AIR AND VAPOR RETARDERS

An air retarder or vapor retarder sometimes is used as a component of membrane roof assembly to minimize the passage of air or water vapor, respectively, into the roof assembly.

NRCA defines the terms "air retarder" and "vapor retarder" as follows:

Air retarder: A material or system in building construction that is designed and installed to reduce air leakage either into or through the opaque wall

Vapor retarder: A material or system that significantly impedes the transmission of water vapor under specified conditions

Some in the construction industry use the terms "air barrier" and "vapor barrier" instead of "air retarder" and "vapor retarder." NRCA considers the terms "air barrier" and "vapor barrier" to be technically incorrect because few if any materials will provide an absolute barrier from passage. Instead, air retarders and vapor retarders restrict the passage of air and vapor, respectively.

Air retarders and vapor retarders play similar but not identical roles in buildings. Air retarders are intended to restrict the passage of air through materials, and vapor retarders are intended to restrict the passage of water vapor through materials.

NRCA considers the decision to include an air retarder or vapor retarder in the roof assembly to be that of the designer and/or building owner. This chapter is intended to provide general information regarding air and vapor retarder materials and the installation of those materials.

Additional information regarding condensation control in roof assemblies is provided in the Condensation and Air Leakage Control section of The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing.

3.1—Air Retarders

Water vapor diffusion through materials is only one of the mechanisms by which water can be transported into building assemblies, including roof assemblies. Another mechanism, which is now generally considered far more significant, is air leakage. Air leakage occurs when joints, cracks, holes and other openings occur in a building's thermal envelope, creating continuous pathways from inside to outside the building, and an air pressure differential occurs across the opening. Both mechanisms—vapor diffusion and air leakage—may occur at the same time.

The principal function of an air retarder is to restrict inside air from passing through the walls, windows or roof to the outside (exfiltration) and also restrict outside air from passing through the building envelope to the inside (infiltration). These conditions apply whether the air is humid or dry because air leakage can result in problems other than the deposition of moisture in cavities and building assemblies. For example, exfiltration also carries away heating and cooling energy.

Terminology: The term "air barrier" is often used when referring to preventing or controlling air leakage through a building's envelope. Many test standards and some codes use this term then go on to describe prescriptive methods for controlling air leakage or air leakage rates that do not provide for zero air leakage—that being an absolute barrier.

In building, in reality, it is virtually impossible to create an absolute barrier from all air leakage. For this reason, NRCA considers the term "air barrier" to be a misnomer. In this manual, NRCA has adopted and will use the term "air retarder" for what some will refer to as an "air barrier."

Following is additional terminology applicable to air retarders:

- **Air leakage:** The movement/flow of air through the building envelope, which is driven by either positive (infiltration) or negative (exfiltration) pressure difference or both
- **Air infiltration:** Air leakage into the building driven by positive pressure
- **Air retarder:** A material or system in building construction that is designed and installed to reduce air leakage either into or through the opaque wall
- **Air retarder system:** A combination of air retarder assemblies installed to provide a continuous barrier to the movement of air through portions of building enclosure assemblies
- **Continuity:** In the context of air retarder systems, an uninterrupted succession of air retarder materials, accessories and assemblies
- **Air retarder accessory:** A transitional component of the air retarder that provides continuity
- **Air leakage rate:** The quantitative measure of air passage through a set surface area of an assembly within a given time period under a pressure differential between the two sides of the assembly

Fundamental concepts: The primary function of an air retarder system is to reduce air leakage through a building's thermal envelope. To create this level of performance, the air retarder should have the following attributes:

- Meet material air permeability requirements
- Be continuous when installed—it should have tight joints and seams in air retarder assembly; tightly sealed penetrations; and effective bonds to adjacent air retarder materials at intersections such as wall-to-roof, wall-to-foundation and wall-to-window joints
- Accommodate dimensional changes caused by temperature or shrinkage without damaging joints or air retarder material
- Be strong enough to support stresses applied to air retarder material or assembly. The air retarder should not be ruptured or excessively deformed by wind and stack effect. Where an adhesive is used to complete a joint, the assembly should be designed to withstand forces that might gradually peel away the air retarder material. Where the material is not strong enough to withstand anticipated wind and other loads, it must be supported on both sides to account for positive and negative wind gust pressures.

In addition, the following properties can be important, depending upon the specific application:

- Elasticity

- Thermal stability
- Fire and flammability resistance
- Inertness to deteriorating elements
- Ease of fabrication, application and joint sealing

An air retarder may control vapor and airflow (i.e., it may act as a combined air and vapor retarder), depending on the characteristics of the materials used. Many designs are based on this concept, with measures taken to ensure the layer with vapor-retarding properties is continuous to control airflow. Some designs treat airflow and vapor diffusion as separate entities, but an airflow retarder should not be located where it can cause moisture to condense if it also has vapor-retarding properties. For example, a combined air and vapor retarder placed on the cold side of a building envelope will result in condensation.

To be considered an effective air retarder material, the air permeance for that material has been established by some building and energy codes as no greater than 0.004 cubic foot per minute per square foot (cfm/ft^2) at a pressure difference of 0.3 inches of water (1.57 pounds per square foot). The 2012 and 2015 editions of the International Energy Conservation Code, (IECC 2012 and IECC 2015), ASHRAE 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," and ASHRAE 189.1, "Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings," reference this value.

Air permeance of air retarder materials is tested according to ASTM E2178, "Standard Test Method for Air Permeance of Building Materials."

The maximum permitted air leakage rate of an air retarder assembly has been established by some building and energy codes as 0.04 cfm/ft^2 at a pressure difference of 0.3 inches of water (1.57 psf). IECC 2012 and IECC 2015, ASHRAE 90.1 and ASHRAE 189.1 reference this value.

Air leakage rates of air retarder assemblies are tested according to one of the following methods:

- ASTM E283, "Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen"
- ASTM E1677, "Standard Specification for an Air Barrier (AB) Material or System for Low-Rise Framed Building Walls"
- ASTM E2357, "Standard Test Method for Determining Air Leakage of Air Barrier Assemblies"

The maximum permitted air leakage rate of a whole building has been established by some building and energy codes as 0.4 cfm/ft^2 at a pressure difference of 0.3 inches of water (1.57 psf). IECC 2012 and IECC 2015, ASHRAE 90.1 and ASHRAE 189.1 reference this value.

Air leakage rate of whole buildings is tested according to ASTM E779, "Standard Test Method for Determining Air Leakage Rate by Fan Pressurization."

Design: In designing air retarders for roof assemblies, designers need to consider the air retarder's desired location for the particular roof system being specified.

The 2012 and 2015 editions of the International Energy Conservation Code (IECC), allow air retarders to be placed on the outside of an assembly comprising the building envelope, within the assembly comprising the building envelope or on the inside of the assembly comprising the building envelope. As this applies to roof assemblies, the air retarder can occur on the exterior side of the roof system, as a component within the roof system, or underneath the roof system, either between the roof deck and the roof system or underneath the roof deck.

In the case of locating the air retarders on the outside of the roof system, some roof system types will function as air retarders without the need for additional testing. For example, IECC 2012 and 2015 recognize the following types of roof systems as air retarders:

- Built-up membranes
- Polymer-modified bitumen membranes
- Fully adhered single-ply membranes
- 1.5 pcf density closed-cell spray foam, minimum 1½ inches thick

The deemed-to-comply option's criteria for closed-cell spray foam, minimum 1.5 pcf density, minimum 1½ inches thick, can be interpreted to include SPF roof systems.

For additional information about air retarders, refer to the Condensation and Air Leakage Control Section of The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing.

3.2—Vapor Retarders

A vapor retarder sometimes is used as an additional component in membrane roof systems.

Currently, there are not consensus or widely accepted guidelines for determining whether a specific membrane roof assembly should include a vapor retarder in its design.

For new construction situations where the use of a vapor retarder as a component of the roof assembly is intended, the vapor retarder should be clearly denoted in the project specifications and on the drawings and construction details that apply specifically to the roof assembly. The specific vapor retarder materials, location, methods of installation and methods of interfacing with any adjacent vapor retarders should be clearly denoted.

Additional information regarding determining a need for a vapor retarder, vapor retarder placement and the amount of R-value necessary above a vapor retarder is provided in the Condensation and Air Leakage Control Section of The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing.

The materials used to construct vapor retarders in roof assemblies using membrane roof systems may be classified into two broad categories:

- Bituminous vapor retarders
- Plastic sheet or film vapor retarders

Bituminous Membrane Vapor Retarders: Bituminous membrane vapor retarders are the most commonly used type of vapor retarders. Modern bituminous vapor retarders are composed of two plies of Type IV fiberglass ply sheet (felt) installed with two or three moppings of hot asphalt. Such a vapor retarder provides a perm rating that approaches 0 perms. Asphalt can be similarly combined with organic felts (e.g., No. 15 or coated sheets) or various base sheets to provide an effective vapor retarder. With these types of vapor retarders, the continuous bituminous film serves as the primary vapor-resistant components.

Alternatives to two-ply bituminous vapor retarders include self-adhering polymer-modified bitumen sheet products and smooth-surfaced APP or SBS polymer-modified bitumen sheet products installed in adhered applications.

Plastic Sheet or Film Vapor Retarders: Typically, plastic sheet vapor retarders are made of polyvinyl chloride (PVC) or polyethylene. Often, these types of vapor retarders are installed loose-laid or adhered using a compatible adhesive to adhere the sheets to the roof deck or substrate. Depending on material type and thickness, permeance of these plastic sheets or film retarders ranges from approximately 0.04 to 0.50 perms. Seams should be sealed or taped, as should all cuts and holes around penetrations.

For certain projects, PVC and polyethylene materials are not recommended for use as vapor retarders for the following reasons:

- Hot flowing bitumen poses a hazard to these plastics. If hot bitumen flows through the joints of the insulation, it can melt the plastic and destroy the vapor retarder's effectiveness.
- Adhesives also pose a problem for plastic sheet vapor retarder systems because the adhesives require time to set.
- A 2- to 4-inch-wide lap of these materials is often difficult to seal dependably in actual field conditions.

Selecting Vapor Retarder Materials: The term "vapor retarder" refers to a broad range of materials used to control the flow of moisture vapor from the interior of the building into the roof system. The following are important considerations when selecting a vapor retarder:

- Roof deck type and possible puncture damage
- Sandwich-type vapor retarder construction
- Insulation type
- Securement

- Compliance with fire- and wind-resistance classifications

Roof Deck Type and Possible Puncture Damage: In Northern climates, for adhered roof systems installed over solid, continuous surfaces, such as cementitious wood fiber panels, lightweight insulating concrete, poured or precast gypsum panels, structural concrete, and wood plank and structural wood panel roof decks, any vapor retarder is best placed at a level directly above the roof deck to minimize the potential for puncturing the vapor retarder.

The placement of a vapor retarder directly over a steel roof deck has proved to be generally unsuitable because the flexible vapor retarder sheet is extremely vulnerable to puncture damage from foot and equipment traffic that takes place between the ribs of the steel panels. Therefore, a vapor retarder should not be placed directly over a steel roof deck unless there is no other alternative.

For a steel roof deck, where the installation of a vapor retarder is designed to be a part of the roof system, NRCA suggests the vapor retarder be installed in the sandwich-type of vapor retarder construction. This method is described in the Sandwich-type Vapor Retarder Construction section that follows.

Sandwich-type Vapor Retarder Construction: When vapor retarders are to be installed over steel roof decks, NRCA recommends sandwich-type construction be employed. In this type of roof construction, a layer of low-R-value, fire-resistant insulation or glass-faced gypsum board is first attached directly to the steel roof deck with mechanical fasteners to serve as a supporting base for the vapor retarder system. The vapor retarder is applied to this base layer. Then, subsequent layers of insulation having a higher R-value than the base layer are adhered over the vapor retarder to serve as the roof system's primary insulation.

This sandwich-type construction can provide a continuous vapor retarder that is uniformly supported and secured to the steel deck, is not penetrated by fasteners and can be designed to achieve a low perm rating approaching 0 perms.

In roof systems that require a vapor retarder, the temperature at the vapor retarder level must be warmer than the dew-point temperature for the vapor retarder to perform its intended function.

Insulation Type: Various types of insulation may be applied over the different types of vapor retarders. However, chemical and physical compatibility are key items to consider when selecting the type of vapor retarder and adhesive to be used with certain types of insulation.

For additional information regarding the compatibility of specific roof insulation types with specific vapor retarder materials, refer to Chapter 4—Rigid Board Insulation.

Securement: Over structural concrete roof decks, bituminous vapor retarders should be adhered to the primed roof deck.

Over nailable roof decks, the base ply of the vapor retarder should be nailed to the roof deck, and then the first ply should be adhered to the base sheet in a solid mopping of hot asphalt.

Compliance With Fire- and Wind-resistance Classifications: FM Global and Underwriters Laboratories rate vapor retarders for their fire resistance and wind-uplift test performance, not for their effectiveness as vapor retarders.

For additional information about vapor retarders, refer to the Condensation and Air Leakage Control Section of The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing.