INCORPORATING AIR BARRIERS INTO POST-FRAME CONSTRUCTION

By Joseph M. Zulovich, PhD PE

Air barriers and vapor retarders have two separate functions in an exterior building assembly. Air barriers provide a barrier to air leakage into or through an exterior building assembly. Vapor retarders provide a resistance to vapor movement into or through an exterior building assembly. This article focuses on the need for air barriers in all post-frame construction regardless of requirements for vapor retarders and issues related to them.

WHAT ARE AIR BARRIERS, AND WHAT DO THEY DO?

The 2015 International Energy Conservation Code defines an *air barrier* as "a single material or a combination of materials" joined together "to provide a barrier to air leakage through the building envelope" (International Code Council, 2015b). Some prescriptive air barriers are listed in the code and are discussed in this article. A basic understanding of air-barrier properties helps one develop a functional and effective air-barrier system.

Two key properties are not specifically defined in the code but can be found in the engineering literature (American Society of Heating, Refrigerating and Air Conditioning Engineers, 2017). First, *air permeability* refers to how porous a material is to air transferring directly through a unit thickness of material because of an air-pressure difference across the material. Second, *air permeance* is the measure of the quantity of air transfer not only through an installed material thickness but also through all joints, cracks and holes in or around the installed material. An air barrier is the part or parts of an exterior building envelope with a material layer having sufficiently minimal air permeability (not greater than 0.004 cfm/ft^2 under a pressure differential of 0.3 inches of water gauge from the interior side of the barrier to the exterior side as measured by a manometer) and installed to minimize air permeance by sealing all joints, cracks and holes. The purpose of an air barrier is to control airflow through and within building components.

Air barriers control six types of airflow in exterior building envelopes: exfiltration, infiltration, cavity ventilation, wind washing, indoor air washing and air looping. **Figure 1,** from the *2017 ASHRAE Handbook—Fundamentals* (ASHRAE, 2017), shows schematics of these six types of airflow.

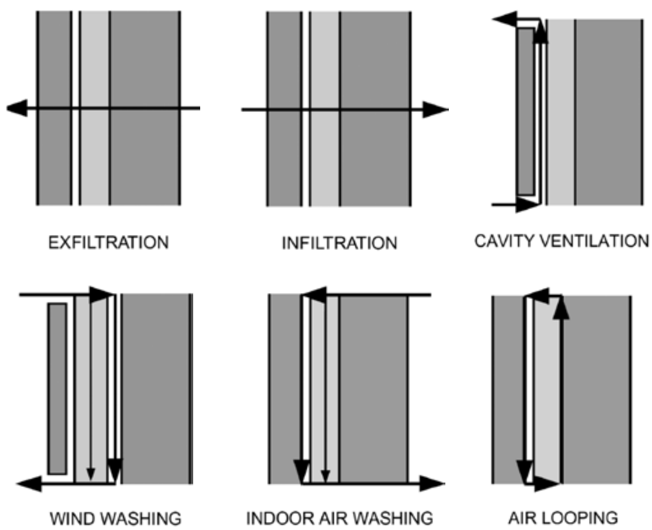

Figure 1. Examples of Airflow Patterns in Exterior Building Assemblies
In each example, the darker-colored portion on the left side of the wall is siding material. The lighter portion in the center is insulation. The larger dark portion on the right is interior wall material. The arrows show air movement. Illustration from *2017 ASHRAE Handbook—Fundamentals*.

Exfiltration (air outflow). Air passes across an envelope component, moving from inside the building to the outdoors. In cold weather, exfiltration will carry moisture-laden warm air into an exterior wall or ceiling where moisture will condense, resulting in moisture problems within exterior building assemblies. Exfiltration leads to energy loss related to the heating, ventilation and air conditioning system. Exfiltration in hot weather for air-conditioned spaces tends not to cause moisture problems but will increase the costs to cool the building.

Infiltration (air inflow). Air passes across an envelope component, moving from the outdoors to the indoors. In cold weather, infiltration does not cause moisture problems in exterior assemblies. However, indoor comfort is often adversely affected by cold drafts. Heating energy costs can increase if infiltration is high. In air-conditioned buildings during warm, humid weather, air leakage into and through an exterior building envelope will tend to carry moisture-laden air into an exterior wall, where moisture will condense, resulting in moisture problems within the exterior building assemblies.

Cavity ventilation or drainage plane. Outdoor air flows along an air cavity at the exterior of the thermal insulation layer without wind washing or penetrating the insulation layer. Cavity ventilation is the only accepted air leakage into exterior wall cavities from the outside. Brick and stone (masonry) veneers typically have an air gap between the inside of the veneer and the outside of the insulated wall to allow any moisture migration through the masonry veneers to dry out and not dampen the exterior of the remaining wall assembly. The air gap between the metal siding and the insulation of a post-frame wall is an example of cavity ventilation. But in this post-frame case, the cavity ventilation allows any moisture migration through the exterior wall from inside to outside to dry out and not collect on the inside of the exterior metal siding.

Wind washing. Outdoor air permeates the thermal insulation or flows along the air layer behind (inside) the insulation. Wind washing is similar to cavity ventilation, but air gets into the insulation from the outside. In cold weather, wind washing will reduce the effectiveness of insulation and can result in moisture problems. The reduced effectiveness of the insulation typically increases heating energy costs. In hot weather, warm, moist outside air entering the exterior assembly can cool because of the inside air conditioning, causing condensation on the outside of the inside surface and resulting in moisture problems in the building envelope assembly.

Indoor air washing. Indoor air permeates the thermal insulation layer or flows along the air layer in front of the insulation. In cold weather, indoor air washing allows warm, moist air to enter an exterior assembly, where the air can be cooled and moisture can condense in the assembly. Heating costs typically increase because the insulation becomes wet and is less effective. In hot weather, for buildings with air conditioning, cool inside air penetrating the exterior assembly can cool exterior parts of the exterior assembly, resulting in moisture problems within the assembly when moisture migration is permitted from outside to inside. Significant indoor air washing can cause an increase in cooling costs.

Air looping. Buoyancy forces cause air to flow around and wash the thermal insulation layer, filling the cavity. Air looping typically does not result in moisture problems in the exterior assembly as long as moisture migration into the assembly is limited. Air looping will reduce the effectiveness of insulation, resulting in increased heating costs in cold weather and increased cooling costs in hot weather.

It is important to keep air leakage into exterior assemblies—except for cavity ventilation when it is required—to a minimum in order to maintain insulation effectiveness and minimize moisture problems within exterior assemblies.

WHAT DO THE CODES SAY ABOUT AIR BARRIERS?

The intent of the 2015 International Building Code (International Code Council, 2015a) is to establish minimum requirements for a reasonable level of safety, public health and general welfare. These minimum requirements are enforceable for all buildings in locations where building codes have been adopted. A review of the 2015 International Building Code found no reference to air barriers. I developed the following theory about why basic codes state or present only what they do. Codes tend to specify or prescribe items or components whose existence or location can be confirmed by visual inspection. A visual inspection cannot always or regularly confirm the existence of an intact air barrier. Therefore, the existence and integrity of an air barrier relies heavily upon building construction and quality (workmanship).

The intent of the 2015 International Energy Conservation Code is to regulate the design and construction of buildings with a focus on the use and conservation of energy over the life of individual buildings. The 2015 IECC discusses air barriers in the air leakage–thermal envelope section (Section C402.5.1). The air-leakage requirement for the thermal envelope can be satisfied by following sections of the prescriptive code requirements, or the envelope can be tested according to ASTM E779 (ASTM International, 2010).

The following section summarizes the prescriptive code requirements for air leakage. A continuous air barrier should be located throughout the thermal building envelope. Air-barrier materials should have all joints, seams and penetrations sufficiently sealed so the seals can remain intact during exposure to positive and negative pressures due to wind, stack effect and mechanical ventilation. Materials deemed to comply with the air-barrier requirements, provided that all joints are sealed and materials are properly installed, include the following:

- plywood with a thickness of not less than 3/8 inch
- oriented strand board (OSB) having a thickness of not less than 3/8 inch
- extruded polystyrene insulation board having a thickness of not less than ½ inch
- foil-back polyisocyanurate insulation board having a thickness of not less than ½ inch
- closed-cell spray foam with a minimum density of 1.5 pounds per cubic foot (pcf) and having a thickness of not less than 1.5 inches
- open-cell spray foam with a density between .4 and 1.5 pcf and having a thickness of not less than 4.5 inches
- exterior or interior gypsum board having a thickness of not less than ½ inch

- cement board having a thickness of not less than ½ inch
- built-up roofing membrane
- modified bituminous roof membrane
- fully adhered single-ply roof membrane, a Portland cement/sand parge, or gypsum plaster having a thickness of not less than 5/8 inch
- cast-in-place and precast concrete
- fully grouted concrete block masonry
- sheet steel or aluminum
- solid or hollow masonry constructed of clay or shale masonry units.

If the above prescriptions are not followed, completion of an air infiltration test according to ASTM E779 (a blower door–based test) after construction is completed can test air infiltration compliance with the IECC.

WHY SHOULD AIR BARRIERS BE INCORPORATED INTO POST-FRAME CONSTRUCTION?

The issue of energy conservation in buildings, including post-frame buildings, will likely maintain importance and even increase in importance over time. Incorporation of a compliant air-barrier system is one way to be compliant with air-infiltration code requirements.

Our understanding of the crucial importance and value of air barriers in a building system's energy performance for all types of building construction is increasing. Those working in the residential home sector have been discussing air infiltration and air tightness for a number of years, and blower-door tests are commonly used to evaluate air infiltration in completed homes. At one session of the 2018 ASHRAE winter meeting, the importance of air barriers and their impact on forced-air heating and cooling systems in commercial multistory buildings were discussed. Air leakage or infiltration through the exterior building envelope causes inefficient operation of heating and cooling systems. In severe cases, excess air leakage or infiltration decreases the thermal comfort of the occupants. Those working on post-frame buildings can and should capture the knowledge about air barriers being gained in other building sectors.

The cost of installing a code-approved air barrier may be prohibitive if one considers only the energy efficiency for a given project. However, post-frame construction uses diaphragms as an integral part of the structural building system. Two code-approved air barriers are plywood or OSB with a thickness of not less than 3/8 inch. Structural diaphragms are often constructed using plywood or OSB. Installing continuous structural diaphragms with sealed joints and seams can also provide for a code-approved air barrier. Although the expenses for the materials and labor associated with installing a sealed diaphragm do add to a building's cost, the sealed diaphragm provides a code-approved air-barrier system without adversely affecting the structural integrity of the building. Another way to provide for a code-approved air barrier is to use sheet steel or aluminum. For some post-frame building projects, the interior cladding is either steel or aluminum sheeting. When the seams of these sheets are caulk-sealed during installation, the interior cladding creates a continuous air barrier. The edges of the interior metal cladding should be sealed to prevent indoor air washing from moving moisture-laden warm air from the inside space into the exterior wall cavities.

Outside metal siding should *not* be sealed to create an air barrier on the outside surface of the exterior wall. Any moisture migration through the wall will collect on the inside surface of the siding if the siding is the best vapor retarder in the exterior wall envelope. Cavity ventilation or a drainage plane should be available to allow any moisture that migrates through the wall to dry. If wind washing is a concern, a building wrap should be installed before the siding is installed.

Overall, the IECC addresses air barriers only as a control for exfiltration and infiltration through an exterior building assembly. It does not address the other four types of airflow within an exterior building assembly. Wind washing and indoor air washing do not really contribute to air exchange–based energy impacts because air does not completely pass through the entire building envelope. However, as discussed, these types of airflow can adversely affect the longevity of the building assembly because of moisture problems. The potential for airflow through and within exterior building assemblies is minimized during the design phase.

Attic ventilation chutes and attic insulation stops at eaves help keep air movement away from problem areas. If wind-driven air can get underneath ceiling insulation through an eave opening of a building, the ceiling insulation essentially gets wind washed, which negates its effectiveness. During cold weather, wind-washed ceiling insulation results in cold ceiling surfaces, where condensation can form on the inside surface of the ceiling and cause an increase in heat loss. During warm or hot weather, wind-washed ceiling insulation results in warm ceiling surfaces. If the interior space is not air conditioned, this wind washing may not be much of a problem. However, if the interior space is air conditioned, the outside surface of the ceiling is likely to be cold, and condensation can form on the outside surface of the ceiling material. Ceiling material that absorbs moisture will likely get moldy on the inside because of the moisture condensing on the outside surface of the ceiling. Attic insulation stops minimize the potential for wind washing of ceiling insulation. Attic ventilation chutes transfer air into the attic space and protect the insulation from wind currents.

As energy efficiency in buildings becomes more crucial, air barriers in post-frame construction will continue to gain importance. The design of post-frame construction often includes structural diaphragms. These structural diaphragms can provide part of an air-barrier system when they are sealed and connected with other parts of the air-barrier system. FBN

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