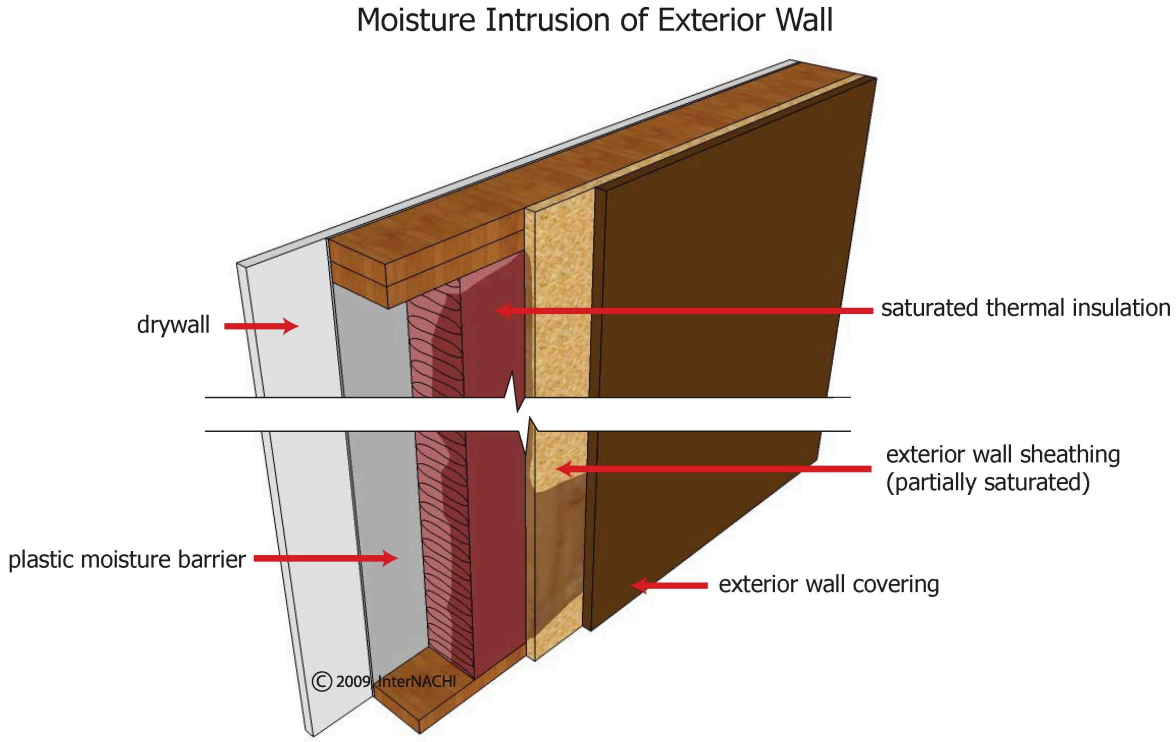
Moisture Movement

By Ben Gromicko



It is important to study moisture in a course that is about inspecting insulation, because wet insulation does not work well. Also, insulation is an important part of the building envelope system, and all parts of that system must work together to keep moisture from causing damage to the structure or creating a health hazard to the occupants. For example, moisture can grow in moist areas and cause allergic reactions to sensitive people and can structurally and cosmetically damage components of a house.

To be able to inspect for moisture intrusion and related problems, an inspector should understand the basics of how moisture can move through a house.

Water vapor moves in only three ways:

1. Air transportation;
2. Diffusion through materials; and
3. Thermal diffusion.

If a builder understands the ways of how water vapor moves and knows what climate the house in which the house is located, then we shouldn't have any major problems with the vapor diffusion retarder that is installed.

The problem is that there are ways to control vapor diffusion that are ineffective at controlling air-transported moisture, and vice versa. An effectively built wall is designed to control both – vapor diffusion and air transportation at the same time in relation to the climate location of the house.

Vapor Diffusion

Vapor diffusion is the how moisture in a vapor state moves through a material because of a difference in pressure (pressure gradient) or a difference in temperature (thermal gradient). Vapor diffusion is not air movement. Vapor diffusion is water vapor moving through a material from a high pressure to a low pressure, or a warm side of a wall to a cool side of the wall. Moisture in air will move from high pressure to low pressure or from high temperature to low temperature only if the air that is moving actually contains the water vapor.

Thermal (or heat) diffusion is when moisture in a vapor state moves from a warm part of an assembly to the cold part. The 2nd law of thermodynamics can explain how water vapor (moisture) can be pressure- and thermally-driven from high (or hot) to low (or cold).

Air Transportation

Diffusion is an important factor to understand, but it is a slow process. Air, however, can move and flow quickly and in large volumes.

Air transportation accounts for more than 98% of all water vapor movement in building cavities. Air naturally moves from a high-pressure area to a lower one by the easiest path possible—generally through any available hole or crack in the building envelope. Moisture transfer by air currents is very fast (in the range of several hundred cubic feet of air per minute). Thus, to control air movement, a house should have any unintended air pathways (holes, gaps, cracks, separations, etc.) carefully and permanently sealed – by a practice referred to in this course as "air sealing."

Diffusion through materials is a much slower processes. Most common building materials slow moisture diffusion to a large degree, although they never stop it completely.

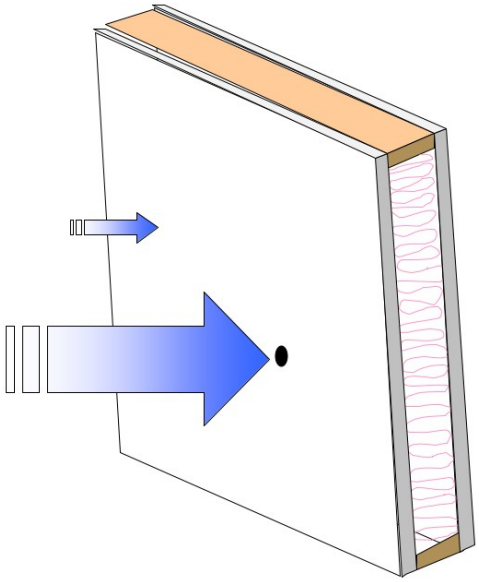


Illustration by Ben Gromicko

Look at this illustration of a wall assembly. Significantly more water vapor travels through a wall by air leakage than by diffusion. The smaller arrow represents vapor diffusion – about 2/3 of a pint of water can travel through a wall during a heating season. The larger arrow represents air leakage through a ½-inch hole - about 50 pints of water can travel through a wall during a heating season. As inspectors, we need to look for air leakage through holes.

The laws of physics govern how moist air reacts within various temperature conditions. The study of moist air properties is technically referred to as "psychrometrics." A psychrometric chart is used by professionals to determine at what temperature and moisture concentration water vapor begins to condense. This is called the "dew point." By understanding how to find the dew point, you will better understand how to inspector for and diagnose moisture problems in a house.

Relative humidity (RH) refers to the amount of moisture contained in a quantity of air compared to the maximum amount of moisture the air could hold at the same temperature. As air warms, its ability to hold water vapor increases; this capacity decreases as air cools. For example, according to the psychometric chart, air at 68ºF (20ºC) with 0.216 ounces of water (H_2O) per pound of air (14.8g H_2O/kg air) has a 100% RH. The same air at 59ºF (15ºC) reaches 100% RH with only 0.156 ounces of water per pound of air (10.7g H_2O/kg air). The colder air holds about 28% of the moisture that the warmer air does. The moisture that the air can no longer hold condenses on the first cold surface it encounters (the dew point.) If this surface is within an exterior wall cavity, wet insulation and framing will be the result. And that's bad.

In addition to air movement, temperature and moisture content can also be controlled. Since

insulation reduces heat transfer or flow, it also moderates the effect of temperature across the building envelope cavity. In most U.S. climates, properly installed vapor diffusion retarders can be used to reduce the amount of moisture transfer. Except in deliberately ventilated spaces, such as attics, properly installed insulation and vapor diffusion retarders work together to reduce the opportunity for condensation in a house's ceilings, walls, and floors.

Moisture Can Be a Problem

When moist air touches a cold surface, some of the moisture that might leave the air and condense (or become a liquid). If the moisture condenses inside a wall, or in the inaccessible attic, you might not be able to see the water, but it will be causing numerous problems.

Don't recommend adding insulation as a quickly remedy to your client too quickly. Adding insulation can cure a problem, or it might cause one. When a wall is insulated, the temperature the space inside that wall is changed. A surface inside that wall, such as the plywood sheathing behind the siding, can become much colder in the wintertime than it was before the wall was insulated. This cold surface could be the place where moisture traveling through wall could condense and cause trouble. The same thing in the wall could happen in the attic.

Four Things Your Client Can Do

There are four general things that your client could do to avoid moisture problems:

1. Prevent Water Intrusion. Water coming into the house, even if it is a small leak, must be stopped.
   - the roof should be in good shape;
   - the exterior windows and doors should be water-tight;
   - gutters should be kept clean;
   - downspouts should divert water far enough away from the house;
   - condensate from the air conditioner should properly drain away;
   - water lawn sprinklers should be adjusted to spray efficiently;
   - caulking around the tub and shower should be checked;
   - exposed dirt in the crawlspace should be covered with a vapor diffusion retarder;
   - all bathroom and kitchen ventilation fans must exhaust outside; and
   - the clothes dryer must exhaust outside and not into the attic.

2. Ventilate. The home needs to be ventilated. Your client will generate moisture when they cook, shower, do laundry, and even breathe. More than 99% of the water used to water plants eventually enters the air. Unvented natural gas, propane, or kerosene space heaters exhaust all the products of combustion including the water vapor directly into the house interior. This water vapor can add 5 to 15 gallons of water per day to the air inside your client's home. Just breathing from a typical family can add about 3 gallons of water per day into the home. Baffles or rafter vents can be used to prevent loose-fill insulation from blocking the attic vents.

3. Stop Air Leaks. It is important to that the air leakage pathways between the living spaces of the house and other parts of the building are stopped or sealed closed. Air leakage into a wall or the attic can carry significant amounts of moisture. If there is air leaking around electrical outlets or around plumbing lines in the wall, moisture can be carried along those same pathways. Ductwork needs to be sealed and insulated, especially if the ducts pass through an unconditioned, unheated space like an attic. Returns ducts should be sealed too. Air sealing is important.

4. Provide a Moisture Path of Escape. An example of a path of escape would be how a typical attic will have vents to provide a path for moisture to escape. Cold air usually contains less water than hot air, so diffusion usually carries moisture from a warm place to a cool place. A wall can be designed to allow moisture to escape from a wall cavity to the exterior to dry during the winter. Or a wall can dry to the indoors during summer by avoiding the use of vinyl wall coverings or low-perm paint.

Conclusion

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For more information about moisture movement and building science, visit us at www.nachi.org/education.