Air Barrier Systems Defined

By Gary Osmond,

MASSACHUSETTS WAS THE FIRST STATE to regulate a minimum performance criterion for the building envelope by adopting the Massachusetts Energy Code in January 2001. The code regulates a number of issues related to building science technology, design and energy conservation. More recently Minnesota and Wisconsin adapted similar codes that identify key elements in the building envelope design to increase thermal performance and prevent uncontrolled air leakage.

Today's architect sees the value in a well designed building envelope system, incorporating air barrier membranes into their construction documents. The selection process to specify the right air barrier membrane system will depend on a number of factors, with the best time to make that decision during design development. Some key factors to consider are:

- Seasonal exterior to interior design temperatures, impact of extreme weather conditions;
- Wall construction types, connections, deflection and building movement;
- Cladding (rain screen) system, location of secondary rain barrier;
- Cladding anchors and/or brick ties, wall openings and other penetrations; and
- Location and placement of thermal insulation.

Although there are a number of products that may exhibit resistance to air leakage, it should be understood that air barriers are more than a line on the drawing, they need to be designed as a "system", in other words, continuity through the six sides of a box that represents a building. In this article, we will focus on fluid-applied air barrier materials and self-adhered sheet membrane air barrier materials as part of the whole air barrier system.

During and after construction shots of the cancer research center at SUNY Albany in Rensselaer, NY, shows a system Air-Bloc 33 permeable, fluid-applied air barrier, UV-resistant coating, and a Trespa, METEON composite panel system outboard air barrier. The architect was Einhorn, Yaffe and Prescott of White Plains, NY, and the air barrier subcontractor was Cornerstone Waterproofing of Cooperstown, NY.

Fluid-applied air barrier membrane systems provide a complete monolithic uniform coating over the intended substrates. They are applied to a specific wet film thickness specified by the manufacturer, which serves a number of issues including; long-term durability, elongation/recovery, crack bridging, water resistance, gasket effect (self-sealing) and ability to effectively seal rough surfaces such as concrete block. It is important to note that manufacturers test products at specific thicknesses to achieve the required test criteria; if applied at less than the specified thickness, the system will not perform as expected or designed.

Fluid-applied membranes are categorized as water vapor permeable or non permeable (vapor retarding) air barriers. Permeable air barriers restrict the flow of air, but allow slow vapor diffusion and are typically referred to as the "air barrier". Non-permeable air barriers restrict the flow of air and vapor; they are "air/vapor barriers". Due to their location in the wall, both permeable and non-permeable air barriers may also be required to resist rain as a water barrier.

Fluid-applied membranes can be further broken down to be summer grade or winter grade when referring to the time of application. Summer grade or water-based air barriers are low in VOC's, can be applied to "green" or freshly-poured concrete and provide excellent elastomeric properties. Winter grade or solvent-based air barriers allow the contractor to continue with the applications during temperatures below 40 degrees F (4C).

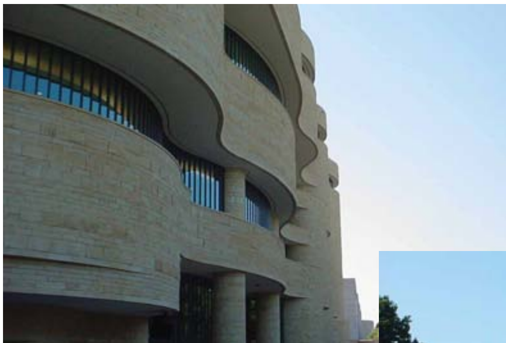
Fluid-applied air barrier systems must also include the use of compatible sheet or transition membranes to span cracks and voids, provide positive connections to window frames in wall openings, roofing and waterproofing systems as well as flashing membranes. For ease of application and conformity to the "system approach", transition membranes are typically self-adhered sheet membranes. As will be discussed below, self-adhered membranes provide the same degree of air and vapor control necessary to achieve the continuity and integrity of the system design.

Self-adhered sheet air barriers are an excellent alternative to fluid-applied membranes. Subject to details and application issues which may be too difficult for a fluid-applied, self-adhered air barriers provide fully bonded protection against uncontrolled air leakage. Self-adhered membranes are also categorized as permeable and non-permeable, summer grade or winter grade; all must be resistant to liquid water penetration. Self-adhered sheet air barriers must also rely on compatible fluid-applied products for terminations, mastics and sealants.

PERMEABLE OR NON-PERMEABLE: CLIMATE

Based on the diverse climate conditions through out the U.S., selecting the right air barrier for the building envelope can not be considered as an "out–of-the-box" design. However, for water vapor performance reasons we can consider northern cold climate conditions, mixed midrange climate conditions and hot, humid climate conditions.

For both cold and mixed climates, the ideal cavity wall design would consist of the exterior cladding, air space, thermal insulation layer, non permeable combination air/vapor barrier on CMU backup wall or sheathing board over steel studs with interior gypsum wall board. The performance advantages of this design are that it maintains a continuous plane of air tightness, the vapor barrier is on the warm or controlled temperature side of insulation (reducing stresses on the membrane), there is no thermal bridging, and the membrane is at a temperature above the dew point of the indoor air based on acceptable levels of indoor relative humidity. For hot humid climates, substituting a permeable air barrier would allow this wall design to dry towards the interior. This wall design is sometimes criticized as too thick, so



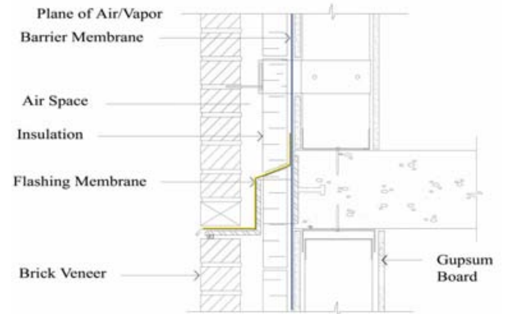
The National Museum of the American Indian (NMAI) is a new Smithsonian Museum in Washington, DC. The Smith Group was the architect for the building, using a Blueskin SA sheet membrane air/vapor barrier with BASF Walltite sprayed polyurethane foam insulation behind sandstone.

Smart Wall Assemblies vs. Smartest Wall Assemblies

Smart Wall Assembly: If the air barrier is also a vapor barrier (i.e. an air-vapor barrier), it must be located on the "warm side" of the primary insulation. This requires that all of the insulation be positioned in the exterior wall cavity. The smart wall design works well but is considered a "thick wall design" because positioning all the insulation in the cavity results in a thicker wall section.

The Smartest Wall Assembly shows how vapor permeable air barrier systems allow for a designer to move the primary insulation into the stud wall (i.e. in the form of batt insulation) and reduce the wall section thickness. Because vapor permeable air barriers are not "vapor barriers" they do not have to be located on the warm side of the primary insulation. In cold northern climates, where a vapor barrier is required, the vapor barrier can be separated from the air barrier, and positioned on the interior side of the wall.

Smart Wall Assemblies



Smartest Wall Assemblies

the resulting gross to net floor areas ratio may not be acceptable and there could be additional cost concerns related to masonry ties and shelf angles.

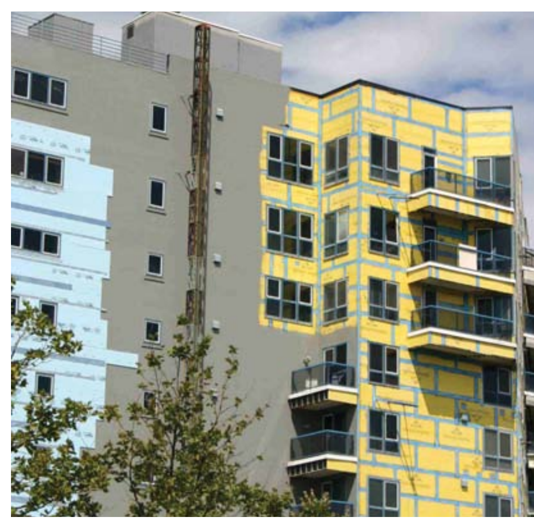
A somewhat thinner wall design for cold climates would consist of exterior cladding, air space, a layer of insulation over a permeable air barrier on sheathing board over steel studs with insulation in the stud cavity, an interior vapor retarder and gypsum wall board. The benefits of this design are that it still maintains a continuous plane of air tightness, the vapor retarder, is at the warm-in-winter side of insulation, there is reduced thermal bridging, and the temperature of the sheathing is above the dew point of the indoor air based on acceptable levels of relative humidity. The key advantages of this design is that it recognizes nominal R-value v. effective R-value of a wall design that includes stud cavity insulation. Thermal bridging through steel studs can reduce the nominal R-value of the wall by 60 per cent. Un-insulated sheathing board placed over the steel studs will be at air temperatures below the dew point of indoor air. Insulation placed outside of the sheathing board and steel studs stops heat transfer and maintains the sheathing at a temperature above the dew point.

Is sheet the best solution? Sometimes there is difficulty when using a sheet membrane system with pre-installed brick ties and penetrations. Fluid-applied systems can be less costly to install and may produce better results in some cases.

For mixed mid range climates, where the summer temperature period and winter temperature period are about equal in length, many experts agree permeable air barriers are the best option. Typical wall designs may include exterior cladding, air space, a permeable air barrier on sheathing board over insulated steel studs with interior gypsum wall board. A vapor retarder is typically not needed. In this design assembly, in addition to controlling air leakage the air barrier must also provide two other critical functions: water vapor control and resistance to rain penetration. If either of these requirements are ignored, condensation and moisture damage will lead to the premature deterioration of the walls. The performance value of this design is maintained by a continuous plane of air and rain tightness thorough out the building envelope which includes connections to roofing and foundation waterproofing systems.

Building wraps are commonly used as suitable protection to rain, in other words as a building paper and are rarely detailed and constructed as a structurally supported or continuous air barrier system; such construction may result in significant energy consumption due to uncontrolled air movement.

For humid climates, the building science remains the same, but vapor pressure conditions are reversed. A successful cavity wall system design may include exterior cladding, air space, and non-permeable air/vapor barrier over the back-up wall with all insulation to the interior. The performance benefits of this design are that it provides a continuous plane of air tightness over the exterior enclosure of the building, the vapor retarder is on the warm side of insulation, there is no thermal bridging, and the air/vapor barrier is placed in a location above the dew point of the outside air.



The Marina Bay Tower in Quincy, MA, used Georgia Pacific's Dens Glass Gold Sheathing (yellow in photo), Henry's Air-bloc 31 membrane (a liquid emulsion, vapor-permeable air barrier), Dow 1" extruded polystyrene insulation (light blue), and an Alucobond panel system.

FLUID-APPLIED OR SHEET MEMBRANE?

Fluid-applied air barrier membrane systems provide a complete monolithic uniform coating over the intended substrates when applied to a specific wet film thickness. The selection process can be narrowed down to simply permeable or non-permeable, based on the location of insulation and application climate conditions. The advantages of properly installed fluid-applied membranes is that they are faster to apply, since no priming of the wall is required and less preparation of the substrate is needed. Transition membranes and associated priming may be required in 20 per cent or less of the entire wall and water base options allow placement on green or uncured concrete.

Insulation adhesives that are combined as air/vapor barriers are an excellent method of improving thermal performance. The adhesives hold the insulation tight to the wall and reduce thermal short-circuiting by preventing the convective air loops between the plane of insulation and air/vapor barrier.

In open joint-panel-type rain screen systems such as METEON® by Trespa, UV resistant vapor permeable air barriers are available. The above would be common for a thin wall design and would consist of rain screen cladding, air space, a UV resistant permeable air and rain barrier over the exposed insulating sheathing or sheathing board, insulated steel studs with interior vapor retarder and gypsum wall board. The performance advantage of this design is that it provides a continuous UV resistant rain and air barrier. There are other fluid-applied products available that are fire resistant with low flame spread and smoke development ratings if they are required in non-combustible wall systems.

BRICK TIES AND OTHER PENETRATIONS

When considering objects attached through the air barrier such as masonry ties, metal panel clips, Z girts and brackets, both fluid-applied and self-adhered air barriers have advantages over other types of air barriers. Fluid-applied and self-adhered sheets are fully bonded to the substrate, lateral movement of moisture between the substrate and membranes is eliminated. Fluid-applied air barriers remain malleable and elastomeric providing a gasket effect when mechanical fasteners are used. Self-adhered membranes with SBS modified compounds are renowned for their self-sealing characteristics around screw penetrations. When brick ties are already in place, the most cost effective method will be a fluid-applied system.

CONCLUSIONS

Although local codes and regulations may not address air infiltration control performance criteria, the proper application of building science to enclosure design dictates that air barriers should not be ignored. If your project includes a layer of insulation to guard against conductive heat losses, then so should your project need an air barrier to reduce the likelihood of condensation and conserve energy due to infiltration control. Selecting the appropriate product for the application starts with getting the best advice possible.

The first principles of exterior wall design needs to consider the following:

- Design a continuous plane of air tightness. Trace continuity with your pencil throughout building envelope details and assembly transitions;
- Design a complete structural positive and negative load transfer system. Similarly, design air barrier connections to withstand the loads;
- Design a continuous plane for rain control;
- Provide a continuous plane of insulation;
- Avoid thermal bridging;
- Use appropriate analysis of water vapor control. Understand the permeance of the different layers; and

- Accommodate building movement and construction tolerances. Remember, Construction is not a precise process.

Design professionals, architects and consultants commonly rely on qualified manufacturers' product representatives to provide reliable technical building science knowledge but this information cannot begin and end with a data sheet. It is important to select products with a proven history of performance. Well written, technically correct air barrier system specifications are as crucial to the construction documents as understanding the details. Air barriers are "systems" assembled of many materials and components, not just a product with a low air leakage rate.

A knowledgeable product representative will listen to the architect's design criteria, understand the regulations and help the designer apply current technology to help select the appropriate products. Many building enclosure consultants have been working with air barrier systems in an effort to control moisture through wall assemblies for years and understand the damage caused by poor details and construction practices.

Architects and building owners should consider retaining an enclosure consultant to directly assist in the enclosure design. Consultants will often continue their contracted involvement through the bid and submittal review process and the construction phase.

Once a suitable design has been detailed and specified, air barrier manufacturers should join the architect or consultant in attending pre-construction meetings as well as providing separate on-site observations. Air barrier designed systems depend upon proper installation for continuity and effectiveness. A qualified consulting firm will help ensure the building envelope, including the air barrier, is successfully installed. An effective air barrier system will be one that is supplied by a reputable air barrier manufacturer, properly installed by a qualified air barrier installation contractor, and inspected by a qualified building envelope consultant. ■

Gary S. Osmond CET, CSC has 28 years of experience in the building and construction technology industry. The last eight years have specifically been focused on the air barrier, waterproofing and roofing industry.