HUNTSMAN
BUILDING SOLUTIONS

# Vapor Retarders and Vapor Permeance

BES-102 - DESIGN NOTE

This Design Note reviews vapor retarders and vapor permeance, and how they relate to the building code. It briefly discusses the science behind vapor diffusion and reviews their application. There are sections on building codes, closed and open-cell spray foam, example applications and unique scenarios to consider.

## Vapor Diffusion

Vapor diffusion is the movement of water vapor molecules through porous materials as a result of vapor pressure differences. Moisture will always move from the higher vapor pressure to lower vapor pressure. Vapor pressure differences occur when there are temperature and water vapor content differences in the air. An example is between indoor (conditioned) air and outdoor (unconditioned) air. Any difference in temperature or relative humidity between the indoor and outdoor environments will create a vapor pressure differential, and cause a potential for vapor diffusion.

## Vapor Retarders

A vapor retarder is a material that reduces the rate at which water vapor can move through it. A material's ability to retard vapor diffusion is measured in units of permeability or "perms". To determine the perm rating of a specific material, it is tested using the desiccant method of ASTM E96. According to the International Residential Code and the International Building Code, Vapor Retarders are divided into three classes.

Class I: 0.1 perm or less.
Class II: 0.1 < perm ≤ 1.0 perm.
Class III: 1.0 < perm ≤ 10 perm.

Prior to the 2009 version of I-Codes, vapor barriers were defined as having a perm rating ≤ 1.0. Therefore, a Class II vapor retarder is "equivalent" to the previous term vapor barrier, as it provides the same level of vapor permeance.

## Building Codes

The IRC and IBC have specific requirements for when to use, and when not to use, vapor retarders in construction. According to R702.7* (IRC) and 1404.3.1* (IBC) Class I or Class II vapor retarders are required on the interior side of frame walls in climate zones 5, 6, 7, 8, and Marine 4. Exceptions include: basement walls, below-grade portion of any wall, construction where moisture or its freezing will not damage the materials.

Section 1404.3.1 goes on to state "Class I and II vapor retarders shall not be provided on the interior side of frame walls in climate zones 1 and 2. Class I vapor retarders shall not be provided on the interior side of frame walls in zones 3 and 4."

Further, Section 1404.3.2 specifically states that "Only Class III vapor retarders shall be used on the interior side of frame walls where foam plastic insulating sheathing with a perm rating of less than 1 is applied…on the exterior side of the frame wall." It is important to follow all IRC and IBC guidelines for using vapor retarders, as they can help prevent the incorrect design of walls in any climate zone.
* Sections are based on the 2018 versions of I-Codes. Other versions may have different section numbers.

## Closed-Cell Spray Foam

One advantage of closed-cell spray polyurethane foam (SPF) is its ability to provide 3 functions in 1 product. Insulation, Air Barrier, and Vapor Retarder. HBS closed-cell SPF insulations have been tested to determine their R-value, air permeance and vapor permeance. All HBS closed-cell products are approved as Class II vapor retarders. Each product has been 3rd party tested to determine the minimum required thickness to achieve a perm rating ≤ 1.0. Typical minimum thicknesses range between 1" - 2" to achieve a perm rating ≤ 1.0.

Applications of closed-cell spray foam differ from project to project, and can be sprayed at almost any thickness. The best way to estimate the water vapor permeance of the installed product is to divide the listed permeance at 1" by the applied thickness. An example chart is listed below:

| Thickness | Water Vapor Permeance |
|---|---|
| 1.0" | 1.25 |
| 1.5" | 0.83 |
| 2.0" | 0.63 |
| 3.0" | 0.42 |
| 4.0" | 0.31 |
| 13.0" | 0.09* |

* Calculated vapor permeance that may achieve similar performance to other Class I vapor retarders.

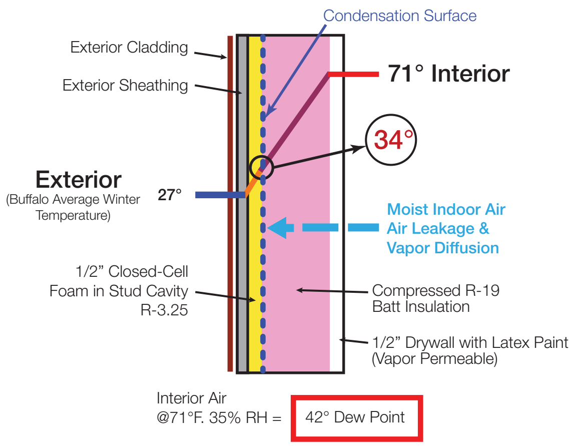
## Open-Cell Spray Foam

Similar to closed-cell spray foam, open-cell spray foam also provides multiple functions in one single product. Open-cell spray foam acts as insulation and an air barrier, but only performs as a Class III vapor retarder. Although open-cell spray foam is typically used in warmer climate zones, where a vapor retarder is not required, it can also be used in Climate Zones 5, 6, 7, 8, and Marine 4 provided the addition of an approved Class II vapor retarder towards the interior of the assembly. This provides flexibility for an alternate product/design to be used in any climate zone.

## Applications

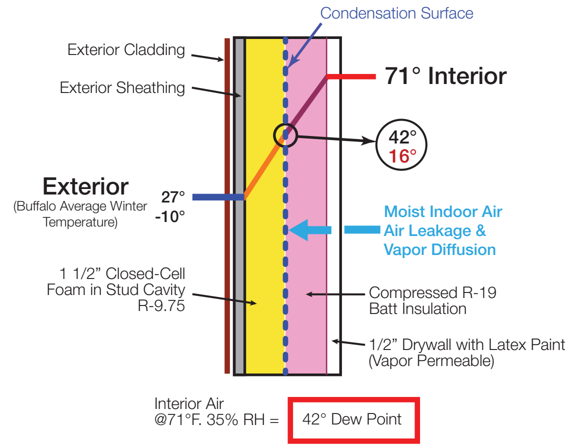
The I-Codes give perspective requirements for minimum R-values and when to use vapor retarders in construction. Even with this information, it is easy to misinterpret the design and create a scenario where moisture can become an issue in your building. Below are 3 example wall sections using the same 2"x 6" exterior wall construction, with different insulating techniques. These examples assume to be in Climate Zone 5 where the minimum insulation value for walls is R-20 (IECC Table R402.1.2).

### "Flash" and Batt



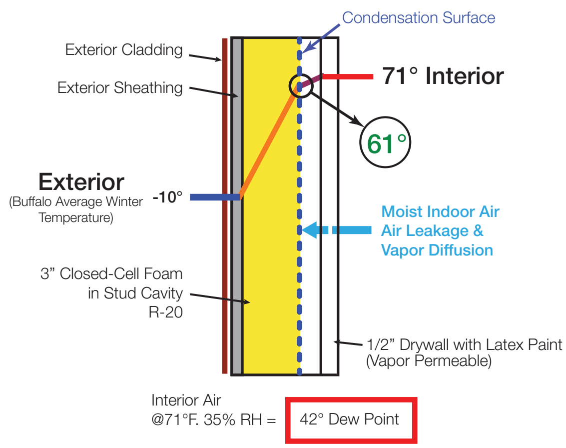

This wall section poses the risk of condensation forming in the wall, even at average winter temperatures. In addition, the closed-cell spray foam is not at an acceptable thickness to achieve a Class II vapor retarder rating. This system will require an additional vapor retarder on the interior side of the fiberglass insulation to lower the risk of moisture problems.

### Hybrid System



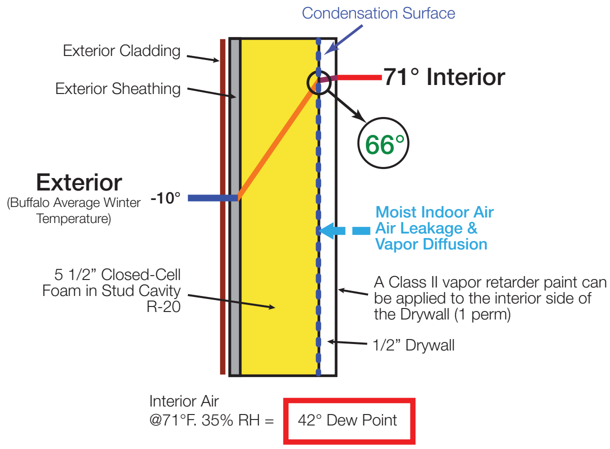

This wall section has an acceptable thickness of closed-cell spray foam to be a Class II vapor retarder. Condensation is less likely during average winter temperatures, but an extremely cold period can create issues, even with a total R-value (28.75) much greater than the required R-20. This wall assembly will allow the wall to dry towards the interior, when temperatures rise, but does not remove the risk of moisture forming to begin with.

### Closed-Cell Insulation




This wall section is properly designed using closed-cell spray foam. The applied thickness meets the minimum required R-value and is adequate to achieve a Class II vapor retarder rating. This wall section effectively places the vapor retarder layer on the interior side of the wall, and removes most risk for condensation forming.

## Open-Cell Insulation




This wall section is properly designed using open-cell spray foam insulation and a Class II vapor retarder (required in Climate Zones 5, 6, 7, 8 and Marine 4), applied to the interior side of the wall assembly.  This wall assembly meets all prescriptive building code requirements for R-value and vapor retardance, and removes most risk for condensation forming.

## Other Considerations

### Vapor Retarder Location

When using a vapor retarder, it is always important to place the vapor retarder layer in the correct location of an assembly. Typically this means on the interior side in cold climates, and on the exterior side of warm climates. Since the building code does not require vapor retarders in warmer climates (and even excludes the use in some areas), it is not as common to see their use in these areas.

### High Humidity Applications

In high humidity areas (e.g. swimming pools, saunas, etc.) it may be prudent to use a Class I vapor retarder. This can provide additional protection, even when used in conjunction with closed-cell spray foam. This practice also applies to areas where the humidity drive is relatively constant for long periods of time such as in cold rooms and freezers.

## Summary

Understanding the concepts of vapor permeance and vapor retarders are important in the design of the building envelope. It is necessary to know when vapor retarders are required, where they need to be located, and when to leave them out of the design all together. Even using a vapor retarder improperly can mean be the difference in an effective wall design. Open-cell spray foam acts as an effective insulation, but requires an additional Class II vapor retarder when required.  Closed-cell spray foam can be used as both an insulation and vapor-retarder in one product, but must be applied at a proper thickness to achieve the desired level of vapor permeance. Following the building code is a great first step in using vapor retarders, but hopefully this design note has provided additional context for specific applications and unique scenarios.



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