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WASHINGTON STATE ENERGY OFFICE

Washington Energy Extension Service

Home Conservation

Wise Use of Resources Through Education

Reducing Moisture Problems

INTRODUCTION

Excessive moisture in the home can be a common and annoying problem during the winter. Not only does it often result in fogged windows and mildew growth, but it can also promote wood decay, blister paint, and reduce the effectiveness of insulation. This factsheet will discuss the sources and consequences of moisture in the home, the nature of water vapor movement, and ways to control moisture problems.

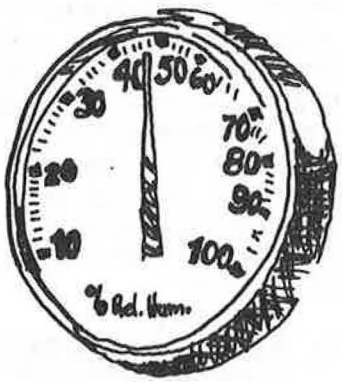
SOURCES AND CONSEQUENCES OF MOISTURE

Although you cannot normally sense water vapor, the gaseous state of water, it is always present in household air. Water vapor comes from a variety of common sources including cooking, cleaning and bathing, but the greatest sources are respiration (breathing) and perspiration, so household size can play a key factor. Typically, a family of four will introduce two to three gallons of water per day into the air. Indoor plants, aquariums, pets, and wet laundry hung to dry are other sources. 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 crawl spaces.

To some extent water vapor is necessary in the home to maintain comfort. At indoor temperatures, humid air makes the house or apartment feel warmer, prevents dry throat, reduces static electricity, and keeps furniture from shrinking and cracking. However, excessive moisture can make the air seem stuffy and increase household odors. People generally find a relative humidity between 30 percent and 60 percent most agreeable. You can measure the relative humidity in your home with an inexpensive meter called a "hygrometer" available in hardware and department stores.

High humidity combined with low outdoor temperatures can result in condensation on both exposed and hidden building surfaces. Recurring moisture problems can cause stains on ceilings and walls and contribute to mildew growth. Moisture condensing on windows will often collect on the sill. If not remedied, such conditions may result in wood decay of sills, walls, attics and crawl spaces. 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.

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



A Hygrometer Is Used To Measure Humidity

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THE NATURE OF WATER VAPOR MOVEMENT

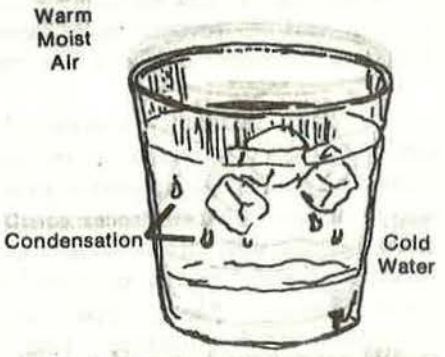
When you take a shower or heat a pot of water some of the liquid becomes a gas or "water vapor", which migrates inconspicuously throughout the home. In fact, any source of liquid water in the home will slowly but continuously evaporate adding water vapor into the air. Water vapor only becomes visible when it "condenses" into a liquid, either as fine airborne droplets (steam and mist) or as droplets formed on cool surfaces (dew and condensate).

The amount of water vapor that can be held in air is limited and depends on the air temperature. Warm air can hold more water vapor than cooler air. When air can hold no further water vapor it is said to be "saturated". The term used to describe the extent to which air is saturated is called "relative humidity" and is expressed as a percent. Relative humidity gets its name from the fact that saturation levels are dependent on temperature.

Another term less often used, "absolute humidity", refers to the actual amount of moisture in the air. One measure of absolute humidity is "vapor pressure" which is the amount of gas pressure exerted by water vapor. You may be aware that at sea level the air exerts a pressure of 14.7 pounds per square inch (psi). Likewise, water vapor exerts additional pressure, though it is only a small fraction of total atmospheric pressure. Vapor pressures are usually expressed in inches of mercury (in. Hg for short). Standard atmospheric pressure (14.7 psi) is the equivalent of 29.92 in. Hg.

Vapor pressure provides the driving force for the movement of water vapor throughout the home. Water vapor can also be carried by convective air currents caused by air at different temperatures. As with all gases, water vapor moves from areas of high pressure to low pressure. Vapor pressures are easily found using Table 1, if temperature and relative humidity are known. As an example, if the inside air is 60°F and at 60 percent relative humidity, the vapor pressure is 0.31 in. Hg. If the outside air is 40°F and saturated (100 percent relative humidity), the vapor pressure is 0.25 in. Hg. In this example, the indoor vapor pressure is greater than the outdoor vapor pressure (0.31 > 0.25). Thus, during cool weather water vapor will often be forced to the outside, even when it is raining! Under these conditions, much of the water vapor escapes through cracks in the home, although some will also diffuse through porous building materials such as wallboard, insulation and siding.

As air is cooled its capacity for holding water vapor is reduced and the relative humidity will rise. The temperature at which the air becomes completely saturated with water vapor (100 percent relative humidity) is called the "dew point" since condensation thus begins to form. The more moisture in the air, the higher the dew point will be. From Figure 1, the dew point can be found for any value of water vapor pressure. Let's take another example. On warm days, the indoor air may be 75°F and at 40 percent relative humidity. From Table 1, the vapor pressure is 0.36 in. Hg, and from Figure 1, the dew point is 50°F. Thus, there would be no problem with windows fogging since the window temperature is greater than 50°F. On the other hand, a glass of ice-cold lemonade would be dripping wet because its temperature is lower than 50°F.



Water Vapor Condenses When Cooled To Its Dew Point

CONTROLLING MOISTURE PROBLEMS

Since problems with moisture arise from high moisture levels coming in contact with cool building surfaces then any method of preventing these conditions should help solve them. Alternatives include lowering moisture levels as well as raising surface temperatures and using vapor barriers. The ideal solution will really depend on the specific nature of the problem, its severity, and cost considerations. Sometimes the best approach will be to follow several strategies. Be sure to consider both the initial and operating expenses of the various alternatives, as well as any indirect benefits. For example, storm windows will reduce drafts in addition to fogging.

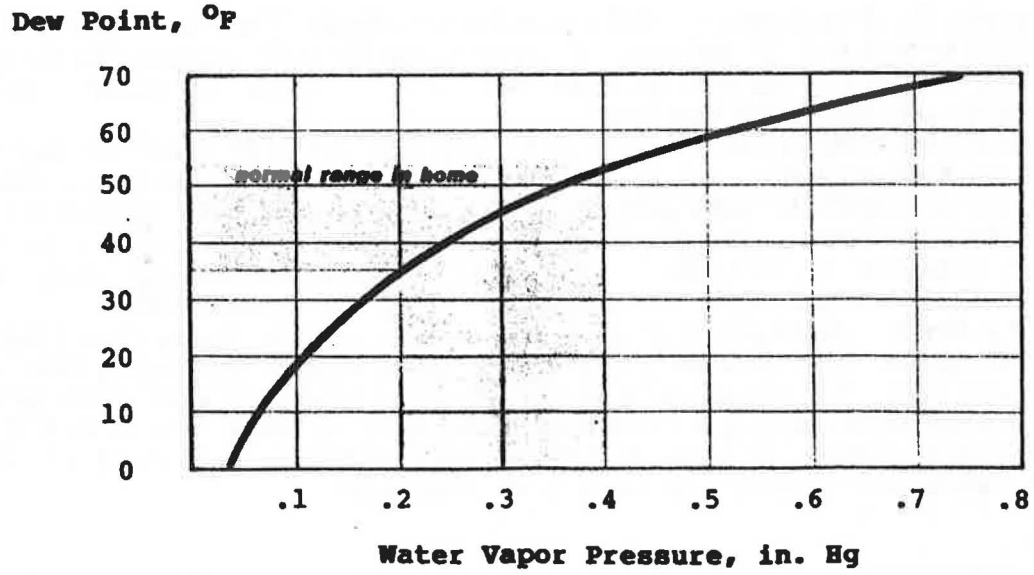
Table 1. Water Vapor Pressure, Inches Hg

(Standard Atmospheric Pressure = 29.92 in. Hg = 14.7 psi)

Air Temp., °F	Relative Humidity, %									
	10	20	30	40	50	60	70	80	90	100
80	.10	.21	.31	.41	.52	.62	.72	.85	.93	1.03
70	.07	.15	.22	.30	.37	.44	.52	.59	.67	.74
60	.05	.10	.16	.21	.26	.31	.37	.42	.47	.52
50	.04	.07	.11	.15	.18	.22	.25	.29	.33	.36
40	.02	.05	.07	.10	.12	.15	.17	.20	.22	.25
30	.02	.03	.05	.07	.08	.10	.12	.13	.15	.16

normal range in home

Figure 1. Dew Point, °F



Reference: Psychrometric Tables, ASHRAE Handbook of Fundamentals

Reducing moisture levels is a broad topic and is divided into four areas -- living spaces, attics, crawl spaces and leaks. Preventing condensation on windows is discussed separately. Vapor barriers for preventing moisture from contacting building surfaces are typically utilized when insulating the home and are covered in detail in the WEES "Home Insulation" Factsheet.

Reducing Moisture Levels

This strategy includes minimizing the entry of moisture into the home as well as removing moisture that is already present.

Living Spaces

Common sources of moisture can be controlled to some extent by minor changes in lifestyle. While cooking, try to keep pots and pans covered. If you have an exhaust fan be sure to use it. This also holds true in the bathroom when showering and bathing. If you have trouble remembering to turn fans off, you may want to install a timer switch or humidistat so this is done automatically. A damper in the flue that closes when the fan is off will prevent air from constantly escaping.

If you don't have exhaust fans, you will have to use windows to vent unwanted water vapor. Even when it's raining outside, as long as the outdoor air is cooler, moist indoor air will be forced outside due to its greater vapor pressure. While venting a kitchen or bathroom, try to keep doors shut so that moisture doesn't move to other areas of the home. For fixed windows that aren't designed to open, a passive ventilator (non-powered) installed in the pane, will help to vent moist air and may prevent condensation problems. It's true that during the heating season you will be sacrificing a small amount of energy by exhausting warm air but this cost is easily justified by avoiding potentially greater moisture problems.

Sometimes you may notice mildew growing on walls or ceilings, particularly exterior walls behind furniture. Although mildew and mold thrive where moisture is present, they also like places where the air is cool and still. Since exterior walls are cooler than other room surfaces and there is little air circulation behind furniture or in corners, these areas are prime targets for moisture problems. Occasionally warming up these surfaces and allowing air to circulate to them will help prevent the growth of mildew. Wall insulation, by raising the inside wall temperature, is another solution, though costly. On unusually mild, dry days throughout the heating season, you can thoroughly air out the house by shutting off the heat and opening all doors and windows for several hours or until it gets too cold inside.

In the laundry area, the clothes dryer should be vented to the outside. There are devices that can be attached to the dryer exhaust duct for trapping lint and diverting the warm exhaust into the room therefore saving energy. Although this may be acceptable in very cold and dry climates, serious moisture problems will occur in most Northwest homes.

Another option for removing moisture, other than ventilation is a room dehumidifier. Although effective, these units are fairly expensive and should probably only be used as a last resort where a persistent moisture source is present. Dehumidifiers cost from $150 to over $300 depending on size and controls, and use a substantial amount of energy, up to 600 watts. Many models are limited to service in spaces above 65°F so make sure the unit selected is designed for the actual conditions likely to be encountered. More information on dehumidifiers can be found in WEES Technote TN1004.

With the trend in new homes being toward tighter construction, adequate ventilation has become a significant issue to the public. One technology employed to insure a controlled level of ventilation without losing much heat is the "heat recovery ventilator" (HRV), also referred to as an "air-to-air heat exchanger" (AAHX). These units are designed to transfer heat from stale, humid exhaust air to fresh, dry supply air. Although the energy requirement is lower than humidifiers, up to about 200 watts, HRV's are still rather expensive and mostly used in new home construction.

Attics

Although not generally obvious, moisture can become a problem in attics since convective air currents and consequently water vapor movement in most homes is upward. In worst cases, high moisture levels in attic spaces result in condensation on insulation and roofing materials leading to ruined insulation and wood decay. On the positive side, a well ventilated attic (not too common) can

serve as a convenient escape route for excess moisture in the home. To avoid the buildup of moisture in the attic requires the proper sizing and placement of various vents. The minimum recommended ventilation level is one square foot of net-free venting area per 300 square feet of attic floor space.

Crawl Spaces

It is important to reduce moisture levels in unheated, dirt crawl spaces for a variety of reasons. Soil moisture levels are extremely high during most of the year in Washington. Without mitigating efforts, the air inside a crawl space would often be close to saturation. Wood flooring members exposed to this humidity could invite mildew, mold or insect attack. If condensation is present, wood decay could result. Another potential problem is the possibility of humid air leaking into the living space through penetrations or cracks in the floor. Finally, if forced air heating ducts are routed through the crawl space, it's possible for humid air from the crawl space to be drawn into the duct work and then into the home.

To eliminate crawl spaces as a source of moisture problems, the minimum recommended ventilation level is one square foot of net-free area per 150 square feet of exposed dirt surface. This level can be significantly reduced if the ground is covered with a vapor barrier such as 6-mil polyethylene film. The recommended ventilation area ratio is then 1:1500. The plastic film should overlap 12 inches or more and extend 8 to 12 inches up the foundation wall. The film can be held in place by rocks, bricks, or any heavy object. If your home has a heated plenum (crawl space), the floor will probably be covered with a thin layer of concrete. Because concrete is not impervious to moisture movement, a vapor barrier in this case is also recommended. For more information on both attic and crawlspace ventilation recommendations, again refer to the "Home Insulation" Factsheet.

Leaks

Water leaking into the home may not contribute much to humidity but in a short time can ruin interior finishes and eventually lead to wood decay. Leaks in the roof can be difficult to find and repair. Try looking for the leak in 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 sealing compound. Flashing that is badly corroded may need to be replaced. Leaks directly through the roofing material indicate the need for major repairs or perhaps a completely new roof. To protect siding and foundations from water damage, make sure that gutters and downspouts are working properly - they should be clean, undamaged and free of leaks. Effective gutters are especially important on houses without eaves to prevent water from penetrating behind siding and entering wall cavities. Water from downspouts should drain away from the foundation. Splashblocks, gravel drainage pits or other forms of diversion should carry water 2 - 3 feet from the foundation.

Preventing Condensation On Windows

Windows are often the first indication that a moisture problem exists in the home. Initially they may simply fog up with tiny water droplets, but if condensation persists, water begins pouring down them forming small puddles on the frames and sill. To prevent condensation from occurring, it is recommended that attempts be made to lower humidity levels in the home as described above. However, another effective solution is to raise the temperature of the inside window surface.

The main reason that single-pane windows fog so easily is that they are extremely poor insulators and have inside surface temperatures that are close to outside temperatures. For example, if it is 30°F outside and 65°F inside, the inside window temperature would be 37°F! Under these same conditions however, a double-pane window would have an inside temperature of 52°F, or 15°F warmer. Remember that water vapor in the air will condense when it is cooled to its dew point. Warmer windows mean less chances that dew point temperatures will be reached. You don't have to replace windows with expensive new ones to make them warmer. Storm windows including those made of inexpensive plastic film, can be installed easily and provide the same insulating effect, or "R" value as sealed, double-pane window units. Other benefits of double-pane glass and storm windows include reduced drafts and energy savings.

Regardless of the style of storm window selected, it is important that it forms a tight seal with your existing window frame. If air is allowed to leak around the edges, condensation may occur as shown in Figure 2(A). If the storm window (exterior mounted) is installed tightly but your primary window is leaky, e.g. a sliding window, you may get condensation between the panes as shown in Figure 2(B). In either case, the point is that an effective "dead" air space is required to insure maximum R-values and inside surface temperatures.

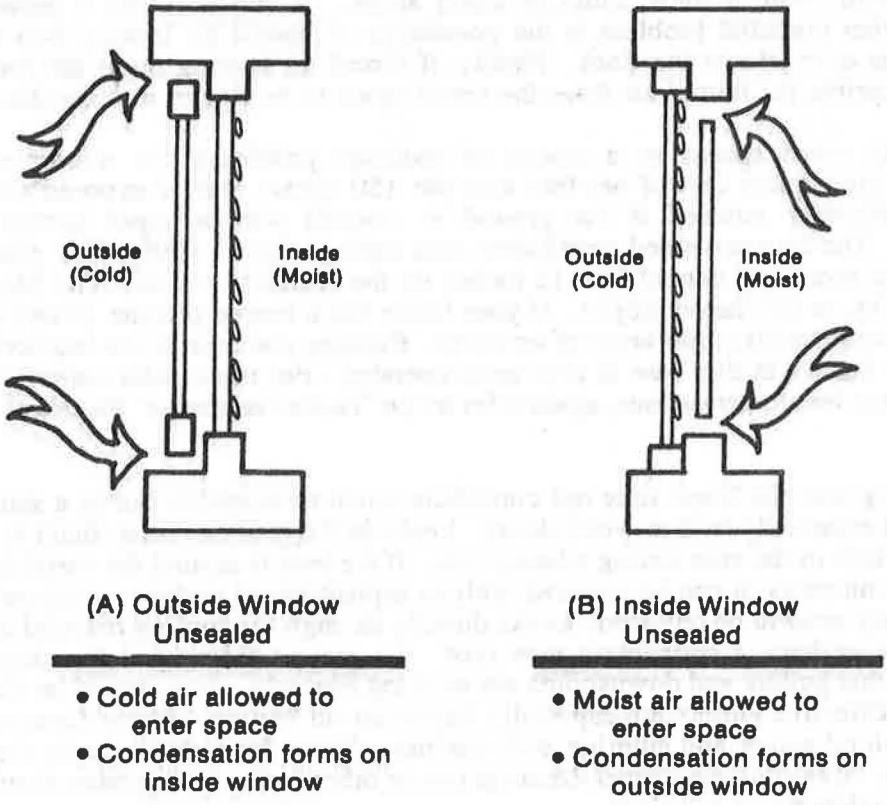
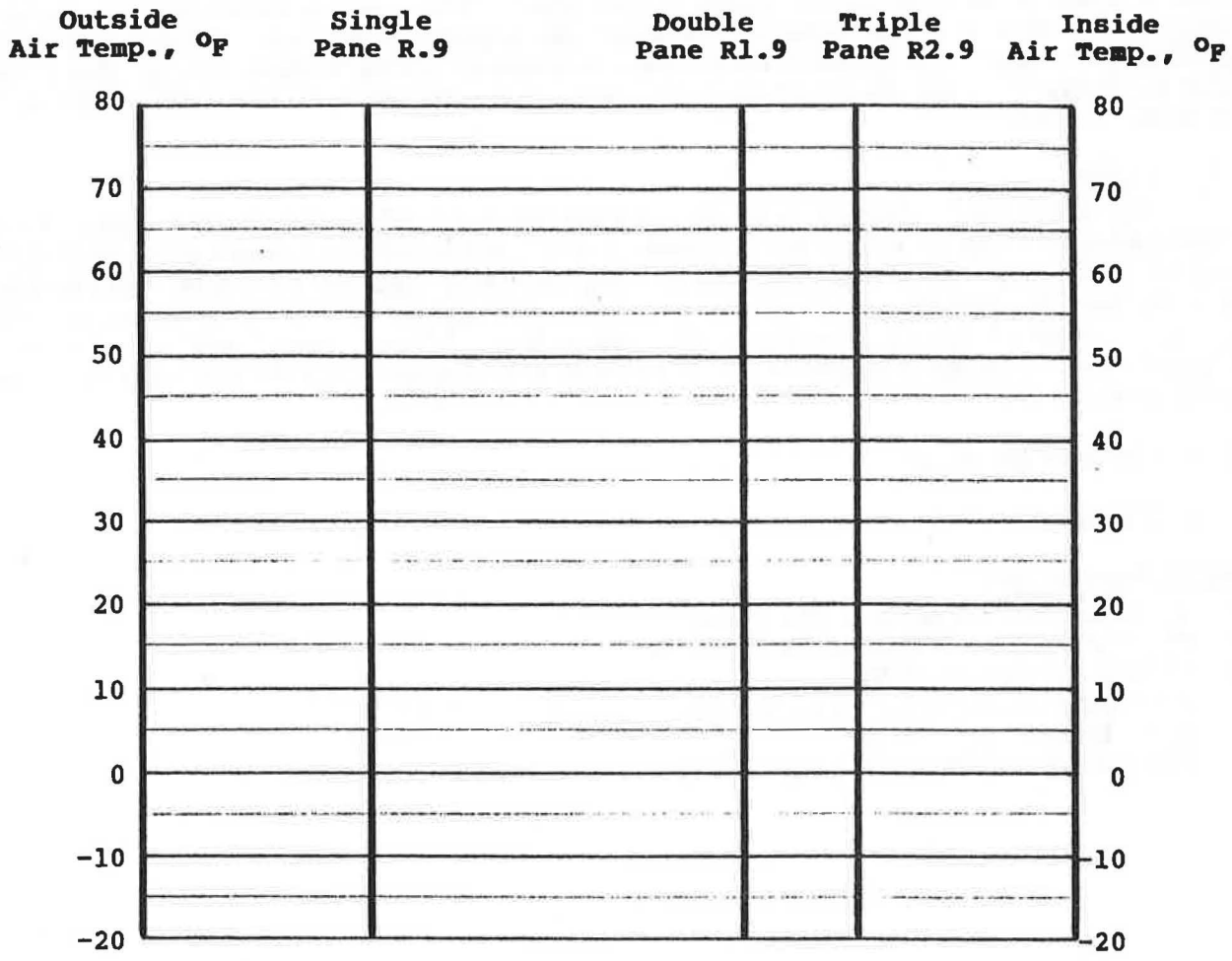


Figure 2. Condensation on Windows

To estimate the temperature of inside window surfaces use the nomograph given in Figure 3. By lining up outside and inside temperatures with a straight edge, inside window temperatures can be read directly from the appropriate reference line for various R-values. Estimating temperatures helps us to predict at what relative humidity we may expect condensation to occur. To illustrate how, let's take one more example. Condensation problems are usually worst at night when both inside and outside temperatures may be lower than during the day. To reflect these worst case conditions, assume 60°F inside and 10°F outside temperatures. Connecting these points on Figure 3 indicates a 38°F inside window temperature with double glazing (or storm windows). If we then wish to determine what level of relative humidity must be maintained to avoid condensation we first refer to Figure 1. Using a 38°F dew point (same as inside window temperature), the corresponding water vapor pressure is 0.24 in Hg. Refer next to Table 1. On the 60°F air temperature line move to the right till reaching 0.24 in Hg. Since 0.24 lies about halfway between 0.26 and 0.21 we estimate that relative humidity should remain below about 45 percent (halfway between 50 and 40 percent) to avoid condensation at these conditions.

Figure 3. Inside Window Temperatures



To find inside window temperature:

Connect known outside and inside air temperatures with a straight line; then read where this line intersects the appropriate glazing line.

Example:

Assume outside air temperature is 20°F and inside is 70°F. Connecting these points, the reference glazing lines are intersected at 32°F (single), 52°F (double), and 58°F (triple). This indicates that the higher the R-value, the warmer the glass and less likely that condensation will occur. If the dew point was say, 50°F, condensation would occur on single pane glass but not on double or triple pane.

If you have metal framed windows, condensation may form on the frames first. This occurs because metal is an even poorer insulator than glass. The result is extremely low metal frame temperatures when it is cold outside. To avoid this situation is not easy. Moisture levels should probably be reduced. To eliminate the problem may require adding a storm window that completely seals the frame from the source of moisture. For more information on this subject refer to WEES Technote TN1005.

SUMMARY

By monitoring humidity with an inexpensive hygrometer and learning when to expect condensation by using the data in this Factsheet, you will be alerted when to take appropriate corrective actions. Moisture problems can sometimes be complex, site specific, and persistent. Finding a solution is somewhat like detective work and may require experimentation. As you review the different strategies presented, try the lower cost alternatives first. Minor repairs, small changes in habits, improved ventilation and inexpensive storm windows will typically solve the vast majority of moisture problems in the home.

Written by: Jack Brautigam

SUGGESTED READING

WEES Publications

- *Air-to-Air Heat Exchangers* (FS-1502)
- *High Performance Windows (January 1988)*
- *Home Insulation* (FS-1102)
- *Preventing Condensation on Metal Frame Windows* (TN-1005)
- *Storm Windows* (FS-1103)
- *Using Dehumidifiers in the Pacific Northwest* (TN-1004)

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