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Air Barriers, Vapor Retarders and Weather-resistive Barriers: Are They All the Same?

Proper moisture control in the exterior envelope of buildings primarily depends on controlling moisture flow in vapor form, and preventing moisture penetration in liquid form. While complete elimination of moisture condensation within wall assemblies under all climatic conditions may be difficult, the goal of a designer should be to prevent moisture accumulation, and to ensure that short-term exposure to moisture does not affect wall components adversely. Since the quantity of liquid moisture penetrating through the exterior wall deficiencies can be significantly larger than moisture condensation, the primary goal for building envelope design is to prevent moisture penetration through the exterior surface or the back-up materials.

During the past several years, energy efficiency has been a top priority in designing and constructing building exterior walls. Although model energy conservation codes have been in existence for many years, their adoption by various states and municipalities has made energy-efficient design mandatory.

Increasing energy efficiency in the exterior walls involves the use of more insulation (higher R-value) and various measures to reduce energy loss from infiltration/exfiltration. However, the use of more insulation increases the potential for condensation within the wall assemblies as the temperature differential between the inner and outer surfaces of the walls increase. For this reason, the proper use of vapor retarders and air barriers is critical for proper performance of exterior wall assemblies.

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In addition to issues with energy efficiency and moisture condensation, the design of any exterior wall assembly also should include provisions for controlling penetration of moisture in liquid form (i.e., rain). In barrier-type walls, such penetration is resisted entirely on the outer surface of the wall (such as a non-drainable EIFS system). However, in drainage-type systems (such as a masonry cavity wall), resistance to water infiltration is primarily provided within the wall assembly through the use of a weather-resistive barrier.

This article summarizes the functional aspects of vapor retarders, air barriers and weather-resistive barriers.

Air Barriers

THERE ARE MANY FACTORS that produce differential air pressure between the interior and exterior of a building. These factors include stack effect on tall buildings, mechanical pressurizations/depressurization, and wind.

Air movement through exterior walls also significantly reduces their thermal performance and energy efficiency.

In order for an air barrier to be effective, all of its penetrations and seams need to be sealed. Lack of flashing around this louver will also render this air barrier ineffective if it is intended to serve as a weather-resistive barrier. Also, note that the sheet material has been stapled to the substrate and its seams are not taped. Stapling the membrane to the substrate typically does not provide adequate resistance to wind pressure.

Differential air pressure results in air movement through the building envelope. Research and experience has shown that the vast majority of moisture condensation within wall assemblies is caused by movement of moist air from the warm side of the assembly to the cold side. As air moves through the assembly, it carries the humidity with it. Once the humid air reaches colder sections of the wall assembly, it condenses. Since air can move large quantities of moisture, condensation can be very significant. In addition to potential problems with condensation, air movement through exterior walls also significantly reduces their thermal performance and energy efficiency.

Air barriers are designed to prevent the movement of air through a building's exterior walls. In many cases, the air barriers should not prevent moisture permeance (refer to the section on location of air barriers, vapor retarders and weather resistive barriers). However, there are cases where an air barrier can prevent moisture permeance as well as resist penetration of liquid water. Vapor retarders and weather-resistive barriers serve these functions primarily.

Although the 2006 (and prior versions of) International Building Code (IBC) published by International Code Council

(ICC) does not require the use of air barriers in building exterior walls, their use has been mandated in Canada as of 1995 [IBC adopts by reference International Energy Conservation Code (IECC) that dictates the use of vapor retarders, but not air barriers]. Subsequently, a few states also required the use of air barriers in exterior walls. In 2006, the American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. (ASHRAE) approved a revised version of AHRAE 90.1 "Energy Standard for Buildings Except Low-Rise Residential Buildings" that requires the use of air barriers. AHRAE 90.1 is adopted by reference in the IECC, which is in turn adopted in IBC. It is likely that the next version of the IBC (to be issued in 2009) will incorporate a new version of ASRAE 90.1 that will make the use of air barriers mandatory. Once various states and municipalities adopt the future versions of the IBC, the use of air barriers will be mandatory in those locations.

Asphalt saturated felt can be used as a weather-resistive barrier (but not an air barrier or vapor retarder). However, to function properly, penetrations through it should be properly flashed. In this photo, the louver penetration through the backup renders the weather-resistive barrier ineffective where it is most susceptible to water intrusion.

Air barriers come in a wide range of materials. The most popular air barriers (also known as building wraps) are mechanically fastened sheets, typically flash spun polyethylene. Other types of air barriers include self-adhered, rubberized asphalt sheets, and liquid-applied membranes of various chemical compositions. Performance criteria for air barriers are specified in various standards, including ASTM E 1677 "Standard Specification for an Air Retarder (AR) Material or System for Low-rise Framed Building Walls." Other standards, such as ASTM E 2357 "Standard Test Method for Determining Air Leakage of Air Barrier Assemblies," help in the evaluation of wall assembly performance in controlling air movements.

There are several issues that need to be noted regarding the application of air barriers:

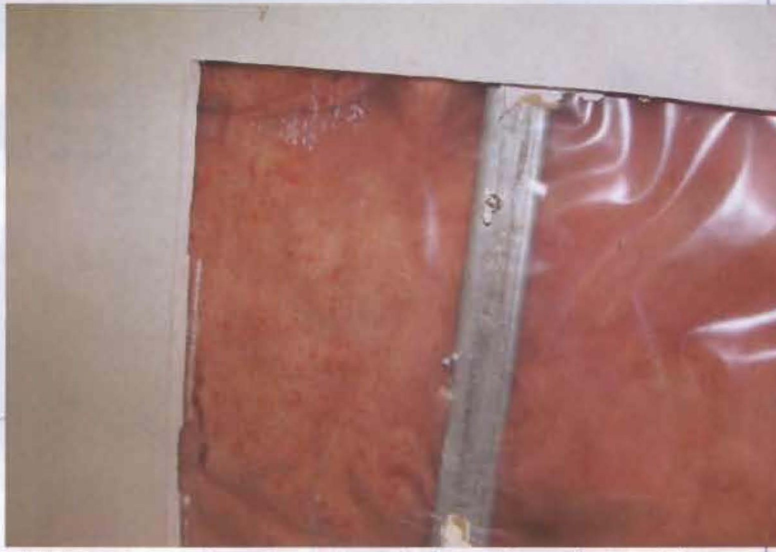
- Some air barrier materials also can act as weather-resistive barriers. In some cases, they can act as weather-resistive barriers *and* vapor retarders, as well as their primary function. As such, it is imperative that the wall designer evaluates the proper location of the air barrier within the wall assembly and specifies the correct type of air barrier for the application.
- Air barriers can only be effective if they are installed in a continuous manner with all penetrations and seams sealed. Unsealed penetrations through air barriers can render them ineffective.
- If an air barrier also is used as a weather-resistive barrier (such as a building wrap), all penetrations through it have to be sealed and properly flashed to resist water penetration.
- Air barriers will have to be designed and installed to resist wind loads. While they are concealed within the wall cavity, wind loads can transfer to the air barrier causing it to separate from its substrate. This is particularly a problem with mechanically-attached air barriers.

Most vinyl wall coverings act as a vapor retarder. In warm humid climates, application of a vapor retarder on the inner surface of the wall can result in condensation to form on the cool side of the wall (the interior). This typically results in mold growth on the gypsum sheathing.

Vapor Retarders

WITH THE EXCEPTION of metals, all building materials are permeable to water vapor (i.e., they allow movement of water vapor molecules through them when subject to differential water vapor pressure). Some materials, such as polyethylene, are less permeable than others, such as CMU or gypsum. Likewise, certain coatings are less permeable than other coatings.

The WRB, flashings and the drainage system should be considered as a system of various components that work together to prevent water penetration through the exterior walls.



Polyethylene sheets are often used as a vapor retarder. However, the use of a vapor retarder can impede evaporation of moisture that leaks into a wall cavity due to deficiencies in the wall. Note the water accumulation in the fiberglass batt insulation (behind the polyethylene sheet).

The IECC defines a vapor retarder as: "A vapor-resistant material, membrane or covering such as foil, plastic sheeting, or insulation facing having permeance rating of one perm (5.7 X 10^{-11} kg/PA.s.m^2) or less when tested in accordance with the desiccant method using Procedure A of ASTM E 96. Vapor retarders limit the amount of moisture vapor that passes thorough material or wall assembly."

Although vapor permeance does not play as significant of a role in moisture control as air movement, the use of a vapor retarder in an exterior wall assembly is required by many model building codes, including IBC [Required by IECC, which is referenced in IBC]. In its 2006 version, the IECC requires the use of vapor retarders in cold climates with certain exceptions [Exceptions include Climate Zones 1 through 3, cases where moisture or its freezing do not damage construction materials, and where other means of condensation control in unventilated walls is provided].

It should be noted that a vapor retarder also can act as an air barrier if all of its penetrations and terminations are sealed properly.

Weather-resistive Barriers

WHILE VAPOR RETARDERS and air barriers are intended to control moisture condensation within wall assemblies, weather-resistive barriers (WRBs) are intended to prevent the penetration of liquid water through the exterior walls. As such, they typically are made of materials that can resist water and are not damaged by exposure to water.

With the exception of certain types of walls, such as solid concrete or masonry walls, the IBC requires the installation of a WRB in exterior wall assemblies with drainage provisions. Such WRBs should be integrated with the mandated flashings to provide for "a continuous weather-resistive barrier behind the exterior wall veneer."

There are many types of WRBs, with the most traditional type being asphalt-saturated felt installed in a shingle fashion. Many of the air barriers available on the market today also can act as a WRB.

The WRB should be placed within the drainage cavity of a wall – typically attached to the back-up material – and integrated properly with the flashings and drainage system at various locations within the wall; the proper integration is critical for providing good resistance to water penetration. The WRB, flashings and the drainage system should be considered as a system of various components that work together to prevent water penetration through the exterior walls. One method to envision proper installation of the weather-resistive system is to consider the exterior cladding as only a decorative layer, such that if the exterior cladding material is removed, water still could not penetrate the exterior walls.

In masonry cavity construction with CMU back-up, incorporation of a WRB on the back-up is important. While the IBC does not state clearly that CMU back-up is required to have a weather-resistive layer, it is the authors' opinion that CMU is not a weather-resistant material and can absorb large quantities of moisture that in turn can harm other building components, including interior sheathing and insulation materials.

Proper Locations for Air Barriers, Vapor Retarders and Weather-resistive Barriers

LOCATING THE AIR BARRIER, vapor retarder and WRB within a wall assembly should be performed by the designer. The proper location of these components is critical in thermal and moisture performance of the building envelope. Given the changing requirements of model building codes, building envelope designers should be thoroughly familiar with the building code requirements and industry standards regarding these components.

In addition, designers should be aware of the different performance characteristics of various materials that are marketed as air barriers, vapor retarders and WRBs. As previously mentioned, there are many materials that can function as all three, or two out of the three.

In order to properly evaluate the performance of exterior walls that incorporate air barriers, vapor retarders and WRBs, Sophisticated computer modeling tools can be used to better evaluate the potential for condensation within wall assemblies, and to predict moisture accumulation.

simple dew point analysis may not suffice. More sophisticated computer modeling tools can be used to better evaluate the potential for condensation within wall assemblies, and to predict moisture accumulation. The use of such sophisticated modeling tools is more critical when specifying new wall assemblies without long-term track records, or when specifying building envelope assemblies for special-use buildings, such as cold storage facilities or swimming pools. Buildings located in severely cold, or hot and humid climates also should receive special attention during the design phase.

Although there are countless variations of exterior building assemblies that can perform satisfactorily in various climate conditions, the authors recommend considering a particular wall assembly that can perform well in all climate conditions, depicted in Figure 1. As shown, a material that can perform as an air barrier, vapor retarder and WRB – many products such as self-adhering rubberized asphalt sheets or liquid-applied membranes and some mechanically-attached sheet membranes can perform this function – is installed on the exterior face of the back-up material and is integrated with all wall flashings. Moisture-resistant insulation, such as extruded polystyrene, is then placed on the outside of this layer. The drainage layer and cladding are then placed on the outer side of the wall assembly.

While this wall assembly can add to the overall thickness of the wall, it presents several advantages. One major advantage is that the vapor retarder, WRB and air barrier are all combined into one material. Also, this wall assembly does not pose any risk of moisture condensation or accumulation regardless of the climate zone.

As previously mentioned, many other types of wall assemblies can provide adequate moisture performance. However, they are more susceptible to moisture condensation than the example provided. For instance, in cold climates, the vapor retarder typically is placed on the warm side of the wall, directly behind the interior finishes. During cold weather, warm and moist interior air is driven toward the exterior, but is stopped by the vapor retarder. Since the vapor retarder is on the warm side of the insulation, the moist air will not condense. On the other hand, during warm weather, the warm moist exterior air is driven toward the interior. Again, the vapor barrier stops the

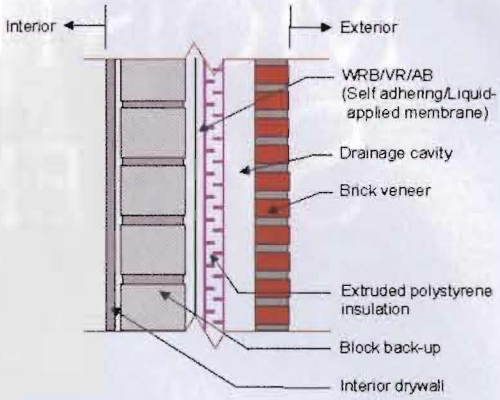


Figure 1: A conceptual wall assembly that resolves moisture condensation issues in combined climates where both warm humid and cold conditions are encountered.

movement. However, since is it now on the cold side of the insulation, condensation can form within the wall. In this case, it is important that any weather-resistive barrier or air barrier placed over the exterior sheathing be permeable (not act as a vapor retarder), to allow water vapor to escape the wall cavity.

For these reasons, proper placement of the vapor retarder, air barrier and WRB in a wall is critical.

Summary

WITH THE EMPHASIS ON thermal performance of building exterior walls, the proper design, selection and installation of vapor retarders, air barriers and WRBs is important. While these three components are intended to serve three, distinct functions, they can be combined into one or two materials depending on the properties of the materials. However, please note that improper selection or placement of these materials can lead to moisture failure.

The proper placement of air barriers, vapor retarders and WRBs requires an analysis and understanding of the moisture movements through various wall components. The appropriate selection of the materials for these components also requires a thorough understanding of each material's physical properties.

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