BRAINY MEMBRANE

A vapor retarder that changes permeability with changing relative humidity provides added protection against moisture problems in exterior walls.

BY MARC ZULUAGA

In cold climates such as Wisconsin's, the common practice of installing vapor retarders on the room side of wall insulation reflects the reality that indoor air humidity is higher than outdoor air humidity for much of the year. In this case, kraft paper or polyethylene vapor retarders restrict the diffusion of water vapor from household moisture sources into wall cavities. However, even if cold-climate building assemblies tend to dry to the outside, there are often times when there is a potential for drying to both the outside and the inside. In the case of a 2 x 4 bottom plate that is saturated due to a water leak, an interior vapor retarder eliminates the possibility of significant drying to the inside. All else being equal, that bottom plate will stay wetter longer if it can dry only to the outside than it will if it can dry to both the outside and the inside. In addition, there can be instances where there is a potential for building assemblies to dry to the inside but no potential for drying to the outside. Even cold climates have sunny and humid afternoons when the outside environment acts as a moisture source instead of a drying agent. When moisture is driven into a building assembly from the outside and an interior vapor retarder does not allow for significant drying to the inside, there will be moisture accumulation until outdoor conditions change.

There is a growing awareness in the building science community that moisture management involves both minimizing the wetting rate and maximizing the drying rate of building assemblies. In recognition of this best practice design approach, CertainTeed has commercialized a new nylon-based vapor retarder product that changes its properties

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(top and bottom) In 2004, the MemBrain vapor retarder was installed in a Veridian prototype house. The walls were insulated with blown-in fiberglass, supported by CertainTeed's OPTIMA Fabric.

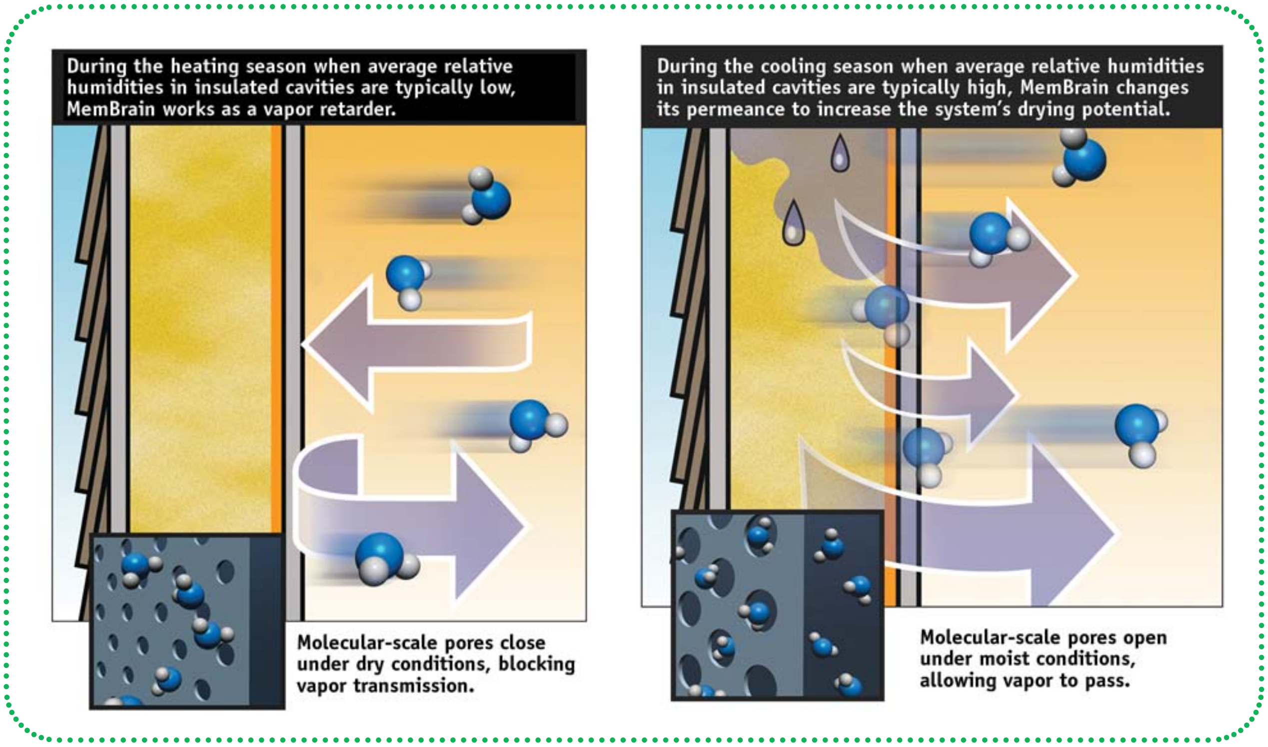

Figure 1. When outdoor RH is low—during the winter, for example—the MemBrain acts like a conventional vapor retarder and restricts the diffusion of water vapor from household moisture sources into a building assembly. When RH is high, whether this is due to hot and humid outdoor conditions or to a water leak, pores in the MemBrain material expand to allow drying to the inside.

depending on the surrounding relative humidity (RH) levels (see Figure 1). When outdoor RH is low—during the winter, for example—the MemBrain acts like a conventional vapor retarder and restricts the diffusion of water vapor from household moisture sources into a building assembly. When RH is high, whether this is due to hot and humid outdoor conditions or to a water leak, pores in the MemBrain material expand to allow drying to the inside. As RH increases, so does the permeability of the MemBrain material; that is, the more critical it is to increase the drying rate of a building assembly, the more drying to the inside the MemBrain allows. The MemBrain vapor retarder has been used widely in Europe for more than ten years.

With funding from DOE's Building America program, the company I work for, Steven Winter Associates, Incorporated (SWA), recently evaluated the performance of CertainTeed's MemBrain vapor retarder in a Madison, Wisconsin, prototype house built by Veridian Homes. Veridian is an industry leader in high-performance production housing through its active participation in the Building America program and the U.S. Green Building Council's LEED for Homes pilot program.

With Veridian, SWA wanted to evaluate performance differences between MemBrain and polyethylene when implemented in U.S. housing in a cold climate. In 2004, the MemBrain vapor retarder was installed in a Veridian prototype house (see photos, p. 37). The walls were insulated with blown-in fiberglass, supported by CertainTeed's OPTIMA Fabric. Tyvek house wrap on top of oriented strand board (OSB) sheathing formed the exterior drainage plane for the wall system, which was finished with vinyl siding.

In one south-facing wall section, polyethylene was installed instead of the MemBrain vapor retarder. The resulting performance of the side-by-side installations of the polyethylene and MemBrain in south-facing wall sections was monitored with temperature and RH sensors installed at various locations. Data from these sensors have been analyzed in order to evaluate the moisture performance of the two different vapor retarder systems over a typical winter period, over a worst-case summer day, and over the course of a full annual cycle.

Typical Winter Performance

Measured outdoor air temperatures and solar radiation over two typical winter days illustrates winter conditions (see Figure 2). The first day was cold and cloudy, while the second day was cold and sunny. The resulting RH between each vapor retarder and the fiberglass cavity insulation over these two winter days illustrates the performance of the two vapor retarders (see Figure 3). During this period, indoor conditions were maintained at a fairly constant 40% RH. Throughout the first day and most of the second day, the level of house air RH was significantly higher than the RH level behind the vapor retarders. The large decrease in RH across both vapor retarders indicated that they were both working

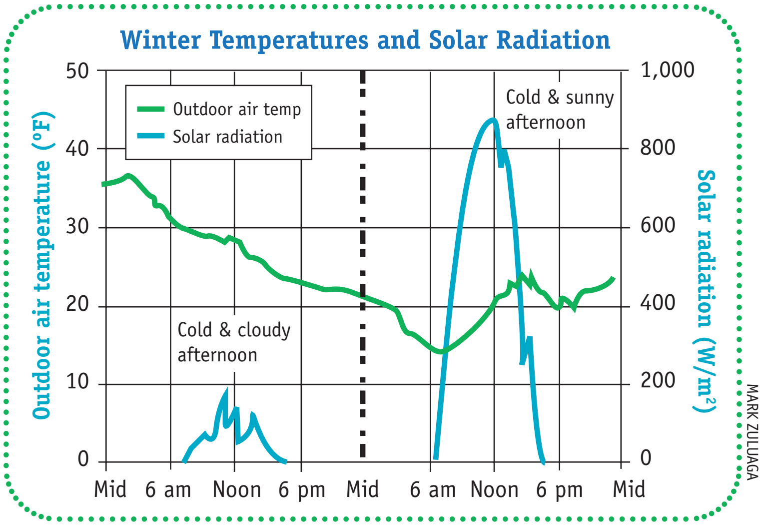

Figure 2. Outdoor air temperatures and solar radiation on one cloudy and one sunny day illustrate winter conditions.

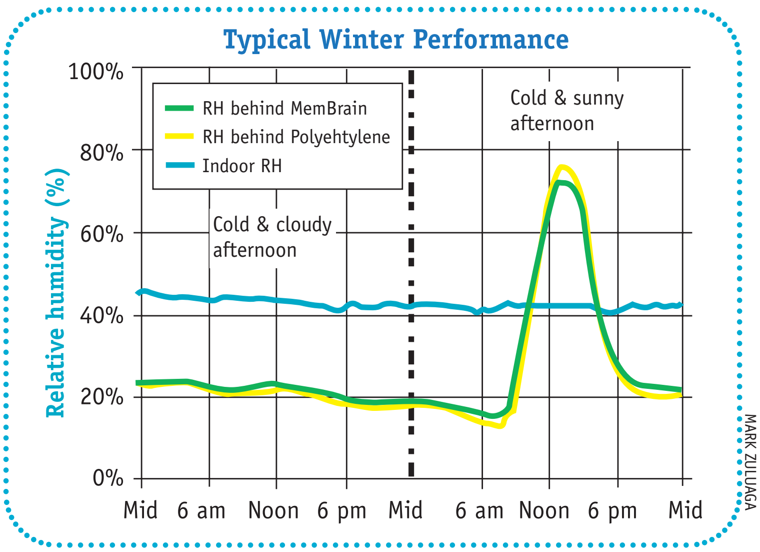

Figure 3. The MemBrain was just as effective as the polyethylene vapor retarder at limiting the diffusion of house moisture into the wall cavity.

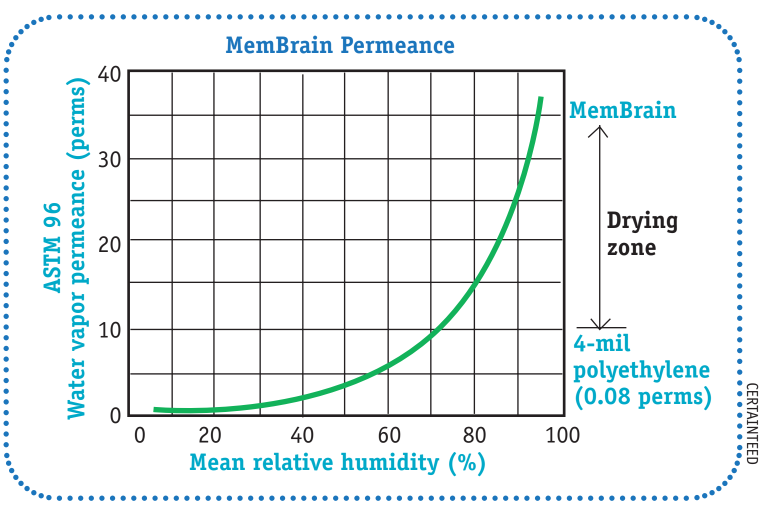

Figure 4. The properties of the Membrain material differ most from those of polyethylene at higher RH levels.

effectively at limiting the diffusion of house moisture into the wall cavity. However, it is interesting to note that during the sunny afternoon conditions on the second day, the RH behind both vapor retarders was higher than the indoor RH. During these few hours, solar radiation acting on the south wall of the building drove moisture into the wall system from the outside.

During these sunny afternoon conditions, the MemBrain vapor retarder did not significantly reduce the buildup in humidity behind it compared to the polyethylene—probably because the properties of the MemBrain material differ most from those of polyethylene at higher RH levels (see Figure 4).

Two primary observations can be drawn from the performance monitoring during typical winter conditions:

1. The MemBrain was just as effective as the polyethylene vapor retarder at limiting the diffusion of house moisture into the wall cavity.

2. Even on a 20ºF afternoon in Wisconsin, solar radiation can act to drive moisture into a wall system from the outside.

Worst-Case Summer Performance

The measured RH between each vapor retarder and the cavity insulation during a worst-case humid and sunny August day illustrates the summer performance of the vapor retarders (see Figure 5). In response to afternoon solar-driven moisture, the humidity buildup behind the MemBrain vapor retarder was significantly less severe in both magnitude and duration than the corresponding humidity spike behind the polyethylene. Because polyethylene does not allow for significant drying to the inside, the RH behind it began to decrease only at the end of the afternoon, when the sun went down. The impact of solar-driven moisture is, of course, most significant in south-facing walls.

Annual Performance

SWA analyzed the performance difference between the two wall systems over the course of a full annual cycle (2005). The frequency in the distribution of RH between each vapor retarder and the fiberglass cavity insulation is presented in Figure 6. From this figure, it is clear that for the vast majority of the hours of the year, the RH behind both vapor retarders was less than 70%.

Thus there is no great difference in the performance of the two systems for most of the year. However, there is a dramatic difference in the performance of the two systems for a relatively small, but significant, number of hours of the year (see Fig-

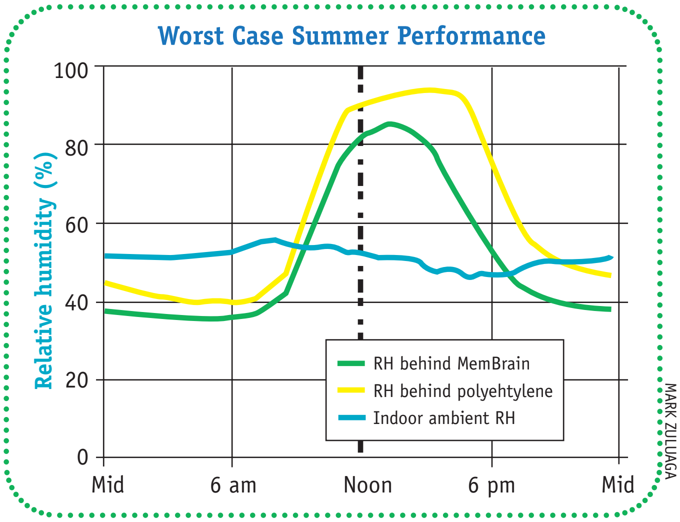

Figure 5. In response to afternoon solar-driven moisture, the humidity buildup behind the MemBrain vapor retarder was significantly less severe in both magnitude and duration than the corresponding humidity spike behind the polyethylene.

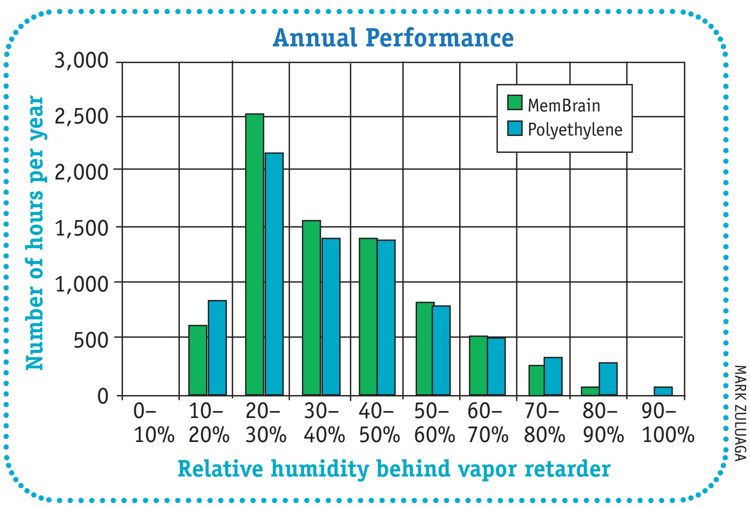

Figure 6. It is clear that for the vast majority of the hours of the year, the RH behind both vapor retarders was less than 70%. The MemBrain completely eliminated any instances of RH above 90% and drastically reduced the number of hours when the RH exceeded 80%.

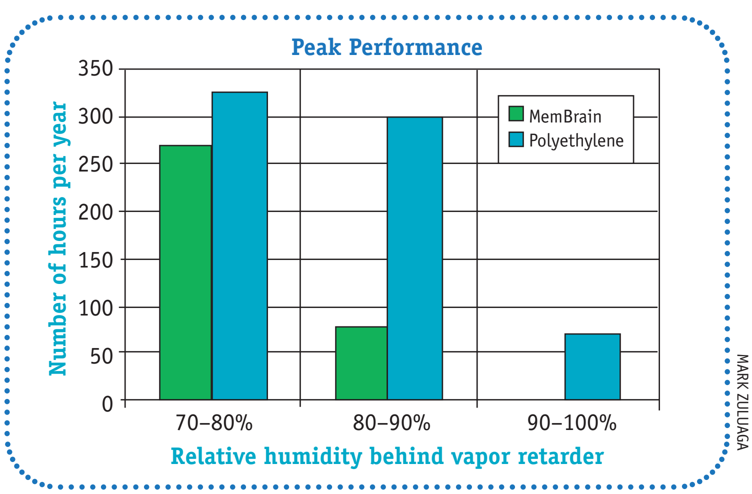

Figure 7. Compared to the polyethylene, over the course of 2005 the MemBrain completely eliminated any instances of RH above 90% and drastically reduced the number of hours when the RH exceeded 80%

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Moisture in buildings can be a touchy subject. This article is not intended to scare people into thinking that there is a mold epidemic behind polyethylene vapor retarders in cold-climate houses—such a leap is not borne out by field experience. Mold growth is complex and depends on temperature, RH, time, and the presence of a food source. The longer a building material stays warm and wet, the higher the probability of mold growth. The 70 hours in 2005 when the RH exceeded 90% behind the polyethylene were not consecutive. It is quite possible that brief instances of high afternoon humidity, as was measured behind the polyethylene in the Veridian prototype house, are too short to trigger mold growth.

However, trying to determine whether a conventional interior vapor retarder will or will not cause a moisture and mold problem in a particular cold-climate house is the wrong way to address the issue. The more appropriate question is, will the choice of a vapor retarder cause the performance of a house to be closer to or further from the tipping point beyond which a moisture and mold problem may arise? Many variables in the construction process affect the moisture tolerance of wall systems. From a builder standpoint, vapor retarder specification may be one of the more straightforward of these variables to control. Results from SWA's field evaluation of the MemBrain vapor retarder indicate that this product can significantly improve drying rate when there is a moisture buildup in exterior wall assemblies. Performance-monitoring results over the course of a full year demonstrate that such instances of moisture buildup consistently occurred in the south-facing wall of a Wisconsin house due to the effects of solar exposure.

Common sense dictates that water leaks may sporadically occur in different parts of an exterior wall system over the life of a building. The MemBrain vapor retarder is no substitute for the proper implementation of construction details designed to keep such water leaks out of exterior wall systems. However, this product is worth the consideration of cold-climate builders interested in improving the drying rates of their exterior wall assemblies in response to the moisture buildup that will inevitably occur in some parts of a wall system during certain parts of its life.

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