

THE GREAT MOISTURE MOVEMENT

By Joseph L. (Cris) Crissinger, CSI, CCS, CCCA

INTRODUCTION

The moans and groans are deafening. "Oh no! Not another moisture article!" You have probably been exposed to numerous articles and seminars about moisture and are wondering what else can be offered. But it's been said that repetition is the key to retention. Hopefully, interest will be maintained by presenting familiar subject material in a different manner.

Many building owners are enthusiastic about their new "digs," thinking they are airtight and waterproof. Well, their parade is about to get rained on, because that nice new building may not be as airtight and waterproof as they think. Folks, you are about to become involved in the "Great Moisture Movement." It is obvious that the desperate Dutchman in *Figure 1* has both hands and a foot deeply committed to the Moisture Movement.

Volumes have been written about moisture and its movement. This discussion will inform the reader of the various ways that moisture can move in and take up residence



Figure 1: Overwhelmed by the movement.

in a building cavity (assembly), such as the space between the exterior and interior walls. For purposes of this discussion, moisture means water in any one of its three physical states – solid, liquid, and gas. The physical states that affect buildings the

most are liquid and vapor. Although general methods of controlling moisture movement may be mentioned, actual corrective measures are not within the scope of this article.

THE RULES

Moisture movement occurs when it moves from one state or one point to another. Sounds simple enough, doesn't it? How does this happen? Well, let's review a few simple rules regarding moisture movement:

- Moisture flows downhill.
- Moisture looks for an opening.
- Moisture follows the path of least resistance.
- Warm air holds more moisture than cool air does.
- Moisture moves from a higher humidity to a lower humidity.
- Moisture moves from warmer temperature to a cooler temperature.
- Moisture moves from higher vapor pressure to a lower vapor pressure.

Put another way, just think high to low, like the evening weatherman showing a high pressure moving to a low pressure.

Beginning with water in its solid state (ice), if enough heat is added, it changes to water. If more heat is added, the liquid changes to a gaseous state. Removing heat causes the reverse to occur. Therefore, it can be said that heat or the absence of heat is the mechanism that allows water to change states.

When I studied general science in grade school many years ago, we were taught that the earth's surface was approximately 75 percent water. I recently read that the earth's surface is 77 percent water. Now that is moisture movement! Could it be from all of the man-made lakes that have been constructed or all of those thirsty folks carrying bottles of water everywhere?

METHODS OF MOVEMENT

Moisture does not just enter a building assembly as an obvious cascading liquid flow. Sometimes it has more subtle ways of making a grand entry, such as:

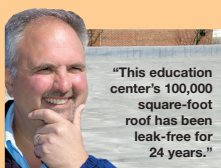
- Catching a ride in moving air.
- Moving up a concrete foundation as capillary action.
- Hiding as invisible moisture in vapor diffusion.

Generally, moisture will move through any building material that is porous or fibrous, such as wood, brick, concrete, fibrous insulation, and drywall. It just moves through some porous materials faster than through other porous materials. The cell structure of the building material determines which state of moisture will move through a material and how easily it

will move through the component. Materials that do not completely block moisture movement and allow some moisture transmission are called "retarders" because they only retard or slow transmission. Materials that block moisture transmission are called barriers because they form a barrier to stop moisture movement.

For discussion purposes, four methods of moisture movement will be considered, and any one of them can dampen your sprits. The four methods are as follows:

1. Air Movement
2. Capillary Action
3. Liquid Flow
4. Vapor Diffusion



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Air Movement

Under the right conditions, air movement can move moisture into the building assembly from both exterior and interior sources. However, air movement cannot deposit moisture into a building assembly unless the following conditions exist:

1. The moving air contains moisture.
2. There is some type of opening in the building shell.
3. There is a difference in air pressure as measured across the opening.

Moisture gets in exterior air from surrounding soil that obtains its moisture from weather events such as rain, snow, hail, heavy dew, etc. Moisture enters the interior air from normal occupancy activities, such as drying clothes, cooking, taking showers, and normal bodily functions such as breathing and perspiring.

Openings in the building shell include intentional openings, such as doors and windows, and unintentional openings, such as cracks and missing components, such as brick, sealant, etc.

Difference in air pressure is a function of temperature and absolute humidity. Absolute humidity is the actual amount of moisture in a given volume of air, regardless of temperature. Excluding the effects of condensation, changing the temperature or volume of the air will not change the quantity of moisture in the air. Relative humidity is measured in percent and represents the amount of moisture in a given volume of air at a specific temperature as relative to the amount of moisture that volume of air can actually hold at that temperature. In other words, relative humidity is the ratio of moisture actually in the air to the amount of moisture that the air will hold. Changing the temperature or volume of the air will

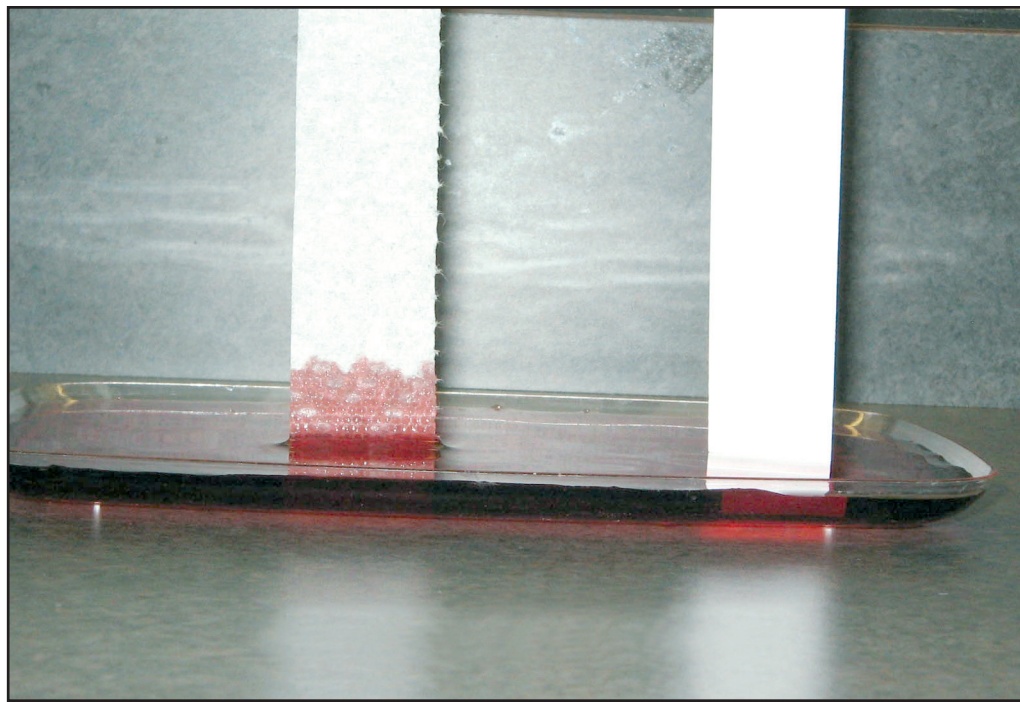


Figure 2: Capillary action.

change the relative humidity.

Air movement can be controlled by one of or a combination of the following methods:

1. By reducing the amount of moisture in the air.
2. By controlling size, location, and number of openings in the building.
3. By controlling the pressure differential across the opening.

Capillary Action

A tube that has an opening the approximate size of a hair is a capillary (a derivative of the Latin word capillaries, meaning “hair-shaped.”) Capillary action or suction occurs in porous materials, such as masonry, concrete, and wood. Remember the paper towel commercial that shows how one paper towel absorbs better

than another. That demonstrates capillary action. Figure 2 shows a comparison of the capillary action of a paper towel on the left and that of ordinary cotton stationery on the right. Note how the colored water rises

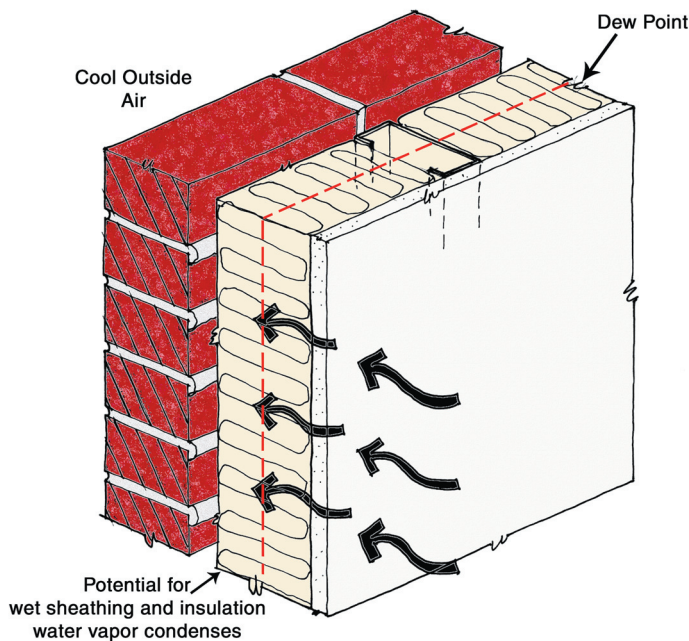


Figure 3: Insulated assembly without vapor retarder.

higher than the level of the colored water in the container. Capillary action depends on the size of the pores and the amount of moisture available and can occur above grade and below grade. Surprisingly, increasing the pore size does not increase capillary action. Actually, the opposite happens if pore size is increased. Thus, a burlap bag does not absorb water as well as the paper towel.

It is possible to set up capillary action with materials that, individually, do not support capillary action. For instance, when two pieces of aluminum, vinyl, or painted wood siding are installed with overlapping edges in ship lap fashion, the space where the siding overlaps can become a simple capillary that can allow moisture to enter the building assembly. In this situation, there can be a small enough gap between the overlapping edges to allow water to drain off the surface of the siding, over and under the edge, and then be sucked up between the two edges and into the structure.

Capillary action can exist above grade and below grade, but it seems to be more aggressive in below-grade conditions.

Below-grade Capillary Action: This can occur when ground water is absorbed

by concrete or masonry footings, then migrates, by capillary action, through the foundation walls and into a concrete slab or wood floor, and eventually seeps into the building assembly or even evaporates into the building interior.

Above-grade Capillary Action: Above-grade capillary action includes conditions such as moisture being deposited on the face of exterior brick. A brick's anatomy includes a maze of small pores that suck up the moisture with no help from outside forces, such as wind or gravity. The capillaries carry the moisture through the brick and into the building assembly.

Controlling Capillary Action: Capillary action can be controlled by:

1. Reducing or eliminating moisture.
2. Plugging the pores.
3. Increasing pore size.

Liquid Flow

Liquid flow is probably the most dynamic method of moisture movement. *Figure 1* suggests liquid flow in an extreme condition. It involves both groundwater and rainwater reacting to outside forces such as gravity, wind, or air pressure differential.

Controlling

Liquid Flow: Liquid flow from groundwater can be controlled by installing one of or a combination of the following:

1. Drainable backfill such as coarse gravel.
2. Control joints in concrete to control cracking.
3. Drainable building materials, such as specialty drainage products, grooved rigid insulation, etc.
4. Perforated piping that ties into the building storm drainage.
5. Waterproofing membranes.

Liquid flow from rainwater can be controlled by providing proper roof drainage and surface water runoff, by how a building is sited, etc.

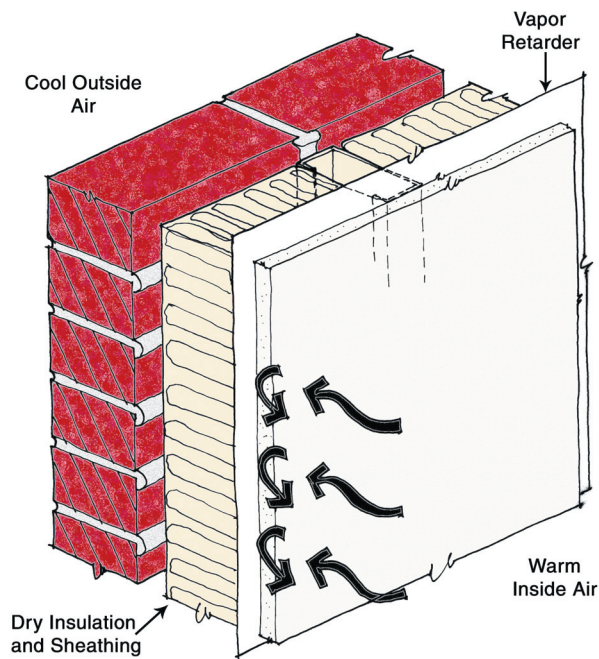


Figure 4: Insulated assembly with vapor retarder.

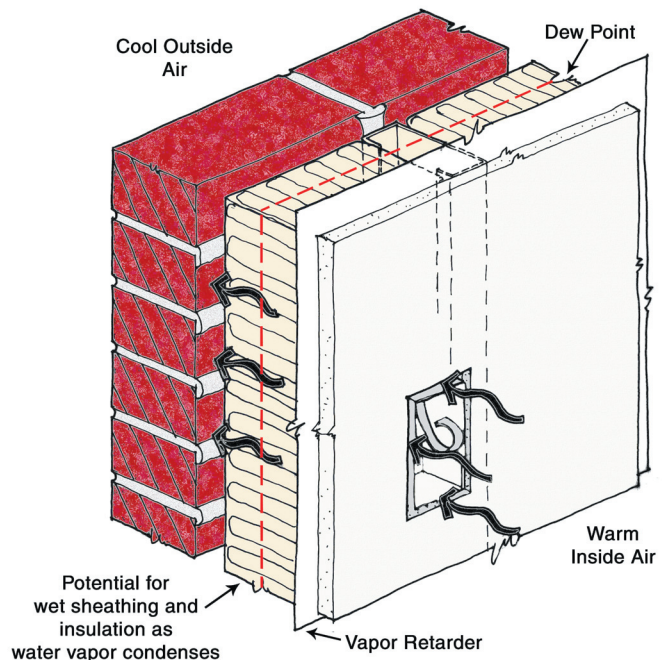


Figure 5: Water vapor movement by air leaks.

Building Material & Thickness	Perm Rating in Perms (per ASTM E-96)
Aluminum foil, 1 mil	0.0
Polyethylene, 6 mil	0.06
Kraft facing, asphalt-coated, dry cup	0.3
Exterior plywood, 1/4 inch	0.7
Brick, 4 inch	0.8
15-pound asphalt felt, dry cup	1.0
Polystyrene, 1 inch	1.2
Alkyd paint, primer plus finish coat	1.6 to 3.0
Plaster on metal lath, 3/4 inch	15
Gypsum wallboard, 1/2 inch	50.0

Table 1 - Perm rating of building materials (from the ASHRAE Fundamental Handbook).

Perm Rating in Perms (per ASTM E-96)	Performance Category
Less than 0.1	Impermeable
1 to 10	Semi-permeable
More than 10	Permeable or Breathable

Table 2 - Material categories based on perm rating.

Vapor Diffusion

Vapor diffusion can also move moisture into the interior building assembly from the interior conditioned space and from the exterior.

Diffusion occurs when a vapor pressure exists across a material that has a high permeance rating. The amount of moisture passed depends on the material's perm rating, the vapor pressure differential, and the area of the material. The perm rating of a material is its ability to resist moisture movement. Thus, materials that block only a portion of moisture transmission are often called vapor "retarders" because they retard, but do not stop, vapor movement. A vapor barrier stops or at least reduces mois-

ture movement. Figures 3, 4, and 5 illustrate how vapor diffusion may react to a wall assembly without a vapor "retarder," a wall assembly with a vapor "retarder," and to an interior finish wall with an opening.

Table 1 lists the perm ratings, from the lowest to the highest, for common building materials. The rule to remember is: The lower the number, the better the performance.

As shown in Table 2, building materials are sometimes referred to as impermeable, semi-permeable, or breathable. By applying the materials with their perm ratings listed in Table 1 to the categories listed in Table 2, polyethylene would be considered to be impermeable; brick, semi-permeable; and plaster, breathable.

It is possible for a material to provide waterproofing, but not be a vapor "retarder" or vapor barrier. Vapor diffusion can be controlled above and below grade with vapor "retarders" or barriers.

Typically, in a heated space that is in a cold climate, vapor diffu-


sion is from the warm interior to the cold exterior. In a cold space that is in a warm climate, vapor diffusion is from the warm exterior to the cool interior.

However, there are exceptions to this rule. For instance, when the sun (yes, the sun does shine up north) heats exterior brick that has been wetted by dew, rain, snow, etc., the heated brick warms the moisture in the brick, thus driving the moisture into the cooler building assembly. Even buildings with heated interior spaces in a cold climate can be subject to this phenomenon.

The temperature of the brick and the moisture within the brick can exceed the temperature of the heated interior, which creates a pressure differential between the interior and exterior. When this happens, moisture can move from the warmer surface of the brick to the cooler building assembly and possibly into the building interior. This phenomenon is one of the main reasons why interior finishes – such as latex or acrylic paint on an exterior wall – should be breathable, and why vinyl wall covering as an interior finish on an exterior wall may be a recipe for trouble.

Actually, this would be true for any type of wall construction that passes vapor, including EIFS and precast concrete. Finish materials that do not breathe can act as a vapor retarder and trap moisture behind them. Perforated vinyl wall covering is often marketed as breathable. However, it only breathes through the perforations, which can become clogged when painted. Most latex paints can be recoated multiple times and still remain breathable. Furthermore, depending on the building assembly, the wall cavity can act as a duct and provide a passage for moisture to move into an interior wall partition assembly.

SUMMARY

Like an enthusiastic shopper, moisture is always on the move. When I served in submarines, a frequent question that was asked during a candidate's qualification examination was, "What is the difference between a leak and a flood?" Of course, the correct answer was, "If I find the water, it's a leak. If the water finds me, it's a flood." Knowing how moisture moves through a building assembly will allow proper moisture control through careful design and selection of materials, and will allow you to find the moisture before it finds you. 

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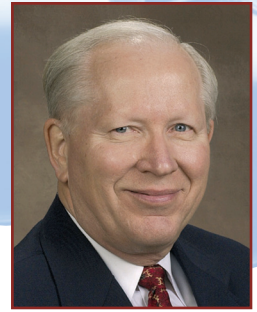
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ACKNOWLEDGEMENTS

I extend my sincere gratitude to Charlie Martin, AIA, of McMillan Smith & Partners Architects for creating the graphics that illustrate the principles of moisture movement; to Angela Napolitano of McMillan Smith & Partners Architects for adding computer graphics; and to my wife, Linda, for editorial review. Their time and contributions to this article are truly appreciated.

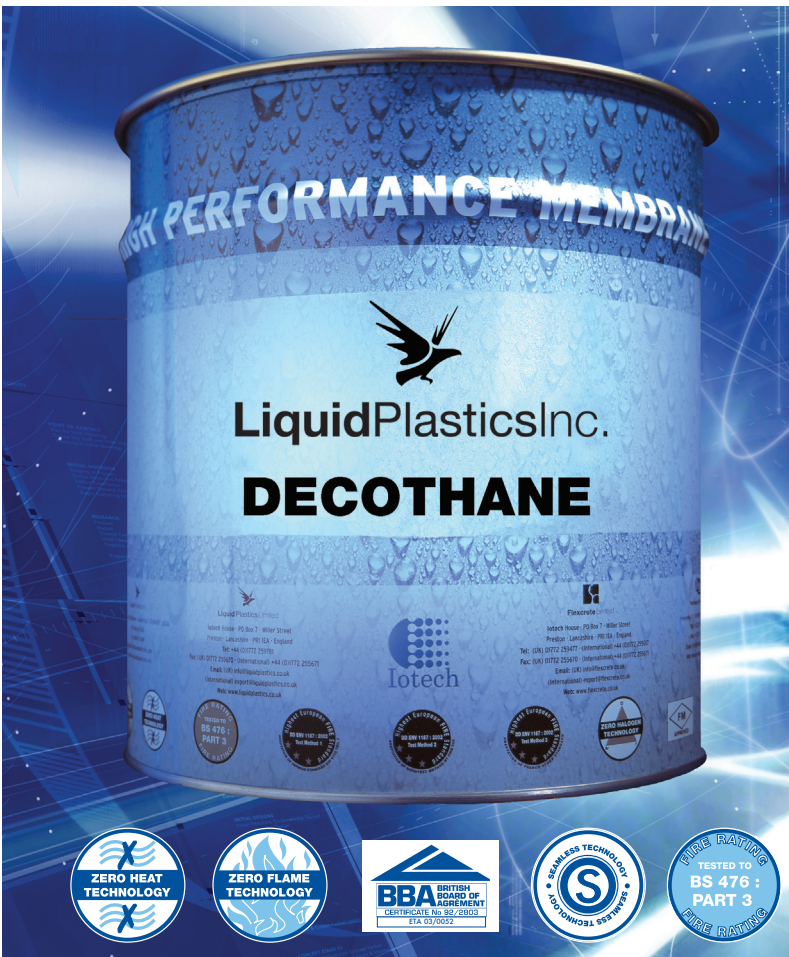
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