Washington Energy Extension Service

REDUCING MOISTURE PROBLEMS

EY 3020
March 1985

Excessive moisture is a common and annoying problem during the winter. Not only does it fog windows and promote mildew growth, but it can also accelerate wood decay, blister paint, and reduce the effectiveness of insulation. This pamphlet will discuss the sources and consequences of moisture in the home, the physics of water vapor movement, and ways to minimize moisture problems.

Definition of Terms

A list of terms with their definitions is provided below. Familiarity with the terms will help you understand the discussion that follows.

Water Vapor	--	The gaseous state of water.
Moisture	--	Dampness that is felt as vapor in the air or as condensed liquid on solid surfaces.
Saturation	--	The point at which no more water vapor can be absorbed by the air; 100% relative humidity.
Relative Humidity	--	A ratio of the amount of water vapor actually in the air to the amount of water vapor that the air could potentially hold; usually expressed as a percentage.
Dew Point	--	The temperature at which air is saturated and water vapor begins to condense as a liquid.
Vapor Pressure	--	The gas pressure exerted by water vapor; usually expressed as torr (metric unit of gas pressure).

Sources and Consequences of Moisture

Although you cannot normally sense water vapor, the gaseous state of water, it is always present in household air. Water vapor comes from cooking, cleaning, bathing, plants, fish tanks, and the people themselves. Typically, a family of four will introduce two to three gallons of water per day into the air. Water can also enter the home through leaks in the roof, walls, windows, or foundation. A major source of water vapor often overlooked is exposed dirt in the crawl space. It has been said that moist dirt in the crawl space can release more water vapor than if the house

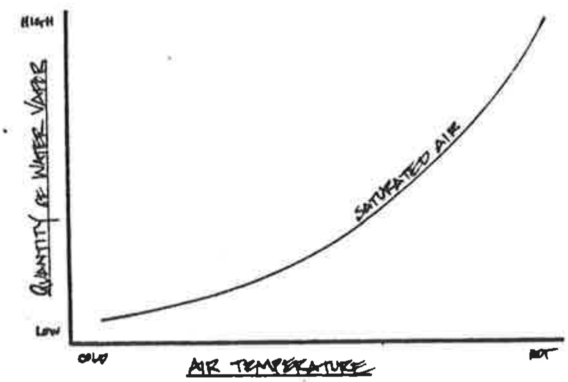

Figure 1. Amount of water vapor held in air as a function of air temperature.

Washington Energy Extension Service is funded by the U.S. Department of Energy and the Bonneville Power Administration
Offered in cooperation with PUGET POWER

were built over a swimming pool!

To some extent water vapor is necessary in the home to maintain comfort. Humid air makes the house or apartment feel warmer, prevents dry throat, and keeps furniture from shrinking or cracking. However, excessive moisture can make the air seem stuffy and increase household odors. Most people find a level of relative humidity between 30% and 60% most agreeable. You can measure the relative humidity in your home with an inexpensive hygrometer, available in hardware and department stores.

High humidity combined with low outside temperatures can result in condensation on wood in the walls, attic, or crawl space, and promote wood decay. Many types of insulation, such as rock wool, fiberglass, and cellulose, that are exposed to water can be permanently damaged and will lose some of their insulating capability. Continuous moisture problems can cause stains on the ceilings and walls, and promote the growth of mildew. Moisture condensing on windows will often collect on the sill and damage the wood.

Although you may find it impossible to totally eliminate all your present moisture problems, you should be able to reduce them significantly. Before discussing the strategies for controlling moisture, it is instructive to develop a basic understanding of moisture movement in the home.

Physics of Water Vapor Movement

When you take a shower or heat a pot of water some of the liquid becomes a gas -- water vapor -- which migrates inconspicuously throughout the home. It only becomes visible when it condenses into fine airborne water droplets (steam and mist) or as liquid on cool, solid surfaces.

The amount of water vapor that can be held in the air is limited, with the actual amount dependent on the temperature of the air. That is, warm air can hold more water vapor than cold air (see figure 1). The term relative humidity is used to describe the extent to which air is saturated. As an example, air having a relative humidity of 50% is only half saturated and has the capacity to hold additional water vapor.

The temperature at which air becomes saturated and condensation begins to occur is known as the dew point. Dew point temperature varies considerably with air temperature and relative humidity (see table 1). Referring to table 1, note that the dew point of air at a household temperature of 70°F with 60% relative humidity is about 55°F. Under these conditions, water vapor coming in contact with a surface at or below 55°F, such as an uninsulated window, will begin to condense. Condensation

	Relative Humidity				
Air Temp. (°F)	100%	80%	60%	40%	20%
70°	70°	63°	55°	44°	27°
60°	60°	53°	46°	35°	19°
50°	50°	43°	36°	26°	10°
30°	30°	23°	18°	9°	-7°

Table 1. The dew point (°F) for various combinations of temperature and relative humidity.

on the window is visible as water droplets that adhere to the glass surface and may eventually run down to the sill. The expression weeping windows is frequently used to describe this occurence.

The last concept that needs to be introduced is vapor pressure, which is the amount of gas pressure exerted by water vapor in the air. You may be aware that at sea level the air exerts a pressure of 14 pounds per square inch, or 760 torr (the metric equivalent). Likewise, water vapor exerts a measureable pressure, though it is only a small fraction of the total atmospheric pressure. As with dew point, vapor pressure can vary considerably because it increases with higher temperature and higher relative humidity (see table 2).

	Relative Humidity				
Air Temp. (^{o}F)	100%	75%	50%	25%	0%
86^{o}	31.9	23.9	16.0	8.0	0.0
68^{o}	17.6	13.2	8.8	4.4	0.0
50^{o}	9.2	6.9	4.6	2.3	0.0
32^{o}	4.6	3.5	2.3	1.2	0.0

Table 2. Vapor pressure (in torr) for various combinations of temperature and relative humidity.

Vapor pressure provides the driving force for the movement of water vapor throughout the home. As with all gases, water vapor moves from areas of high pressure to areas of low pressure. From table 2 it can be seen that in a home at 68^{o}F with 50% relative humidity, vapor pressure is 8.8 torr. If the outside air is 32^{o}F and saturated (100% relative humidity), the vapor pressure is only 4.6 torr. Because indoor vapor pressure is greater than the outdoor vapor pressure, the water vapor will tend to move from the home to the outside. Thus, during cool weather water vapor will often be forced to the outside, even when it is raining!

Water vapor moves to the outside through cracks in the home and diffuses through porous building materials, such as wallboard, insulation, and siding. If it is cold enough, water vapor may encounter its dew point inside the building material and condense. Long term exposure to this moisture can damage many types of insulation and promote wood decay.

Controlling Moisture Problems

There are four basic strategies for dealing with excessive moisture buildup in the home: 1) minimize the entry and release of moisture, 2) protect building components with vapor barriers, 3) remove water vapor with ventilation or dehumidifiers, and 4) raise the inside surface temperature of windows. Each of these strategies is discussed in depth in the following pages. Before choosing a strategy, evaluate its cost and energy efficiency. Some of the techniques require a minimal investment of money and maintain or improve energy efficiency. Others may require a greater financial investment or utilize additional energy in order to operate. The strategy you choose should depend on the type of moisture problem you have and the degree to which it is damaging your home.

<u>1) Reducing the Entry and Release of Moisture</u>

Common sources of moisture can be controlled to some extent by minor changes in lifestyle and the repair of water leaks.

While cooking you can reduce the amount of water vapor released into the air by covering pots and pans. When cooking, isolate the kitchen from the rest of the home by closing doors, if practical. Similarly, the bathroom should be isolated during and following a shower or bath until the moisture has had a chance to escape through an exhaust vent or open window.

In the laundry area the clothes dryer should be vented to the outside. There are devices that can be attached to the dryer's exhaust duct which will trap lint and divert the warm exhaust in the utility room, therefore saving energy. Although that may be acceptable in very cold or dry climates, the use of such a device will cause serious moisture problems in most Northwest homes.

Leaks in the roof can be difficult to find and repair. The source of the leak can often be found by exploring the attic during a heavy rain. If the leak is around the metal flashing of vents, flues, skylights, or chimneys, it can be repaired with an asphalt-based caulking compound. Flashing that is corroded badly may need to be replaced. Leaks through the roofing material itself are usually a serious problem and may indicate the need for a new roof.

To protect your siding and foundation from moisture make sure that your gutters and downspouts are clean, not corroded, and working properly. Gutters should be fastened securely and positioned to catch all of the run-off from the roof. Well designed, effective gutters are especially critical on houses that lack eaves.

Joints between sections of gutters and downspouts should be examined for leaks. Make sure that the downspout empties water at least two or three feet away from the foundation. If it doesn't, a splashblock can be placed under the downspout which will divert water from the foundation. Another option is to dig a drainage pit at the end of the downspout. The pit should be as deep as the foundation and filled with gravel. Water entering the pit will drain into the soil before it has a chance to seep under the foundation.

Exposed dirt in the crawl space releases vast amounts of moisture that may damage wood and enter the living space. It is very important that the dirt be covered with a plastic film, such as 6-mil polyethylene. Polyethylene is very durable and inexpensive, costing about 2¢ to 5¢ per square foot.

Sheets of plastic film should overlap 12 inches or more and extend 8 to 12 inches up the wall of the foundation. The film can be held in place with rocks, bricks, or chunks of concrete.

If your home has a heated plenum (crawl space), the floor of the crawl space will probably be covered with a thin coat of concrete. Because concrete transmits moisture, a plastic film covering the floor of the plenum is also recommended.

<u>2) Protecting Materials with Vapor Barriers</u>

As discussed earlier, water vapor can diffuse through many common building materials, such as insulation, wood, and wallboard. Under appropriate weather conditions the vapor may condense inside or on the material and shorten its life. The easiest and least expensive way to eliminate this problem is to shield the materials with a <u>vapor barrier</u>.

A vapor barrier can be any material that is highly impermeable to water vapor. Some common materials that qualify as effective vapor barriers include polyethylene, aluminum foil, asphalt laminated kraft paper, and vinyl wallpaper. When installing a vapor barrier it is critical that it be located on the warmer side of the insulation, that is, between the heated living space and the insulation (see figure 2).

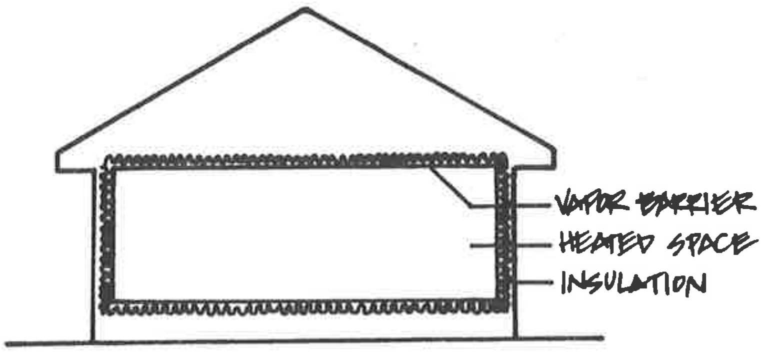

Figure 2. Proper location of vapor barrier.

Vapor barrier paints can also be applied to the ceiling and the inside surface of exterior walls. When selecting a paint make sure that its perm rating, which is an indication of a material's resistance to water vapor, is less than one. Using vapor barrier paint or vinyl wallpaper is probably the easiest way to block moisture after insulation has been installed.

During construction or remodeling, a 6-mil vapor barrier can be stapled or glued to the inside surface of the studs or ceiling joists and covered by wallboard, paneling, etc. (see figure 3). Another method of installing a vapor barrier under the attic insulation is to staple polyethylene in the areas between ceiling joists (see figure 3).

Not everyone agrees that a vapor barrier under ceiling insulation is desirable. If you are sure that you have adequate attic ventilation (see following section), a vapor barrier may not be necessary. Unfortunately, most existing homes do not have enough ventilation to protect the insulation and attic structure from moisture accumulation. If this is the case with your home, it is recommended that a vapor barrier be placed in the ceiling.

Often insulation, such as fiberglass batting, has a vapor barrier made of aluminum foil or asphalt laminated kraft paper attached to one side. Occasionally, you may find insulation that has been installed incorrectly with the vapor barrier on the colder side where it can trap moisture. This error occurs most often underneath floors, and can be partially corrected by slashing the vapor barrier with a knife. If your insulation is very damp, you may need to slash the vapor barrier as often as every four inches.

If you are adding new insulation over old insulation in the attic or elsewhere, be sure to buy insulation without a vapor barrier. A vapor barrier in the wrong place is worse than no vapor barrier at all.

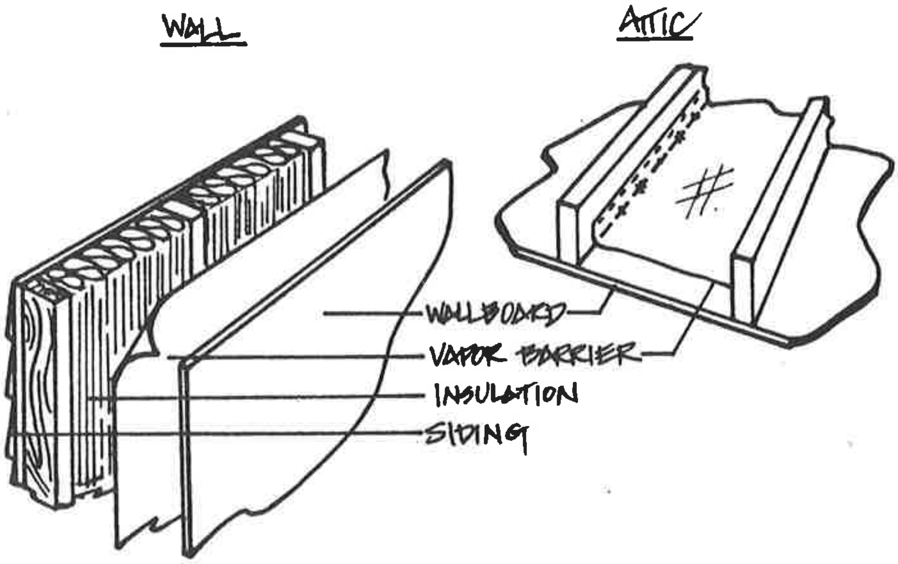

Figure 3. Location of vapor barrier in wall and attic.

3) Removing Water Vapor: Ventilation and Dehumidification

One of the major actions you can take to alleviate moisture problems is to ventilate localized areas of high humidity, such as the kitchen and bathroom. Exhaust fans in these areas can be effective at removing a significant amount of the moisture. One disadvantage is that exhaust fans can remove a lot of warm air with the water vapor. Therefore, it is recommended that you only use them for short periods of time. You may want to install a timer switch or humidistat so the fan will automatically cut itself off. A damper in the flue that automatically closes when the fan is off will also minimize the escape of warm air through the vent.

Another type of ventilation system is the through-glass ventilator that mounts in the window pane. Both passive (non-powered) and electric-powered ventilators are available which will vent excess moisture near the surface of the window to the outside. Passive units cost about $50 and powered units cost $100 to $250. They are particularly useful in rooms that do not have operable windows. Remember that using these vents will increase losses of warm air.

If your home does not have exhaust fans or ventilators, turn down your heating system and open your windows as often as possible, especially during mild, dry weather. If the heating system is turned off, you can get rid of moisture without wasting much energy.

Ventilation in the attic and crawl space is extremely important. It is recommended that the attic have one square foot of net free ventilation for every 300 square feet of attic space, if a vapor barrier is present, or at least one square foot of ventilation for every 150 square feet of attic space without a vapor barrier. Crawl spaces require one square foot of net free ventilation for every 1500 square feet of floor area, or 1½ square feet of net free ventilation for every 25 linear feet of foundation wall. Net free ventilation is the total area of the vent minus the area taken by louvers and screens. Most new vents will be labeled with their net free ventilation area. If not, you can estimate the net free area by multiplying the total area by two-thirds. It's best to have the vent area distributed on opposite sides of the house to facilitate cross-ventilation. In the attic, half of the vent area should be in the soffits (under eaves) and half should be on or near the ridge.

Various types of attic vents are illustrated in figure 4. Vents with electric fans are available but not necessary in this climate, if adequate vent area is provided.

If moisture problems in the living space persist, additional ventilation can be attained without losing a great deal of energy by using an air-to-air heat exchanger. These ventilation devices are designed to transfer heat from outgoing stale, humid air to incoming fresh, drier air with an efficiency of 60% to 80%. They cost from $250 to over $700, and use 30 to 200 watts of electricity. For an air-to-air heat exchanger to effectively remove moisture, its exchanger should be made of an impermeable material, such as

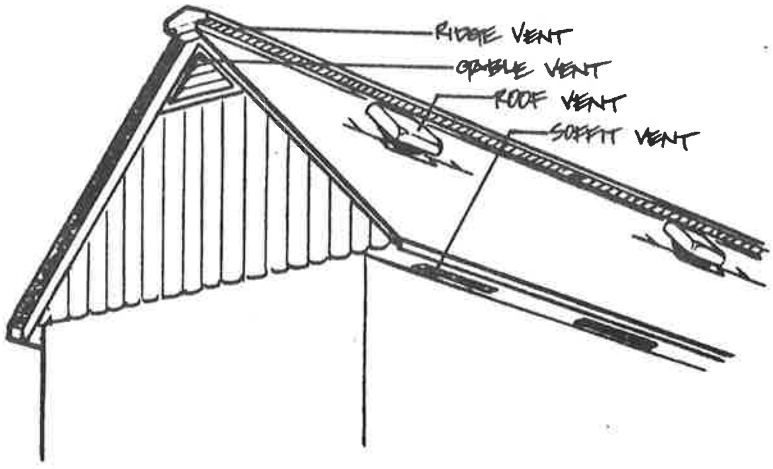

Figure 4. Various types of attic vents.

metal or plastic. Heat exchangers with paper partitions are generally less effective at venting water vapor.

Another option for removing moisture is to use a dehumidifier in the most humid areas. Room dehumidifiers cost from $150 to $300 and use 250 to 600 watts of electricity. Because these devices require a sizeable investment and an additional use of energy, it is suggested that you use them only as a last resort. Another consideration is that they are not recommended for use in rooms that are colder than 65^{o}F.

4) Raising Surface Temperatures

The main reason single-pane windows fog up so easily is that they are extremely poor insulators. As a result, they have very low inside surface temperatures that are often below the air's dew point. For example, if it is 32^{o}F outside and 68^{o}F inside, the inside surface temperature of a single-pane window will be about 40^{o}F. Under these conditions, air having a relative humidity of 35% or more will result in condensation on the glass. By adding a storm window or replacing the window with insulated glass the inside surface temperature will be raised to 57^{o}F, and condensation will not occur below 70% relative humidity. As a result, condensation on the glass should occur rarely in this climate with properly installed storm windows or insulated glass. As a bonus, heat loss through the window may be cut in half!

If the frames of the storm window and primary window are both made of aluminum, direct contact between the frames should be avoided to prevent condensation on the metal. Direct contact can be prevented by inserting foam or felt weatherstripping, or by leaving a gap between the frames.

Another important consideration is to minimize air leakage around the windows by adding weatherstripping. If air leaks around the inside window, moisture may condense on the inward surface of the outer glazing. For this reason the tighter fitting window should be to the inside. That is, if the storm window is tighter than the primary window, then it should be installed on the inside. If the storm window is leakier than the primary window, install it on the outside.

If, after installing a storm window on the outside, condensation still occurs between windows, it may be necessary to drill two or three weep holes through the storm window frame or the window sill to let water vapor escape. The weep holes should be angled downward to prevent the entry of rain, and they should be plugged loosely with fiberglass insulation or cotton to keep out insects.

Under certain conditions moisture may condense onto uninsulated exterior walls. This can promote the growth of mildew and may cause structural damage. As with windows, adding insulation will raise the inside surface temperature and may prevent condensation. Realize, however, that adding wall insulation is costly, and should be installed primarily for decreasing heat loss, and not just for reducing condensation.

Moisture problems can be very complex, site specific, and persistent. Finding a solution may require considerable "detective work" and experimentation. As you review these different techniques try the low-cost options first. If your problems persist, you may need to resort to more sophisticated strategies.

Suggested Reading:

"Vapor Barriers". Solar Age. November, 1979. pp.49-50.

"Air-to-Air Heat Exchangers for Houses" by William Shurcliff. Solar Age. March, 1982. pp. 19-22.

Insulation and Weatherstripping. Sunset Books. Lane Publishing Co.; Menlo Park, Calif. 1978.

This factsheet was written by David Schaub.

Illustrations provided by Steve Tracy.