glazed	1.10

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.

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.

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 humidity 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.

Conclusion

Home moisture problems are complex to solve, especially with our unique climate of cold winters and hot, humid summers. In general, problems will occur whenever there is an imbalance between the moisture input to your home and the ventilation rate of your home. The thermal characteristics of building materials also enter into the mix. The solution often lies with some combination of reducing the moisture input, increasing the ventilation, and improving the thermal performance of the building materials.

This guide has provided some guidance on how to troubleshoot for various moisture problems and how to correct them. Since every home is unique, there is no formula that will apply to all situations. Some problems are best diagnosed and solved with the help of a house diagnostician (see Detecting Air Leaks on this page). You can also call the Energy Information Center to discuss your particular concern.

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