U.S. Department of Energy - Energy Efficiency and Renewable Energy

Energy Savers

Vapor Barriers or Vapor Diffusion Retarders

In most U.S. climates, vapor barriers or vapor diffusion retarders should be considered as part of a moisture control strategy for a home.

How They Work

A vapor barrier or vapor diffusion retarder (VDR) is a material that reduces the rate at which water vapor can move through a material. The older term "vapor barrier" is still used even though it may inaccurately imply that the material stops all of the moisture transfer. Since everything allows some water vapor to diffuse through it to some degree, the term "vapor diffusion retarder" is more accurate.

The ability of a material to retard the diffusion of water vapor is measured by units known as "perms" or permeability. A perm at 73.4°F (23°C) is a measure of the number of grains of water vapor passing through a square foot of material per hour at a differential vapor pressure equal to one inch of mercury (1" W.C.) Any material with a perm rating of less than 1.0 is considered a vapor retarder.

Vapor diffusion retarders can help control moisture in these areas:

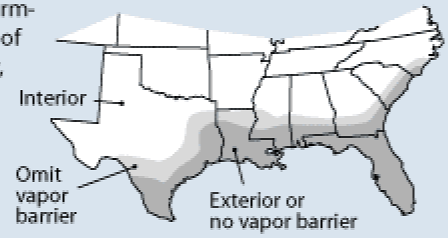
- Basements
- Ceilings
- Crawl spaces
- Floors
- Slab-on-grade foundations
- Walls

Effective moisture control in these areas and throughout a home includes air sealing gaps in the structure, not just the use of a vapor diffusion retarder.

How, where, and whether a vapor diffusion retarder should be used depends on the climate. Typically, the number of Heating Degree Days in an area is used to help make these determinations. A Heating Degree Day is a unit that measures how often outdoor daily dry-bulb temperatures fall below an assumed base, normally 65°F (18°C).

Vapor Barrier Placement By Geographical Location

In most cold climates, vapor barriers should be placed on the interior(warm-in-winter) side of walls. However, the map shows that in some southern climates, the vapor barrier should be omitted, while in hot and humid climates, such as along the Gulf coast and in Florida, the vapor barrier should be placed on the exterior of the wall.



Perm Ratings of Different Materials

(Rating of 1 or less qualifies as a vapor barrier)

Asphalt-coated paper backing on insulation	0.40
Polyethylene plastic (6 mil)	0.06
Plywood with exterior glue	0.70
Plastic-coated insulated foam sheathing	0.4 to 1.2
Aluminum foil (.35 mil)	0.05
Vapor barrier paint or primer	0.45
Drywall (unpainted)	5 0
Drywall (painted - latex paint)	2 -3

Types of Vapor Diffusion Retarders

Vapor diffusion retarders are typically available as membranes or coatings. Membranes are generally thin, flexible materials, but also include thicker sheet materials sometimes called "structural" vapor diffusion retarders. Materials such as rigid foam insulation, reinforced plastics, aluminum, and stainless steel are relatively resistant to water vapor diffusion. These types of vapor diffusion retarders are usually mechanically fastened and sealed at the joints.

Thinner membrane types come in rolls or as integral parts of building materials. A common example of this is aluminum- or paper-faced fiberglass roll insulation. Foil-backed wallboard is another type commonly used. Polyethylene, a plastic sheet material, can be used as a vapor diffusion retarder for above-grade walls and ceilings (only) in very cold climates (in locations with 8,000 Heating Degree Days or higher).

Most paint-like coatings also retard vapor diffusion. While it was once believed that only coatings with low perm ratings constituted the only effective vapor diffusion retarders, it is now believed that any paint or coating is effective at restricting most water vapor diffusion in milder climates.

Installing Vapor Diffusion Retarders for New Construction

In climates with less than 4,000 Heating Degree Days, materials like painted gypsum wallboard and plaster wall coatings impede moisture diffusion to acceptable levels. Usually, no further vapor diffusion retarder is needed.

In more extreme climates, vapor diffusion retarders are advisable for new construction. They perform best when installed closest to the warm side of a structural assembly; in cold climates, this is towards the interior of the building. In hot/wet climates, this is towards the exterior of the building.

Reasonable rules-of-thumb to follow when placing vapor retarders include the following:

- In climates with 2,200 or more Heating Degree Days, locate the vapor diffusion retarder on the warm side of the exterior structural assembly. If possible, locate it on the inside of the assembly using the "one-third, two-thirds rule": the vapor diffusion retarder has one-third of the cavity insulation to its warm side, two-thirds to the cold side. This protects the retarder from physical damage through errant construction or remodeling activities.

- In climates with fewer than 2,200 Heating Degree Days (cooling-dominated climates) and where the building is near, but not quite in, the 2,200 Heating Degree Days zone (a.k.a. fringe zone), place the vapor diffusion retarder in the same location as climates farther north.
- Farther south (about 1,900 Heating Degree Days) it is unimportant where the vapor diffusion retarder goes. For climates even farther south and generally hotter and more humid, some professionals recommend omitting the vapor diffusion retarder completely. This is due to the winter heating loads and summer cooling loads being roughly equal. Any location ends up having the vapor diffusion retarder on the wrong side of the structure during part of the year. However, other building science research indicates that it should be applied directly under the exterior finish and is sometimes itself the exterior finish. A combination air barrier/vapor diffusion retarder may be a better choice for this situation.

Knowledgeable builders typically use vapor diffusion retarders with ratings of 0.1 or less. However, if you carefully seal the warm-side vapor diffusion retarder and interior finish, you can also safely install a low-permeable material, such as rigid foam board insulation (a perm rating as high as 1.4), on the cold side of walls. A good rule-of-thumb: to prevent trapping any moisture in a cavity, the cold-side material's perm rating should be at least five times greater than the value of the warm-side. Use a vapor diffusion retarder with a perm value of less than 0.50 if you also have a high water table.

When installing a vapor diffusion retarder, it should be continuous and as close to perfect as possible. This is especially important in very cold climates and in hot and humid climates. Be sure to completely seal any tears, openings, or punctures that may occur during construction. Cover all appropriate surfaces; otherwise, you risk moist air condensing within the cavity, which would lead to dampened insulation. The thermal resistance of wet insulation is dramatically decreased, and prolonged wet conditions will induce mold and wood rot.

Installing Vapor Diffusion Retarders in Existing Homes

Except for extensive remodeling projects, it's difficult to add materials like sheet plastic as a vapor diffusion retarder to an existing home. However, many existing homes don't really need a more effective vapor diffusion retarder than the numerous layers of paint usually on their walls and ceilings. These multiple layers are quite effective as a vapor diffusion retarder in all but the most extreme northern climates.

"Vapor barrier" paints are also an effective option for colder climates. If the perm rating of the paint is not indicated on the label, find the paint formula. The paint formula usually indicates the percent of pigment. To be a good vapor diffusion retarder, it should consist of a relatively high percent of solids and thickness in application. Glossy paints are generally more effective vapor diffusion retarders than flat paints, and acrylic paints are generally better than latex paints. When in doubt, apply more coats of paint. It's best to use paint labeled as a vapor diffusion retarder and follow the directions for applying it.

Metrics

The following unit conversion information is pertinent to the subject of VDRs:

BASIC METRIC CONVERSIONS	TO GET	MULTIPLY	BY
Permeance at 73.4°F [23°C]	$ng/m^2.s.Pa$	$grain/ft^2.h.1in.Hg$	57.2148

Thermal Resistance ® [RSI]	RSI	R	0.1761
Thermal Conductance (U) [k]	W/m^2.°C	Btu.ft^2.h.°F	5.6783
Vapor Transmission Rate (WVTR) at 73.4°F [23°C] and 50% RH	G/m^2.d (WVT=permeance x vapor pressure differential at specific temperature and RH)	grain/ft^2.d	0.6975

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Related Links

- Smart Vapor Retarders
  ToolBase Services
- How to Choose Weather-Resistive Barriers
  ToolBase Services
- Facts about Fiber Glass Insulation and Vapor Retarders
  North American Insulation Manufacturers Association

Reading List

- *Weather-Resistive Barriers* (PDF 223 KB). (October 2000). DOE/GO-102000-0769. U.S. Department of Energy.
- "Testing Weather-Resistive Barriers." (August 2003). *Energy Design Update* (23:8); pp. 9-10.
- *Moisture Control for Buildings* (PDF 840 KB). (February 2002). American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
- "The Effect of Vapor Retarders on Wall Drying Time." (September 1996). *Energy Design Update*(16:9); p. 9.
- Fisette, P. (December 1995). "Making Walls Watertight." *The Journal of Light Construction* (14:3); pp. 35-38.
- "Demystifying the Use of Vapor Barriers." (January 2002). *Energy Design Update* (22:1) pp. 14-15.
- "Historic Summit Meeting Looks at Vapor Barriers." (August 2002). *Energy Design Update*. (22:8); pp. 1-5.
- "The Reliability of Vapor Barrier Paints." (May 1995).*Energy Design Update*. (15:5); pp. 6-9.
- "Ceiling Vapor Barrier- Yes or No?" (February 2000). *The Journal of Light Construction*. (18:5); pp. 21, 23, 24.

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