PENNSYLVANIA HOUSING RESEARCH CENTER

MOISTURE CONSIDERATIONS FOR INSULATED ROOF/ATTIC 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 of up a series of assemblies (foundation, floor, wall, roof/attic) that separate interior 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 provide drying of 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.

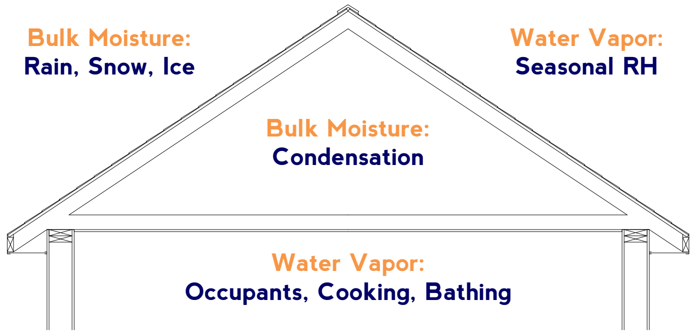

Figure 1: Moisture sources at roof/attic assembly

DESIGN STRATEGIES

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

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

In the context of roof/attic assemblies, many different factors will contribute to the performance of the system. The following sections will walk through some of the main design options for this assembly and will detail the moisture considerations associated with each option.

INSULATION OPTIONS

In this document, three different roof/attic insulation strategies are discussed:

1. **Vented roof/attic assembly**
2. **Unvented roof/attic assembly with rigid foam**
3. **Unvented roof/attic assembly with spray foam**

VENTED ROOF/ATTIC ASSEMBLY

Vented roof systems have long been a standard feature of light-frame residential structures as a means of heat and moisture control. Roof/attic ventilation serves two primary purposes related to moisture:

1. Keeping the roof surface cold in winter
2. Providing ventilation of water vapor present in the attic space

Why a Cold Roof?

One of the main moisture considerations for vented roof assemblies is the prevention of ice dams. Ice dams result from snow melting on the roof surface and re-freezing at roof eaves. This creates a dam by which subsequent snow melt can build up and penetrate the roof assembly and enter the attic space. Ice dams can be combatted in two distinct ways (see Figure 2):

1. Air sealing drywall at attic floor
2. Adequate ventilation

By air sealing the top story ceiling drywall at seams and penetrations (ceiling fixtures, especially recessed lights), warm interior air is less likely to enter the attic space and contribute to roof surface snow melt.

In order to allow for adequate ventilation of the attic space, it is important to not only distribute ventilation openings in the upper (ridge) and lower (soffit) portions of the attic, but to also provide a clear path for ventilation air to travel between these openings. This is typically accomplished through the use of baffles near the eaves to prevent blown or batt insulation from impeding the path of incoming ventilation air.

Ventilation is commonly provided through ridge vents, soffit vents, and other roof deck mounted ventilation systems. The distribution of these is driven by roof design and product selection. Prior to the 2012 International Residential Code (IRC), builders were encouraged to concentrate their ventilation openings in the upper portion of the attic. This created a depressurized attic space, which commonly induced air leakage from interior space into the attic. Starting with the 2012 IRC, however, these requirements changed to encourage a more balanced distrbution, and in some cases, a greater concentration of ventilation openings in the lower portion of the attic. This will slightly pressurize the attic space, thus reducing the likelihood of warm, humid interior air entering the attic space in winter.

Through proper installation of ventilation openings as well as adequate air sealing, not only is warm air less likely to cause snow melt in winter, that same warm, humid air is less likely to condense on cool attic surfaces in winter. A combination of ice dam and condensation prevention is necessary to ensure the durability of an insulated roof/attic assembly.

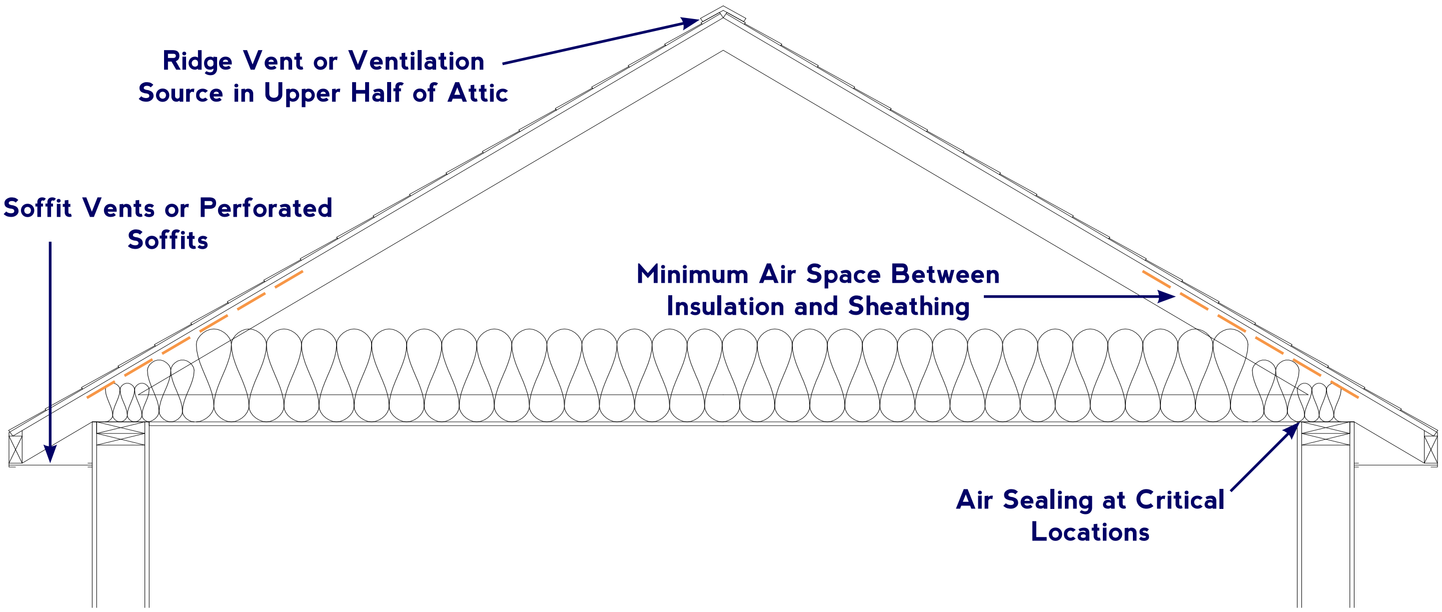

Figure 2: Critical moisture considerations in vented roof/attic assemblies

UNVENTED ROOF/ATTIC ASSEMBLY WITH RIGID FOAM

The fundamental difference between a vented and unvented attic is the location of the building enclosure. For unvented roof/attic assemblies, the envelope is shifted to the roof deck and now includes the finished roof material, underlayment, roof sheathing, and insulation.

Rigid Foam and Unvented Attics

One method to insulate the roof deck of an attic assembly is to install rigid foam insulation on top of the roof sheathing or on the underside of the roof sheathing (see Figure 3). Rigid foam insulation is typically an air-impermeable material and can provide appropriate protection against condensation if designed properly.

The main moisture consideration related to unvented attics which incorporate rigid foam insulation is related to condensation prevention. As condensation occurs when humid air comes in contact with a cooler surface (below the dew point temperature), it is important to install an appropriate amount of air-impermeable insulation in order to raise the temperature of the exposed surface on the attic side to a temperature above the dew point.

When rigid foam insulation is fully used to satisfy roof/attic R-Value requirements, condensation potential is minimized. When rigid foam insulation is used partially, followed by the installation of air-permeable insulation such as fiberglass batts, it is important to provide a minimum R-Value in the rigid foam in order to keep the attic-side surface of the foam above the dew point. Table 1 includes minimum R-Values based on the 2009 IRC for all climate zones in Pennsylvania.

Table 1: Rigid insulation requirements for condensation control in PA (based on 2009 IRC)

Climate Zone	Minimum Rigid Foam or Air-Impermeable Insulation R-Value
4	R-15
5	R-20
6	R-25

Another moisture consideration is related to drying potential of the overall assembly. Since damp roof sheathing will not be able to effectively dry toward the attic when vapor semi-impermeable insulation is installed, it is critical to allow roof sheathing to dry toward the exterior. This will typically impact the selection of a roof underlayment. Many traditional underlayments (i.e. felt paper) are vapor-open; however, some newer synthetic underlayments are Class I or II vapor retarders. An underlayment with a higher vapor permeability will allow for more effective drying of the roof assembly should it get wet from penetrations, storm damage, or ice dams.

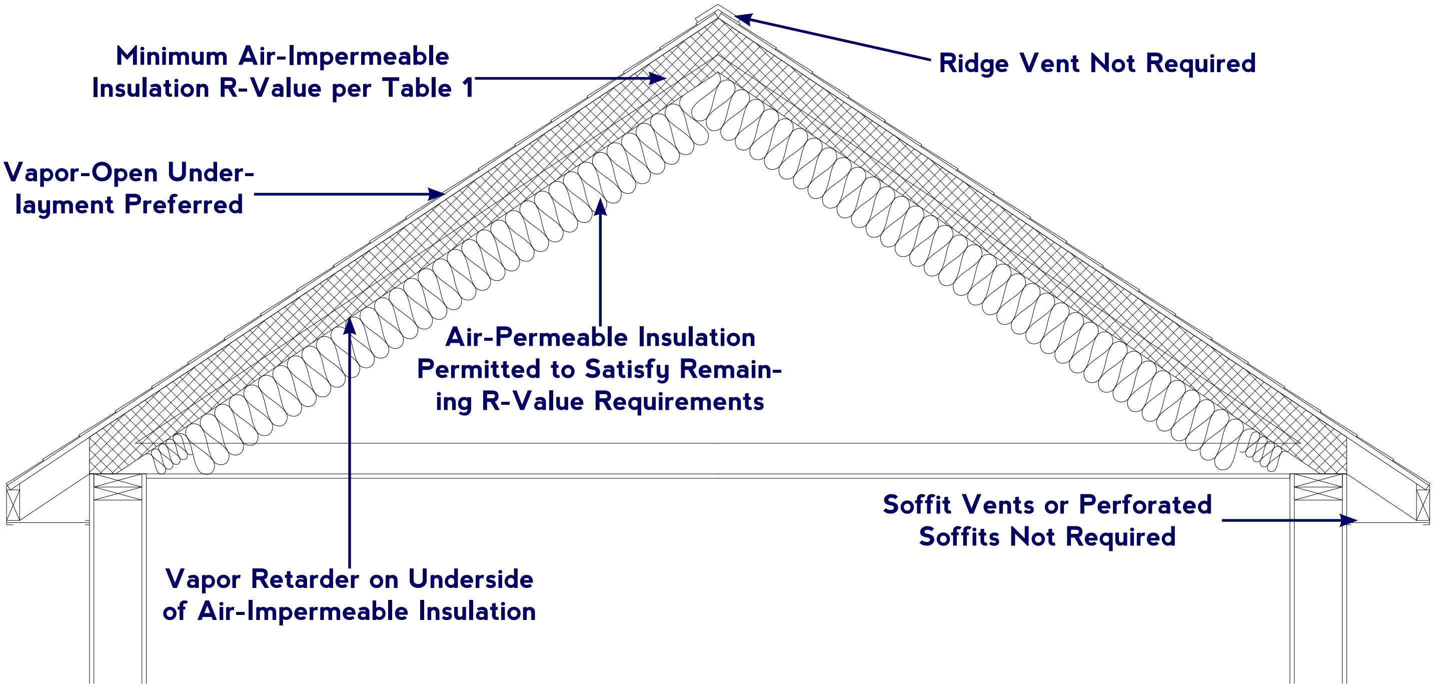

Figure 3: Critical moisture considerations in unvented insulated roof/attic assemblies using rigid foam

UNVENTED ROOF/ATTIC ASSEMBLY WITH SPRAY FOAM

While rigid foam insulation can be used to create an unvented roof/attic assembly, it is more common to see spray polyurethane foam used to pull the attic space into the building enclosure (see Figure 4). Since it is uncommon to use air-permeable insulation in combination with spray foam, the main moisture consideration with these assemblies involves wetting and drying through the transmission of water vapor.

Open-Cell vs. Closed-Cell Foam

As with rigid foam, another moisture consideration is related to drying potential of the overall assembly. It is critical to allow roof sheathing to dry toward the exterior. This will typically impact the selection of a roof underlayment. An underlayment with a higher vapor permeability will allow for more effective drying of the roof assembly should it get wet from penetrations, storm damage, or ice dams.

Consideration for excessive wetting of roof assemblies impacts the selection of a type of spray foam. Open-cell foam is typically considered vapor-open with a vapor permeability greater than 10 perms. Closed-cell foam, however, is tyipcally considered a Class II vapor retarder, with a vapor permeability between 1.0-10 perms, depending on thickness and manufacturer specifications.

With a limited inward drying potential with foam installed on the underside of the roof sheathing, it is critical to prevent wetting of the roof assembly through vapor diffusion. Warm, humid air that is present in the semi-conditioned attic space may introduce water vapor to the assembly without ensuring that a vapor retarder is present on the underside of the foam insulation. The same goes for rigid foam, however most rigid foams are inherently Class II or III vapor retarders. Since closed-cell foam is also inherently a vapor retarder, it tends to be the recommended selection. However, codes typically allow open-cell foam to be installed as long as a vapor retarder coating or layer is installed between the insulation and the attic space.

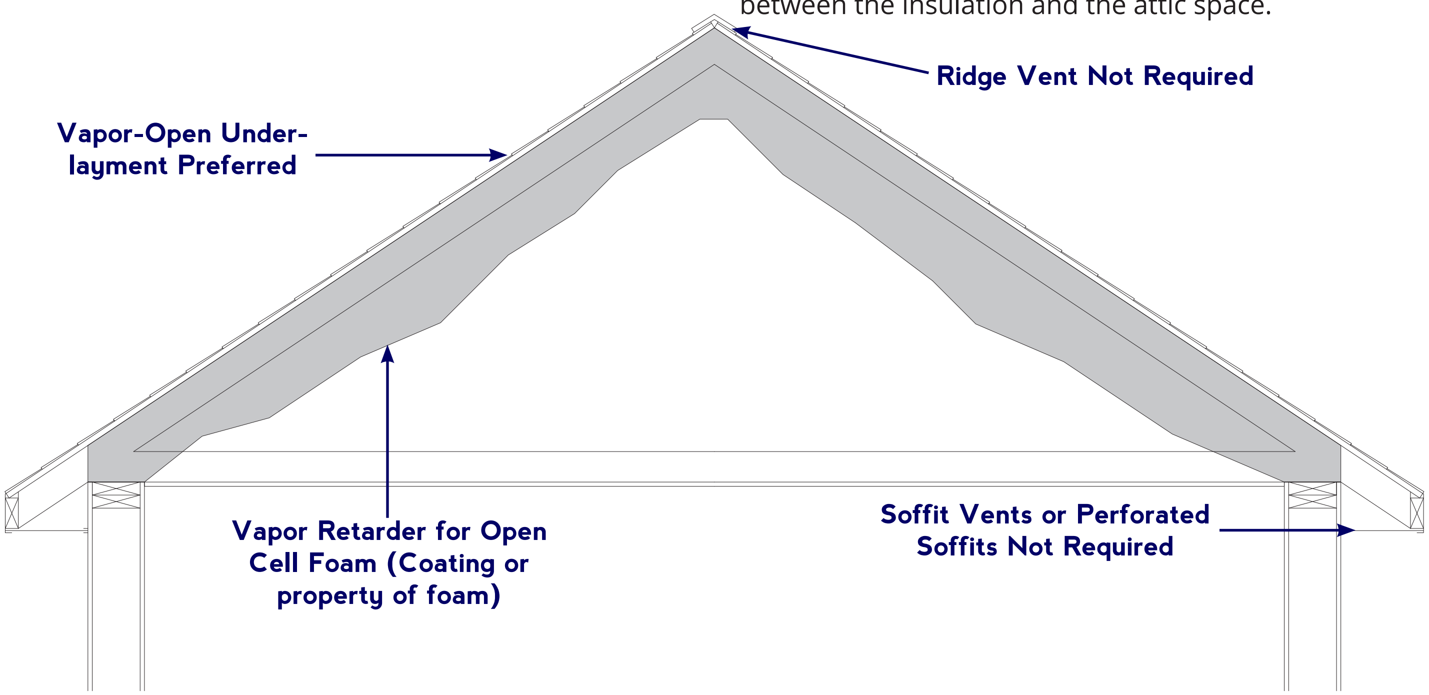

Figure 4: Critical moisture considerations in unvented insulated roof/attic assemblies using spray foam