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Protecting the Building Envelope from Water Damage

Vapor Retarders Play a Crucial Role in Moisture Management

Whether we like it or not, moisture in the form of water vapor diffusion and humid air transport is a force of nature and an ongoing threat to the structural integrity and thermal efficiency of buildings. Water vapor naturally moves, or diffuses, through permeable building materials from areas of high pressure to areas of low pressure. For example, during cold weather, warm interior vapor is drawn through a building's wall assembly to the colder, drier exterior. In the process, the vapor often condenses, leaving moisture trapped in the wall cavity, a catalyst for many factors that could eventually compromise the sustainability of a building.

> The damage potential of water vapor transmission is not something to overlook.

Extended exposure to moisture can decrease the thermal efficiency of the building insulation and decrease its R-value. Moisture can eventually cause the decay of wood-based building components and corrosion of steel structural members. Most importantly, it can spur the growth of mold, which propagates quickly, using cellulose-based materials, such as wood and standard paper-faced gypsum board as a food source. Mold spores from wall cavities can also become airborne and cause respiratory ailments among building occupants. The damage potential of water vapor transmission is not something to overlook.

Building and design professionals can strive to avoid such problems by incorporating effective moisture management strategies into wall assemblies. One very important step is the inclusion of an appropriate vapor retarder.

VAPOR RETARDERS: WHAT ARE THEY?

The main purpose of a vapor retarder is to impede the flow of moisture vapor through the wall section and to protect the building envelope from condensation damage, as many wall assembly components are permeable. In addition to this, a properly installed vapor retarder can also serve as an interior air barrier, reducing the potential for air to transport moisture into insulated cavities during the winter season.

Vapor retarder materials are rated in perms, the unit of measurement for its water vapor permeance. The test method for determining the water vapor permeance of any building material is ASTM E96 Standard Test Methods for Water Vapor Transmission of Materials. This measures diffusion using two possible means — the dry cup method, also known as Method A or desiccant method, and the wet cup method, also referred to as Method B or the water method. A perm rating for a material is equivalent to the number of grains of water vapor (7000 grains = 1 pound) that will pass through 1 square foot of the material in one hour when the vapor-pressure differential between two sides of the material equals 1 inch of mercury (0.49 psi). So, the lower the perm rating, the more successful it is at impeding moisture transmission.

Historically, two North American building codes, the International Code Council (ICC 2003) and the National Building Code of Canada (Canadian Commission on

FEATURED PRODUCTS

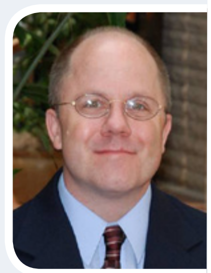
MemBrain™ Smart Vapor Retarder & Air Barrier Film

DATE

September 2009

MemBrain™ in hybrid wall application.

AUTHOR



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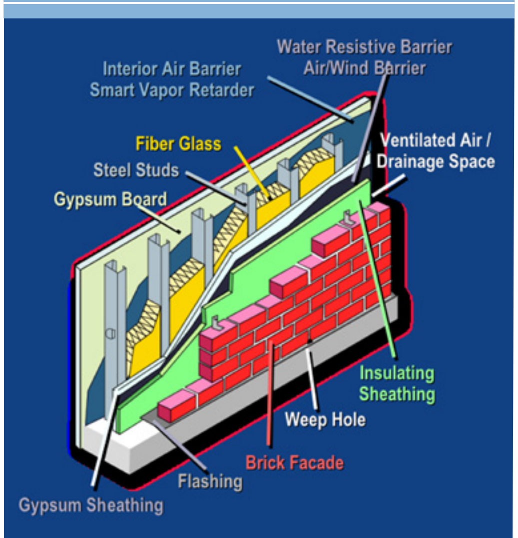

The steel stud cavity assembly is the most common commercial wall construction. For the best moisture management performance, such assemblies should always consist of a water-resistive barrier, insulating sheathings, exterior air/wind barriers, interior air barriers and a smart vapor retarder to not only control the wintertime moisture but also to allow assemblies to breathe during other seasons.

Building and Fire Codes 2005) require that vapor retarders have a water vapor permeance of 1 perm or less when tested in accordance with ASTM E 96 (2005) using standard dry cup conditions of 0 and 50 percent relative humidity, creating a mean relative humidity of 25 percent.

Throughout the building community, vapor retarders are often used interchangeably with the term "vapor barrier," any material that prevents the transmission of water vapor through walls, ceilings and floors. This is somewhat of a misnomer, however, as most of the materials referred to as vapor barriers will permit some vapor transmission. Even 6-mil polyethylene, one of the most common vapor barrier materials, has a .06 perm rating and can therefore be considered a vapor retarder, despite its extremely low permeance.

The 2007 supplement to the 2006 International Residential Code (IRC) provides a new rating system for vapor retarders regarding their permeance:

Class I

Class I covers materials most frequently referred to as vapor barriers. These vapor retarders have a permeance level of 0.1 perm or less and are considered impermeable. Examples include polyethylene film, glass, sheet metal, foil-faced insulation sheathing and non-perforated aluminum foil.

Class II

Class II vapor retarders have a permeance level between 0.1 perm and 1 perm and are considered semi-impermeable. Examples include unfaced expanded polystyrene, fiberfaced polyisocyanurate and asphalt-backed kraft paper facing on fiber glass batt insulation.

Class III

Class III vapor retarders have a permeance rating between 1 perm and 10 perms and are considered semi-permeable. This class includes most latex paints over gypsum board, #30 building paper and plywood. There are specific conditions listed in the 2006 International Energy Conservation Code (IECC), which state where Class III vapor retarders are allowed — when design conditions exist that promote drying through the use of ventilated claddings or reduce closed-cavity condensation potential through the use of exterior insulating sheathings. Refer to Figure 1 for a map of climate zones throughout the United States that determine vapor retarder choice and placement. The table in Figure 2 summarizes the climate zone specific combinations of

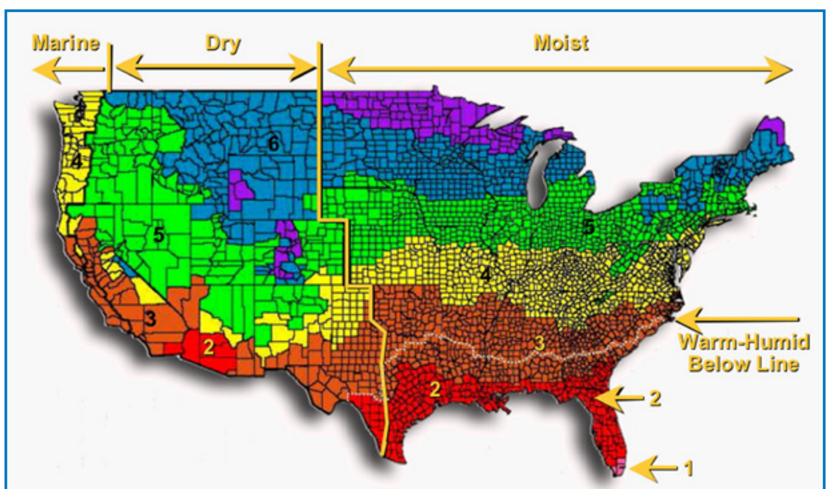

Figure 1. Above is a map of climate zones throughout the United States that determine appropriate vapor retarder choice and placement.

vented claddings, exterior sheathing materials and insulated sheathings that permit the use of Class III vapor retarders.

Any material with a permeance rating of over 10 perms is considered permeable. Figure 3 provides a visual representation of popular vapor retarder materials and how they rate on a permeance scale.

These classifications make it easier for building and design professionals to choose the proper vapor retarder for their particular project. Now, when it comes to the specific positioning of the vapor retarder in the wall assembly, another important factor comes into play — the regional climate of the project location.

VAPOR RETARDERS BY CLIMATE

Climate has a major influence on the positioning and the type of vapor retarders in the exterior wall assembly. In cold climates, vapor retarders should be placed at the interior of the building envelope — condensation occurs as water vapor moves from the warm side of the wall to the cold side, and this helps prevent it. It's best to avoid Class I vapor retarders, such as polyethylene film or aluminum foil, in these circumstances: in climates with high summertime moisture loads, in building envelopes with moisture storage claddings, such as concrete or brick; and in building envelopes with low-permeability exterior sheathings, such as extruded polystyrene.

In mixed-humid climates, it is best to first determine whether the climate is heating- or cooling-dominated. If the project is located in a heating-dominated climate, the vapor retarder should be placed at the interior. But, if the project is in a cooling-dominated climate, the vapor retarder should be placed at the exterior of the building envelope or left out entirely. One of the best choices in these climates is a semi-permeable vapor retarder, such as asphalt-coated kraft paper, which is usually attached to faced fiber glass batt insulation. Another choice might be vapor-retarding paint. It is important to remember, though, in a mixed-humid climate, to avoid using low-permeance poly film or aluminum foil.

CLIMATE ZONE	ALLOWANCE OF CLASS III VAPOR RETARDER
Marine 4	Vented cladding over OSB Vented cladding over Plywood Vented cladding over Fiberboard Vented cladding over Gypsum Insulated sheathing with R-value ≥ R2.5 over a 2x4 wall Insulated sheathing with R-value ≥ R3.75 over a 2x6 wall
5	Vented cladding over OSB Vented cladding ove Plywood Vented cladding over Fiberboard Vented cladding over Gypsum Insulated sheathing with R-value ≥ R5 over a 2x4 wall Insulated sheathing with R-value ≥ R7.5 over a 2x6 wall
6	Vented cladding over Fiberboard Vented cladding over Gypsum Insulated sheathing with R-value ≥ R7.5 over a 2x4 wall Insulated sheathing with R-value ≥ R11.25 over a 2x6 wall
7 and 8	Insulated sheathing with R-value ≥ R10 over a 2x4 wall Insulated sheathing with R-value ≥ R15 over a 2x6 wall

Figure 2. Climate zone-specific combinations of vented claddings, exterior sheathing materials and insulated sheathings that are appropriate for Class III vapor retarders.

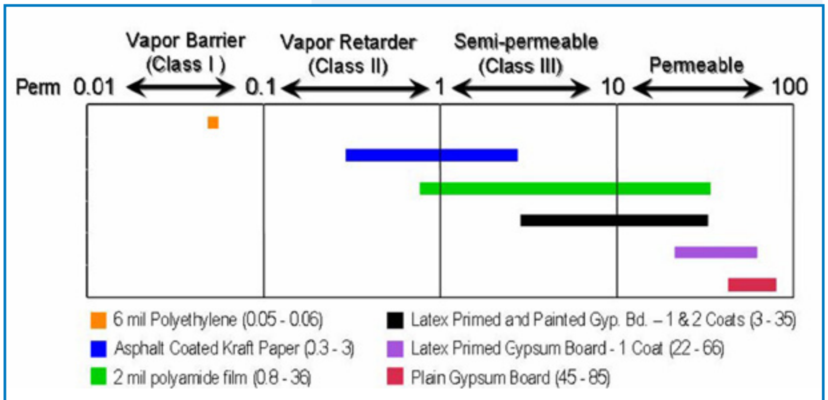

Figure 3. The above chart shows where the most common vapor retarder materials stand in the most current vapor retarder permeance rating system established by the 2007 supplement to the 2006 International Residential Code.

In mixed-dry climates, most of the time, a vapor retarder is not required because rainfall is light and humidity tends to be low. It's still a good idea to check the local building code, as it may require the vapor retarder to be installed at the interior. In a hot, humid climate, the recommendation is to place the vapor retarder at the exterior, outside of the cavity insulation. Rounding out the list, in hot-dry climates, a vapor retarder is not required.

MemBrain™ is a smart vapor retarder that changes its permeability to water vapor as ambient humidity changes.

SMART VAPOR RETARDERS

While low-permeance vapor retarders strongly resist the flow of water vapor through the wall assembly year-round, they also reduce the potential for summertime drying of wet building materials. During the summer, when the sun is more powerful, exterior surfaces of buildings are warmed, often to the point where the exterior is warmer than the interior, thus creating a reverse vapor drive into the interior. This is especially true in mixed-humid climates.

> Climate has a major influence on the positioning and the type of vapor retarders in the exterior wall assembly.

Ideally, a moisture management strategy in a mixed-humid climate would include a breathable wall cavity, featuring airtight drywall construction with a slightly more permeable vapor retarder that allows some moisture diffusion. Drying could occur via vapor diffusion in either direction, and the vapor retarder would actually adapt to varying conditions in humidity. With this concept in mind, some building product manufacturers have developed new smart vapor retarders, which react to changes in relative humidity by altering their physical structure to provide the best moisture flow protection for each season of the year. Originally developed, tested and commercialized in Europe, smart vapor retarders look like polyethylene film, but are actually polyamide, a nylon-based material. The nylon content gives it high tensile strength. (A 2-mil sheet of polyamide has equivalent strength properties to a 6-mil polyethylene sheet.)

Polyamide film retards moisture under dry conditions, usually with a Class II perm rating. However, as relative humidity increases above 60 percent, they dramatically open up to a much higher permeance, which allows drying toward the inside living space of the home. In conditions of low relative humidity, the film's plastic molecules form a tight, impermeable network (1 perm or less using ASTM E96, dry cup method). As soon as the film comes into contact with moisture (60 percent relative humidity), it swells up and becomes soft as the polar water molecules penetrate between the nylon molecules. As a result, the nylon acquires pores through which further water molecules can penetrate, and the permeance increases to greater than 10 perms when tested in accordance with ASTM E96, wet cup method. In summer, when the air is humid, the moisture penetrates through the pores into the building interior, allowing building materials to dry out. If the relative humidity decreases, the pores close up again, and the membrane then acts as a retarder to moisture. In the winter, this retarder protects the building materials behind the membrane from condensation.

Field tests have proven that smart vapor retarders effectively reduce the risk of moisture damage in the building envelope by increasing the construction's tolerance to moisture load. It is appropriate in cold and mixed climates, but it isn't suited for hot climates with high outdoor humidity, as it would always be under high relative humidity conditions. Therefore, it would always be permeable and would not provide vapor retarding benefits. It also would not work well in buildings with exceptionally high, constant indoor humidity levels, such as swimming pools and spas. However, in rooms with short peaks of high humidity, such as bathrooms and kitchens, the smart retarder's performance would not be affected because of the buffering action of interior finishes.

> Smart vapor retarders react to changes in relative humidity by altering their physical structure to provide the best moisture flow protection for each season of the year.

PREDICTING AND GAUGING MOISTURE PERFORMANCE

When designing a building envelope, one of the best tools for predicting its moisture management performance is hygrothermal analysis. Hygrothermal analysis predicts the impact of transient heat and moisture transfer on building envelopes over time. It may be used on new construction projects during the planning stages and on existing buildings with moisture problems. It involves specialized software that helps the user visualize such factors as: surface condensation and mold growth potential; the wetting and drying potential of the building envelope; and moisture content of building components. This analysis helps building designers evaluate potential pre-construction moisture risks. Resulting reports should conform to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 160-2009 "Criteria for Moisture-Control Design Analysis in Buildings."

CONCLUSION

Vapor retarders are an excellent example of building components that have improved with time, as new technology has developed. As we gain a greater understanding of the importance of a dry building envelope to the sustainability and energy efficiency of a structure, we also see the need for today's higher performance vapor retarders in exterior wall assemblies. A building with an effective moisture management strategy and the proper vapor retarder is a healthier, sustainable building.

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