



# MOISTURE CONSIDERATIONS FOR INSULATED WALL ASSEMBLIES

June 2015 | Brian Wolfgang

## INTRODUCTION

One of the main design considerations associated with residential construction involves the building enclosure. The building enclosure is made up of a series of assemblies (foundation, floor, wall, roof/attic) that separate indoor conditioned spaces from the exterior environment. Each building enclosure system is subjected to flows of heat, air, and moisture through the assembly. Much attention has been paid to the installation of thermal insulation to reduce seasonal heat loss or gain in best practice and code requirements. Less attention has been paid to the role of moisture within these insulated assemblies. This document will outline some moisture-related considerations that should be taken into account during the design, construction, and inspection of light-frame residential structures.

## MOISTURE SOURCES

As residential buildings have become more energy efficient, the building enclosure has become more sensitive to moisture-related damage. This is mainly due to the lack of air and heat flow through various building assemblies that provided insurance against moisture damage in the past. Having less heat and ventilation available to dry damp building systems requires greater attention to the design of the assembly up front.

In general, building enclosure assemblies are subjected to two different sources of moisture (see Figure 1):

1. Bulk Moisture – Liquid water originating from moisture intrusion related to exterior precipitation or from condensation (condensation occurs when water vapor condenses on a cool surface that is below the dew-point of the space)
2. Water Vapor – Moisture in gaseous form, typically originating from interior sources (breathing, cooking, bathing) and from exterior seasonal humidity

In Pennsylvania, all 67 counties fall within Climate Zones 4, 5, and 6. These are primarily heating climates. This results in attention being paid to interior water vapor primarily in the winter. Bulk moisture intrusion is a risk year-round due to rain and snow events.

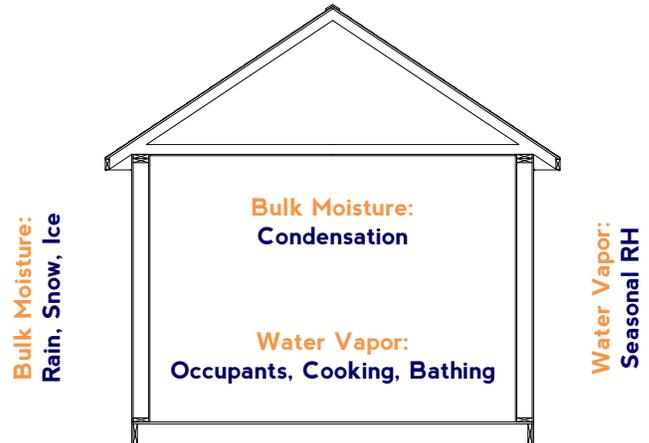


Figure 1: Moisture sources in wall assemblies

## DESIGN STRATEGIES

There are two main building enclosure design strategies that relate to moisture in walls. Design to:

1. Prevent excessive wetting (material specification, flashing details, etc.)
2. Maximize drying potential (material specification, weep details, etc.)

Typically walls become wet through water vapor condensation within walls and bulk moisture intrusion at penetrations. The primary method of drying, however, is through vapor diffusion.

## INSULATION OPTIONS

In this document, three different types of insulated wall assemblies are discussed:

1. Cavity insulation with vented cladding
2. Cavity insulation with reservoir cladding
3. Cavity and exterior continuous insulation

## VAPOR RETARDER REQUIREMENTS

According to the 2009 International Residential Code, portions of Pennsylvania within Climate Zones 5 and 6 (all but 6 counties) are required to have a vapor retarder installed on the interior side of framed walls. This requirement is intended to prevent the diffusion of water vapor into exterior wall cavities in winter. This water vapor is likely to condense on the interior side of the exterior sheathing, as this surface will be at a temperature below the dew point for much of the winter.

While it is clear that keeping water vapor out of wall cavities in winter is beneficial, it must be considered that vapor retarders also retard the flow of water vapor that exists within the cavity. This must be taken into account when selecting wall assembly materials in order to maximize the drying potential of the overall assembly. When specific materials or insulation systems are selected (e.g. exterior insulated sheathing), the selection of a vapor retarder’s class or permeance should reflect this.

Vapor retarders are classified in two different ways, each of which are shown in Table 1.

**Table 1: Vapor retarder classifications**

Permeance (perms)	Vapor Retarder Description	Vapor Retarder Class
< 0.1	Impermeable	Class I
0.1 - 1.0	Semi-Impermeable	Class II
1.0 - 10.0	Semi-Permeable	Class III

While the 2009 and 2012 IRC allow the installation of a Class I vapor retarder (typically a foil facing or poly sheeting), this is not recommended in standard construction in Climate Zones 5 and 6. Class I vapor retarders are usually only appropriate in extremely cold climates.

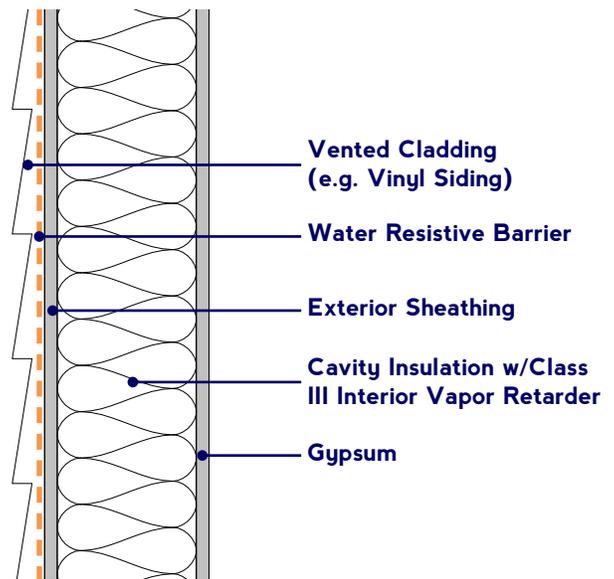
The following sections will discuss specific wall assemblies and their unique moisture considerations. Each section will also discuss exceptions to the prescriptive requirement of a Class I or II vapor retarder on the interior side of framed walls. These exceptions allow the builder to install a Class III vapor retarder under specific conditions, however it does not prohibit the use of a Class I or II vapor retarder. It is critical for the builder to select appropriate materials for the overall assembly.

## CAVITY INSULATION WITH VENTED CLADDING

Vented cladding has been a popular exterior finish material for years throughout Pennsylvania. Vented cladding refers to a few different material options, but this section will focus on cladding options that provide ventilation inherently based on the structure of the material. This mainly includes vinyl lap siding and horizontal aluminum siding (see Figure 2).

One of the main reasons for a builder to select vinyl or aluminum siding for exterior cladding is cost. However, one of the significant benefits of these cladding systems is the inherent ventilation they provide between the cladding itself and the water resistive barrier/ exterior sheathing. The air space that exists behind these types of vented cladding provide ample space for both an effective drainage plane and ventilation of intruding moisture.

The ventilation component in particular allows for some risk mitigation related to exterior sheathing moisture damage. Should exterior sheathing become damp from condensation or bulk moisture intrusion, ventilation can increase the drying potential of the wall to prevent excessive wetting of the assembly. *Some wetting will still occur, however cycles of wetting and drying are common and often tolerable by modern construction materials.* Because of this added protection, a Class III vapor retarder is typically permitted in this location.



**Figure 2: Insulated wall assembly w/vented cladding**

## CAVITY INSULATION WITH RESERVOIR CLADDING

While vinyl and aluminum siding offers many advantages, homeowners often desire alternative finish materials that could be classified as reservoir claddings. Reservoir claddings absorb moisture from the surrounding environment, including rain and snow events. These materials are then able to store significant quantities of moisture. The most common examples of reservoir cladding materials include brick veneer, exterior plaster (manufactured stone and hardcoat stucco), and wood cladding.

When a reservoir cladding material is selected, it is important to account for the added moisture storage capacity in the overall wall assembly. For example, should a hygroscopic cladding become wet during a rain event and then be subjected to significant solar exposure, the solar vapor drive now present will force moisture into the assembly, which must be able to dry.

In general, the added moisture storage associated with reservoir cladding has two main consequences:

1. Higher-perm interior vapor retarder should be selected
2. Back-venting of cladding should be considered

As was discussed previously, the 2009 and 2012 IRC requires a Class I or II vapor retarder on the interior

side of framed walls in Climate Zones 5 and 6. When a reservoir cladding is selected, Class I vapor retarders (i.e. vapor barriers) should be avoided. Interior drying potential is crucial for these types of cladding. In some cases, such as the code-mandated air space of 1" for brick veneer (see Figure 3), Class III vapor retarders are permitted, in which case interior drying potential is maximized.

While some cladding selections are required to have an air space between the cladding and water-resistive barrier/ exterior sheathing, other reservoir claddings are permitted to be installed without a ventilation gap. In order to reduce moisture risk, an air space should be considered in the design process, whether this gap is provided through furring strips or a proprietary mesh product. This ventilation gap forms what is known as a rainscreen. Since insulated wall systems keep the exterior sheathing at cooler temperatures in winter (less heat flow), it is often beneficial to provide the added protection of a rainscreen should that layer become wet.

Rainscreen systems can take many forms and come in a variety of thicknesses. In general, a ventilation gap between 1/4" - 3/4" will provide the benefits of reduced moisture risk (see Figure 4). These systems can be enhanced through upper and lower ventilation openings as well. Often these systems are above-code options and require adherence to manufacturer installation instructions.

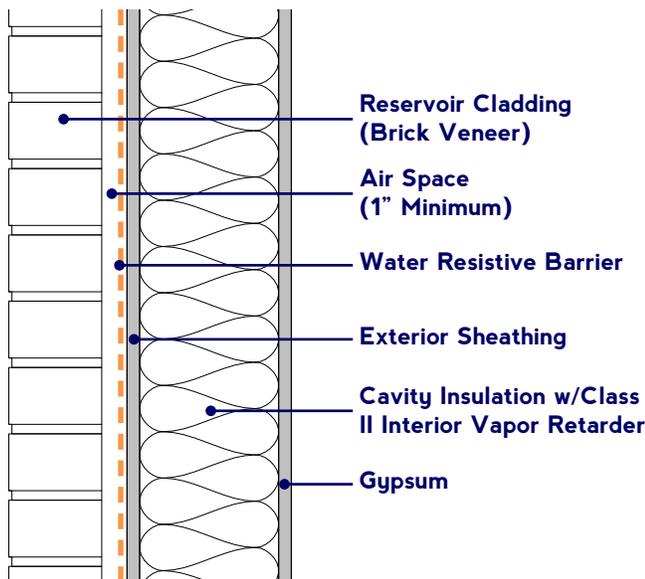


Figure 3: Insulated wall assembly w/brick veneer

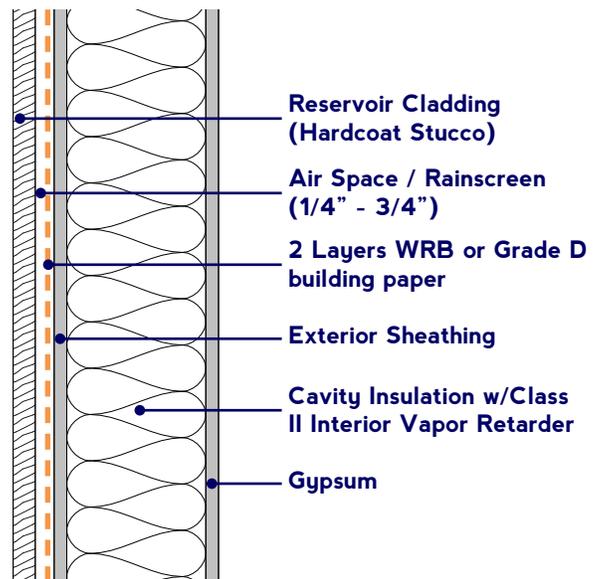


Figure 4: Insulated wall assembly w/ exterior plaster

## CAVITY AND EXTERIOR CONTINUOUS INSULATION

While vented cladding and ventilation gaps can enhance the drying potential of wall assemblies, there are other components that can be added to wall systems that reduce the drying potential in a specific direction. An example of this is the installation of insulated exterior sheathing, or exterior foam insulation.

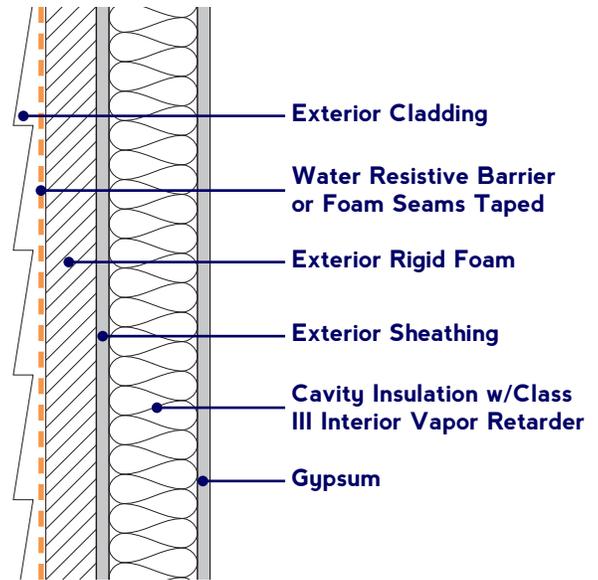
There are distinct advantages of installing exterior rigid foam sheathing over stud framing from an energy efficiency standpoint. However, this type of system alters the drying potential of the overall assembly and must be designed with this limitation in mind.

The installation of exterior insulated sheathing comprises an exception to the Class I or II vapor retarder requirements for Climate Zones 5 and 6 (see Figure 5), for the following reasons:

1. Insulated sheathing raises the temperature of the interior side of the exterior sheathing
2. Exterior rigid foam is often a Class I, II, or III vapor retarder

The concept of raising the interior side of exterior sheathing is one of the primary benefits of exterior continuous insulation beyond energy efficiency. This higher temperature reduces the risk of interstitial condensation in winter from interior water vapor, as the interior surface of the exterior sheathing has the potential to be above the dew point temperature. Should water vapor enter the insulated wall cavity, it is less likely to condense on the exterior sheathing. It is important to provide a minimum level of insulation in order to raise the temperature high enough for condensation prevention. For this reason, codes permit the installation of a Class III vapor retarder, as the risk of condensation is reduced.

The most common types of exterior rigid foam installed



**Figure 5: Wall assembly w/ exterior rigid foam**

as insulated sheathing are extruded polystyrene (XPS), expanded polystyrene (EPS), and foil-faced polyisocyanurate. Depending on the thickness of the insulation, installing these types of foam on the exterior of the building equates to the installation of a vapor retarder on the exterior side of the wall framing. This consequently reduces the ability of the wall assembly to dry to the exterior. It is crucial that the remainder of the wall assembly take this into account.

The reduced exterior drying potential of the overall assembly comprises the second reason for the vapor retarder exception, allowing a Class III vapor retarder (such as latex paint) to be installed on the interior side of wall framing. While drying potential to the interior may not seem as critical since the risk of condensation is reduced with exterior rigid foam, it is still important to take into account the likelihood that the wall assembly will get wet through bulk moisture intrusion stemming from flashing errors, wind driven rain, or long-term failure of caulking joints. Once the wall assembly becomes wet, it must be able to dry toward the interior through water vapor diffusion.

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