Building Envelope

Avoiding Air Barrier Pitfalls

When sub-trade activities are not in sync with air barrier requirements, installation can go poorly.

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Air barriers, when correctly installed, help buildings achieve high levels of energy efficiency by decreasing heat loss.

For example, great pains are taken to stop the uncontrolled passage of air through building envelopes of passive houses, which routinely reduces energy consumption 80 – 90 percent compared to traditional buildings (according to the U.S. Department of Energy).

But, when air barriers are incorrectly installed, they can cause problems for buildings, including deterioration of sheathing structural members, and can contribute to the formation of mold in the wall system. The following case studies explore air barriers both correctly and incorrectly installed. First, let's look at some background.

What Is an Air Barrier?

An air barrier is a component within a building enclosure whose function is to retard air flow between the exterior climate and the interior conditioned environment.

Expensively conditioned air (heated or cooled), leaking through penetrations, seams and minute gaps in wall assemblies from indoors to out, carries energy dollars with it, just as if you'd left a door or window open. When outside air leaks in through those same pathways, it stresses the HVAC system. In both cases, if the vapor carried by the air condenses on chilly surfaces in the wall assembly, and it does, the resulting moisture invites mold.

In a well-known study, NISTIR 7238, the U.S. Department of Energy found that air leaks through the building envelope account for up to 40 percent of buildings' energy costs. In an effort to control air leakage and reduce energy use, architects and owners have used air barriers in buildings throughout the United States for more than a decade. Wisconsin and Massachusetts were among the first states to include air barriers in building codes, circa 2001.

Installation of air barrier assemblies is becoming more common in other jurisdictions as air barriers are included in national standards, such as ASHRAE 90.1-2010 and the 2012 International Energy Conservation Code.

Air barriers provide complete airtight enclosures for buildings through the use of preformed membranes or spray- or roller-applied coatings on sheathing or concrete masonry unit backup walls, along with accessory components, namely tapes and sealants. The air barrier assembly is meant to maintain airtight integrity around penetrations and along transitions between differing substrates and assemblies.

The air barrier can be a membrane and/or coating added specifically to address air leakage, or it can be a material such as drywall, rigid insulation or plywood that has had its joints treated to create an airtight assembly, since air easily passes through the seams between panels.

To be considered an air barrier, the air barrier material or assembly must meet an air-leakage rate of no more than 0.04 cubic feet per minute per square foot when tested at a pressure differential of 1.56 pound force per square foot, in accordance with ASTM E283 or ASTM E2357. The air barrier must be continuous around the entire building envelope with no gaps, voids or holes.

That requires airtight transitions to other assemblies including, but not limited to, below-grade foundations, rising walls, curtain walls, doors, windows and roofing systems. The air barrier also must be sufficiently secured to the building structure to withstand both positive and negative wind pressures, the stack effect and HVAC system operation. Finally, the air barrier needs to function for the life of the building and withstand a wide range of stresses without deterioration.

Types of Air Barriers

Many air barriers are available, with different vapor permeability, fire-resistance and application methods. There are five main types:

- Self-adhered sheet membranes.
- Fluid-applied membranes, both roller-grade and spray-applied.
- Spray-applied insulation.
- Building wraps.
- Panelized sheathing.

Each type can be further categorized by its vapor-permeability rating. For instance, vapor-permeable air barriers have a vapor

A U.S. Department of Energy study found that air leaks account for up to 40 percent of buildings' energy costs. Air barriers are but one of the many efficiency measures at Nashville's new Music City Center. The project used VaproShield's WrapShield SA Self-Adhered Water Resistive Vapor-Permeable Air Barrier Sheet Membrane. Photo by Pamela Simmons.

As shown at a courthouse in Massachusetts, a well-prepared substrate provides a smooth surface for the air barrier installation.
Photos courtesy of Gale Associates Inc.

permeance greater than 10 perms when measured in accordance with ASTM E96. Air/vapor barriers retard the passage of vapor (with a vapor permeance of no more than 1 perm when measured in accordance with ASTM E96).

Air barrier assemblies often include additional components, such as transition strips, tapes or sealants that seal gaps and/or bridge different types of construction. If the air barrier is not adhered directly to the substrate, then fasteners and tapes must mechanically attach the air barriers to nailable substances (i.e., building wraps and panel materials). Fasteners using washers are used to secure unadhered building wraps.

Pre-formed sheathing-type materials commonly used in exterior enclosures also meet the air-permeance and vapor-permeance values required of air barriers. These materials include glass mat-faced gypsum sheathing, plywood and oriented strand board sheathing, and closed-cell plastic foam board insulation.

Like plywood panels, they can serve as air barriers if the joints are taped and fastener holes and other penetrations are sealed.

Closed-cell spray polyurethane foam insulation can also serve as thermal insulation,

Top, at a Rhode Island middle school, membrane air barrier extends from the roof across the soffit and ties in the spray foam, acting as the air barrier on the vertical walls.
Bottom, membrane treatment of openings, penetrations and change in materials in preparation for spray foam installation at the middle school.

air and vapor barriers, and weather-resistive barriers if installed in strict accordance with manufacturer's recommendations.

Identifying the correct air barrier for a specific wall assembly requires an understanding of the exterior and interior climates, mechanical systems and how the exterior wall assembly is intended to handle moisture, heat, air and vapor forces.

Preparation of the Substrate

The performance of an air barrier depends on proper installation and surface preparation of substrates, tasks typically not performed by air barrier installers. Typical substrate issues that require attention include, but are not limited to, the following:

- ***For fluid-applied products,*** the joints of the sheathing boards must be filled or taped, and the mortar joints of masonry units must be filled and cut off flush.
- ***For improved adhesion,*** self-adhering sheet membrane air barriers require the application of a primer to a dry, sound substrate. These self-adhering membranes cannot span voids, gaps or cracks in substrates that exceed a quarter-inch. Wider gaps or joints require application of transition membranes, joint infill treatment or some type of a structural component to span the gap.
- ***Substrate preparation for spray-foam insulations*** includes providing a clean, dry surface and application of primer for impaired adhesion. Processing oils or films on sheet metal components must be removed to prevent bond breaks.
- ***For loose-laid, mechanically attached air barrier membranes*** or rigid insulation board stock, substrate preparation consists primarily of providing smooth, secure surfaces to which the materials can be fastened.

Detailing for Airtightness

Once the substrate has been properly prepared, the air barrier installer must address detailing at junctions between the main field of the air barrier membrane and adjacent construction. For successful air barrier assemblies, drawings must identify critical details and specifications clearly and concisely and must be project-specific. Critical areas for detailing include —

- Foundation-to-wall-transitions.
- Wall-to-door/wall-to-window transitions.
- Wall-to-curtain wall transitions.
- Relieving angles.
- Control/expansion joints.
- Deflection joints.
- Wall-to-louver transitions.
- Mechanical/electrical/structural penetrations.
- Canopy transitions.
- Roof-to-wall transitions.

In addition to assuring continuity of the air barrier, detailing at these locations must address lapping for water drainage, potential movement across joints, and sequence of installation and coordination with details for other systems. Because the exact approach depends on which air barrier materials are used, it is important to refer to details prepared by the air barrier manufacturer.

At a North Carolina elementary school, air barrier membrane is installed over an unprotected wall and damp substrates. While the membrane appears to be well detailed, the membrane was loose and not fully adhered.

Installation Requirements and Methods

Installation requirements and methods for each type of air barrier assembly depend on the materials that comprise the air barrier assembly. Some common considerations follow.

Ambient Conditions: Membranes that rely on adhesion to a substrate typically have a limited range of temperature and relative humidity at which they can be applied. In some cases, ambient conditions must be controlled for a time to properly cure fluid-applied materials. These materials must only be applied in conditions recommended by the manufacturer. Mechanically supported air barriers can often be installed over a wider range of conditions, though wind can cause problems with lighter material.

Installation: Installation methods depend on the particular materials comprising the air barrier assembly. Make sure to strictly follow the manufacturer's recommendations.

Protection: Some air barrier materials degrade when exposed to ultraviolet light, precipitation and temperature extremes. Air barrier manufacturers provide recommendations for covering their exposure-sensitive materials with temporary or permanent weather protection.

Because the exact approach depends on the air barrier materials, it is important to refer to specifications and installation instructions prepared by the manufacturer of the air barrier, or to national standards like the guidelines provided by the Air Barrier Association of America.

Air barrier membrane bridging concave mortar joints at the North Carolina elementary school.

Dos and Don'ts: Four Case Studies

The success of air barrier projects depends on whether they are well-coordinated with sufficient oversight and quality control. Let's look at four case studies to examine a few examples of the DOs and DON'Ts of air barrier installation.

Courthouse, Massachusetts. This courthouse's exterior wall consisted of steel frame with exterior backup walls of concrete masonry unit and gypsum wall sheathing over metal-stud framing, a self-adhering air/vapor barrier membrane, and rigid insulation and brick masonry veneer. Proper substrate construction and preparation resulted in a firmly adhered air/vapor

At the North Carolina elementary school, loose and unadhered air barrier membrane was observed at the windowsill, over moist substrates.

Poor substrate installation and the absence of a quality installer at the North Carolina science building resulted in a self-adhered air barrier membrane demonstrating wrinkles and fish mouth seams.

barrier membrane that was free of defects such as wrinkles, blisters, fish mouths and delamination. (See photo top of page 50.)

The air barrier contractor reviewed each substrate prior to installation of the air barrier and required that all deficiencies be corrected before the air barrier was installed. The roof system was installed prior to the air/vapor barrier membrane wall installation in each area of the building, keeping the substrates dry.

Through his quality program, the contractor reviewed each wall area and installed the air/vapor barrier membrane only if the substrate was free of visible defects and visibly dry. This project was well-documented and well-coordinated and the installers were skilled. Hence, the air barrier installation was smooth and successful.

Middle School, Rhode Island. The importance of substrate preparation does not change, no matter what material is used as the air barrier.

In the case of this middle school, the exterior walls consisted of a steel-framed structure, metal-stud framing and gypsum wall sheathing. A self-adhering sheet transition membrane was installed at changes in substrate plane and around wall penetrations, with a spray-applied polyurethane foam insulating air/vapor barrier applied to the gypsum prior to construction of the outer brick masonry veneer. (See photos, page 50.)

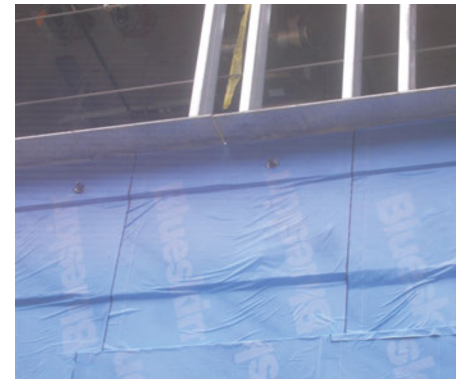
The substrates in the field of the wall and at transitions appeared to be firmly supported and properly prepared to receive the air barrier membrane. This provided a solid backing for installing transition membranes between the roof and wall assemblies and at wall penetrations.

The subcontractor had a quality control plan whereby general contractor personnel immediately corrected substrate deficiencies before the spray-polyurethane foam air barrier was applied. The general contractor responded to deficiencies raised and coordinated subcontractors, resulting in a properly installed air/vapor barrier membrane.

Elementary School, North Carolina. On the other hand, when sub-trade activities are not sequenced with air barrier requirements, installation can go poorly, even with experienced air barrier installers.

At the North Carolina science building, air barrier membrane spans untreated gypsum sheathing boards, which do not abut at the outside corners.

The wall design for this elementary school consisted of a steel-frame structure with concrete masonry unit backup walls, a fluid-applied air barrier membrane, rigid insulation and an exterior brick masonry veneer. The general contractor pushed the subcontractors to install the air barriers so that wall cladding installation could begin. They installed the air barrier membrane while the exterior backup walls were exposed to the elements, including rain and snow. Because the roof system wasn't installed, the concrete masonry unit backup wall became saturated. That degraded adhesion of the air barrier, causing the membrane to flap in the wind.



The air barrier membrane is wrinkled, tented over projections in the substrate and spanning over substrate changes in plane at the North Carolina science building.

Additionally, the concrete masonry unit wall surface was not properly prepared, as evidenced by improperly tooled mortar joints and numerous protrusions. These features caused bridging and tenting of the membranes, increasing moisture infiltration. (See photos, page 52.)

The self-adhering transition membranes bridged the concave tooled concrete masonry unit joints. This condition was widespread, including at control joints and around windows. Mortar joints must be struck flush so that the air barrier will adhere smoothly.

Transition membranes at window headers and sills were unprotected from the weather, resulting in widespread delamination. These locations had to be cut out and replaced.

When these items were reviewed, the air barrier installer indicated they were rushed because the general contractor was anxious to install the insulation and brick veneer. Consequently, the fluid-applied air/vapor barrier was applied regardless of weather and substrate conditions.

Disregard for good construction practice caused widespread membrane deficiencies in the field of the wall. These deficiencies included blisters that contained moisture, as well as several areas where material ran off onto interior walls. The fluid-applied air/vapor barrier membrane did not have a chance to adequately cure, causing widespread blistering.

These conditions could have been avoided or minimized if the construction sequence had been adjusted to meet the project's requirements, and if the general contractor was more familiar with the air barrier installation process and held higher regard for good construction practice.

Science Building, North Carolina. On this project, the building's exterior walls consisted of steel structure, metal stud framing, gypsum wall sheathing, self-adhering sheet membrane, rigid insulation and brick masonry veneer. The air/vapor barrier membrane installation was sequenced to be installed after the roof deck and roof vapor barrier membrane were in place. The project even had the air/vapor barrier membrane manufacturer representative on site full-time to supervise the installation. (See photos, page 54.)

The project seemed to be well-run and the gypsum wall sheathing substrate appeared to be in good condition to receive the air/vapor barrier membrane. However, the sheathing exhibited gaps at changes in substrate plane, such as outside corners and around windows. Transitions between different substrates (i.e., gypsum wall sheathing and steel) weren't properly prepared to receive the air/vapor barrier membrane. That caused the membrane to become unsupported at the transitions.

The air/vapor barrier membrane subcontractor appeared to be unfamiliar with the type and size of the construction. He did not appear to have received adequate training or direction from the membrane manufacturer's on-site representative.

The representative should have been more aware of the poor installation quality of the product. Poor substrate installation and the absence of a quality installer resulted in installation deficiencies that included inconsistent application of substrate primer; tented, wrinkled and bridged membrane; delaminated overlaps; and the absence of termination mastics where typically required by the manufacturer.

As detailed in the above case studies, many elements are involved in constructing a successful air barrier system.

In addition to understanding the way heat, air and moisture move through a wall, the designer needs to select an appropriate air barrier that is correctly located within the wall assembly.

It is of the utmost importance that the contractor coordinates the subcontractors so that the subcontractors not only perform their own work but also prepare the groundwork for the next component. For example, the subcontractor installing the drywall must make sure boards are butted tight with a smooth surface so that the air barrier can be successfully installed. That kind of coordination and preparation is crucial.

Successful air barrier installation depends on it.

About the Authors

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