Break Through Barriers: How Understanding Air and Vapor Barriers Can Help Ensure More Comfortable, Safer Buildings

By David Finley, Director of Building Enclosure Science, The Garland Company

All fifty US States require a continuous air barrier as part of new construction. Code generally contains three compliance options for acceptable air leakage, or permeability, through an air barrier: 0.004 cubic feet per minute per square foot (CFM/ft2) for materials, 0.04 CFM/ft2 for assemblies, and 0.4 CFM/ft2 for the whole building. These standards have trended toward greater levels of air-tightness over time, and will continue to do so, with projected changes to the energy code in the future for the air leakage rate for a whole building getting to a level of just 0.25 CFM/ft2.

In spite of the ubiquity of requirements for air barrier usage, and increasing code standards, there remains a significant amount of confusion and misinformation in the roofing industry regarding air barriers and their distinctions, if any, from vapor barriers and vapor retarders. The goals of this paper are to clarify the definitions and performance characteristics of air barriers, vapor retarders, and vapor barriers; and outline conditions where the performance of an air barrier has a significant impact on the overall building.

What is an Air Barrier?

Air barriers are any material, component, or assembly used in a building's construction that restricts the flow of air across the building enclosure. Air flows naturally from areas of high pressure to areas of lower pressure. Such pressure differentials can occur across the building enclosure by three primary methods:

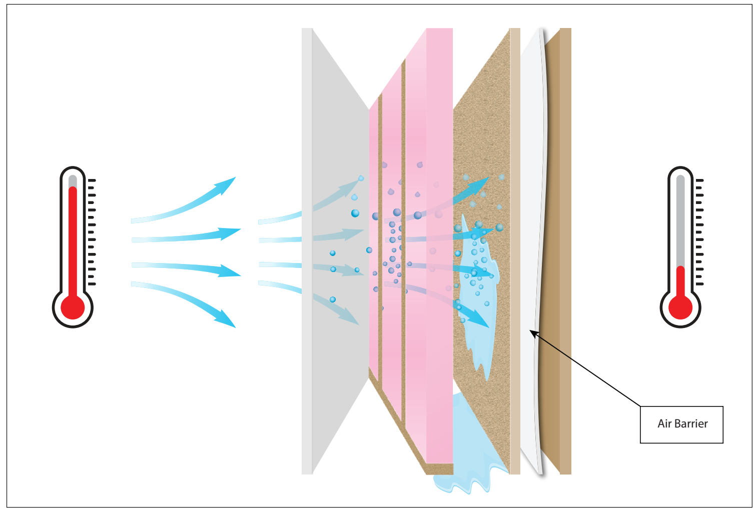
1. Wind may push air into, or suck air out of, a building.
2. Natural buoyancy or stack effect can cause air movement in buildings with large open areas and high ceilings like atriums or natatoriums.
3. Mechanical systems such as HVAC, will supply or remove conditioned air into a space thereby creating a pressure differential across the enclosure.

It is important to utilize air barriers to maintain consistent occupant comfort and reduce moisture issues associated with condensation development. Most buildings wish to maintain neutral or slightly positive pressure inside to regulate thermal comfort, indoor air quality, and energy consumption. Some specialized buildings like hospitals may have areas of negative pressure where the desire is to hold contaminated air inside that designated area.

In addition to occupant comfort issues, air leakage can cause moisture issues as air carries a significant amount of moisture in the form of water vapor. Without a continuous air barrier, interior conditioned (i.e., humidified) air can migrate into interstitial spaces within the building enclosure assemblies. If this air contacts a surface that is below its dew point temperature, condensation could develop on that surface. Depending on the surrounding conditions, this condensation can build and manifest in dripping water to the interior, cause corrosion of ferrous metals, or lead to microbial growth.

What is a Vapor Barrier?

As their name suggests, vapor barriers limit the flow or diffusion of water vapor that is in the air or within a material through a building enclosure. This diffusion of water vapor through materials differs from water



vapor transported via air flow in two significant ways. One the amount of moisture deposition associated with vapor diffusion is orders of magnitude less than that associated with air leakage. Secondly, while both air and water vapor move with respect to a pressure differential, water vapor pressure is directly related to temperature such that it will diffuse from warmer to cooler temperatures. In order to reduce vapor diffusion, a vapor control membrane is installed on the warm side of the enclosure assembly. These vapor control membranes, similar to air barriers, are measured in permeability, but with a different unit of measure called a perm. Some building materials, like glass, solid metal, and asphaltic roofing assemblies of a certain thickness, carry a zero-perm rating, meaning they are impermeable and allow no vapor to pass.

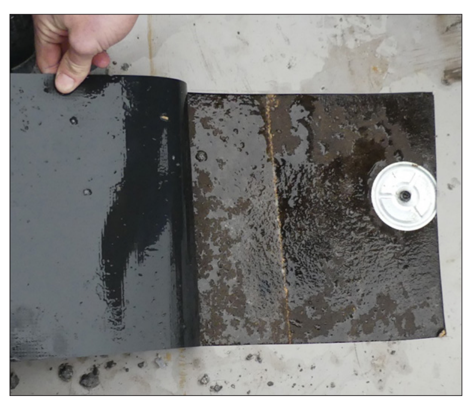
Vapor permeability has three class ratings with the building code:

- Class 1 materials carry a rating from 0.0-0.1 perm.
- Class 2 materials have a permeability between 0.1 and 1.0 perm. The kraft paper backing on fiberglass batt insulation is an example of a Class 2 material.
- Class 3 materials are anything above 1.0 perm rating. Latex paint is an example of a Class 3 material.

This rating system presents one of the first areas of industry confusion around nomenclature. Because both air and vapor barriers are classified according to their permeability ,terminology can often become muddled, and as a result, the wrong material can be specified. Firstly, anything that carries a Class 2 or Class 3 rating for vapor permeability should not be referred to as a vapor barrier; rather, that material is a vapor retarder.

Secondly, vapor retarders can restrict the diffusion of vapor as well as air flow (if detailed and installed continuously); however, not all air barriers can retard vapor diffusion. For example, building wraps are highly permeable (greater than 30 perms). As such, it is important to closely consult manufacturer technical data sheets to ensure that the correct material is being utilized for the intended control layer: air, vapor, or both.

What Can Go Wrong



Anyone who has spent some time in the building enclosure and roofing industry has likely heard the comment, “This assembly has to breathe.” What does that mean, and how can it be achieved, in a construction industry and regulatory climate moving inexorably toward less air migration?

Let’s start with the meaning behind the comment - in reality, it’s not about the air. When we want an assembly to “breathe”, what we really want is for moisture that gets into an assembly to have a way

to diffuse out. But rather than create a system that aids the exit of water vapor from an assembly, we should be focused on preventing or limiting air movement in the first place, which can deposit significant amounts of moisture in the form of condensation within enclosure assemblies.

The risk of a mindset that a building needs to “breathe” is that areas of air leakage are accepted, or the air barrier used in a roofing assembly is not tied into the membranes used in the walls. Condensation that manifests itself as a “leak” is easy to diagnose and address. However, when condensation begins inside an assembly, it may go undetected for years, causing degradation of moisture sensitive materials (e.g., wood and gypsum), corrosion of metal decking and fasteners, and accumulation of microbial growth. These conditions can become truly harmful as buildings invest in mechanical systems to improve thermal comfort and ventilation in the wake of the Covid-19 pandemic. These well-intentioned investments can actually cause greater health risks as they circulate the harmful microbes that have accumulated inside the building enclosure.

Conclusion

Air barriers are a critical component of a building enclosure and can only function as long as they are continuous. It is important to understand how air flows through a building enclosure, and therefore how water vapor flows as well. While having a good working understanding of the basic definitions and proper usage is critical, partnering closely with a enclosure consultant and roofing manufacturer to ensure the right barriers are specified and the correct installation methods followed is recommended to provide more energy efficient buildings with enhanced thermal comfort for its occupants.

David Finley is the Director of Building Enclosure Science for The Garland Company. His building envelope investigative experience includes water infiltration testing of windows, curtain walls, masonry facades, and plaza and below-grade waterproofing; condensation and air leakage testing of glazed fenestrations and masonry facades; performing hygrothermal analyses using steady and transient state techniques; analyzing window and wall systems for two dimension thermal conduction; and more. David is active in ASHRAE Technical Committees 1.12, 4.4, and 160, and serves as the Program Chair and voting member for TC 1.12, voting member for TC 4.4, and Co-chair of the Freeze-Thaw Task Force for SSPC 160.