The Construction Specifier

Air Barrier Systems

For the life of your building

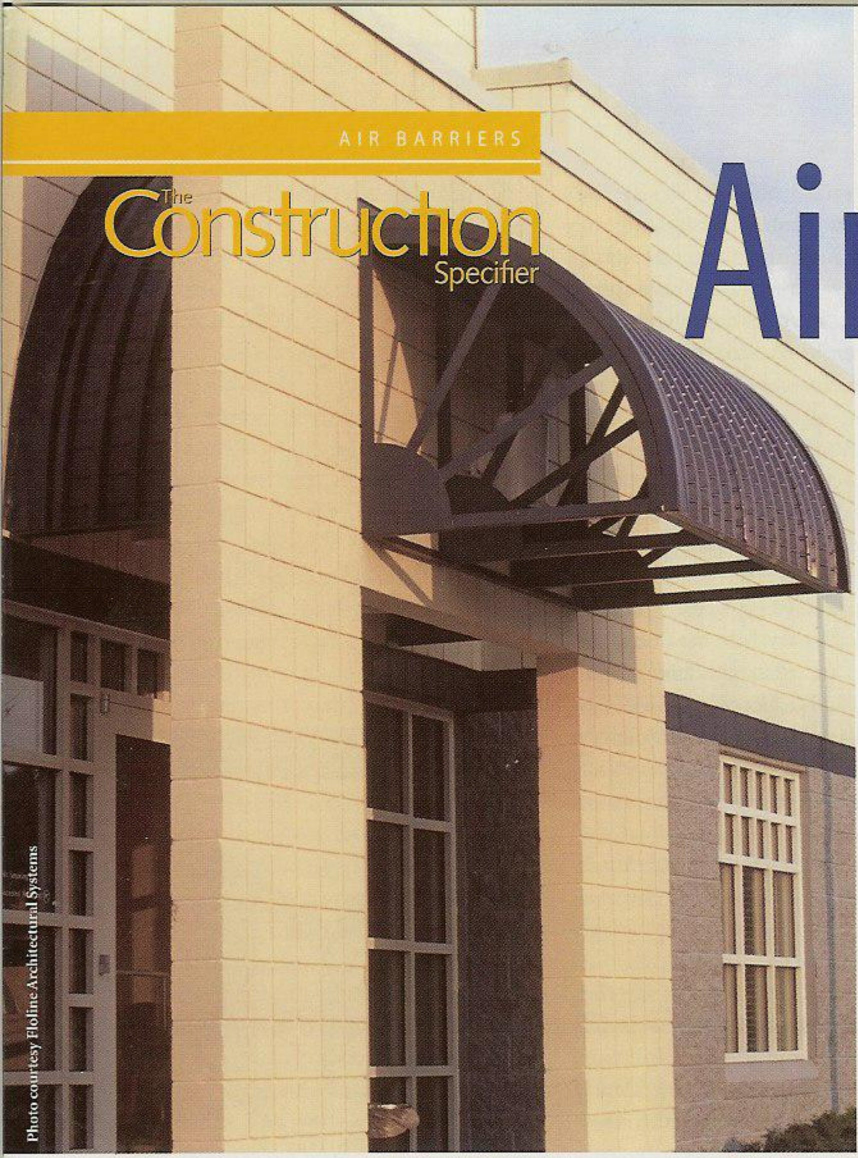


Photo courtesy Firoline Architectural Systems

by Leonard Anastasi, CSI

In the past decade, the use of air barrier systems (ABSs) in the building envelope has been steadily increasing because they have been proven to increase energy efficiency, reduce the potential for envelope system failures, and reduce the occurrence of indoor air quality (IAQ) problems.

To date, ABSs have primarily been included in envelopes for "high performance" or "high-end" buildings, such as field or pool houses, museum storage facilities, and "monumental" buildings. However, research into the theory, science, and performance of ABSs has significantly increased in this country, to the point where their advantages are significant in virtually all buildings.

The U.S. Department of Energy (DoE) has concluded that up to 40 percent of the energy required to heat/cool a building is wasted through uncontrolled air movement. As such, building owners can expect substantial savings in their heating and cooling costs. ABSs can also eliminate the occurrence of building envelope system failures caused by moisture infiltrating the system. Moisture corrodes metals and decreases the thermal performance of insulation.

Air flow has the ability to transport exponentially more moisture into and through building envelopes than can be transferred through vapor migration. By stopping the flow of air through the building envelope, the flow of moisture is virtually halted, and by reducing moisture, one can also eliminate many of the conditions under which mold and fungi grow. These biological agents are a major concern for building professionals due to the effects they have on both IAQ and the health of building occupants.

The incorporation of ABSs in new construction is not a passing fad. The state of Massachusetts, for example, implemented legislation this year requiring air barrier systems in all commercial buildings and certain multi-tenant buildings over 929 m^2 (10,000 sf)—and they are not alone. Currently, 21 states are considering incorporating ABSs in their building codes.

The real deal

Many in the construction industry do not know what an ABS is, nor what it does. The most succinct definition was penned by Lance Robson Jr. of Building Envelope Technologies Inc. for the Air Barrier Association of America (ABAA): "A combination of building envelope components designed and installed in such a manner as to control the infiltration and exfiltration of air through the building envelope.

Through painstaking experiences and research, Canadian and American researchers have determined an effective air barrier material should consist of materials with the following properties:

1. An air permeability not exceeding 0.02 L/m^2 (0.004 cfm/sf) under a pressure differential of 75 Pa (0.3 in. of water).
2. Capable of withstanding positive and negative combined design wind, fan, and stack pressures on the building envelope without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
3. Durable or maintainable.

The air barrier system should have the following properties:

1. An air permeability no greater than 10 times the air permeability of the air barrier system materials 0.2 L/m^2 under a pressure differential of 75 Pa when tested in accordance with ASTM E 283, *Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.*
2. Be continuous with all joints, laps, and seams made airtight.
3. Be joined in an airtight and flexible manner to each other and allow for the relative movement of systems due to thermal expansion and contraction variations, moisture absorption, and retainage properties, as well as creep.
4. Not create conditions for deteriorating building envelope components.

Classification

Air barrier materials can be classified as either vapor permeable or non-vapor permeable. Vapor permeable materials do not impede the migration of vapor through the envelope. Materials that are non-vapor permeable are commonly referred to as "air and vapor barrier materials," and as their classification implies, they also halt the migration of vapor through the envelope. As such, they must be carefully located with respect to the building's insulation layer, as well as local annual weather conditions to eliminate the formation of condensation within the envelope.

Any material that meets the aforementioned requirements can be an air barrier, including metal, plywood, self-adhering waterproofing and flashing membranes, rubberized asphalt, roofing membranes, fluid-applied membranes, glass, and gypsum wallboard (GWB). However, not all of these will meet the aforementioned air permeability requirement, nor will all manufacturers possess the knowledge or technical support to assist in the proper design and use of the component.

Consequently, it is best to use products with proven track records in the Canadian market that are also available here, including W. R. Meadows' Air-Shield™, Bakor USA's Blueskin®, and W. R. Grace's Perm-A-Barrier®. These products are air and vapor barrier materials (non-vapor permeable) and must be placed on the winter-warm side of the envelope's insulation layer for cold weather climates (Figure 1), and the reverse for warm weather climates.

Fluid-applied air and vapor barrier materials have been garnering a larger share of the market in Canada, and may soon become the material of choice because of the speed with which they are applied. These include Bakor's Air-Bloc 21S, W. R. Meadows' Sealtight® Meadow-Pruf™ Seamless, W. R. Grace's Procor®, and Rubber Polymer Corp.'s Rub-R-Wall® Airtight. (Currently, only Bakor offers a vapor permeable membrane that is fluid-applied.)

Certain exterior gypsum sheathing and extruded insulation (or similar) can be used in conjunction with other air barrier materials to form a vapor permeable ABS (Figure 2). Unfortunately, these systems have difficulty meeting air permeability requirements, and possess questionable longevity.

Siliconized glass fiber-wrapped GWB sheathing has become a popular exterior sheathing due to its ability to withstand prolonged exposure to ultraviolet (UV) rays. Unfortunately, it affords a poor bonding surface for ABS components because of its surface composition, and the fact that it absorbs primer materials before they have a chance to properly dry.

Torch-applied membranes and spray

Figure 1

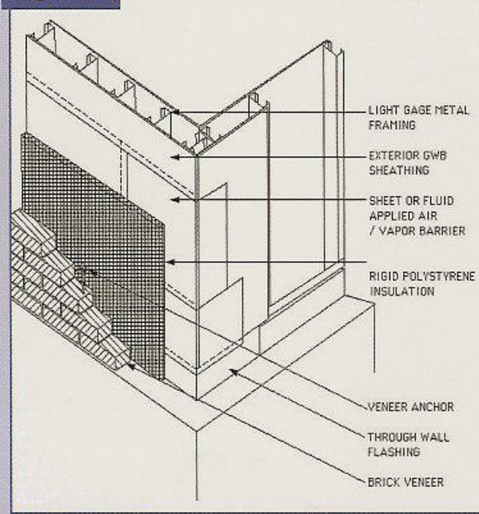


Figure 2

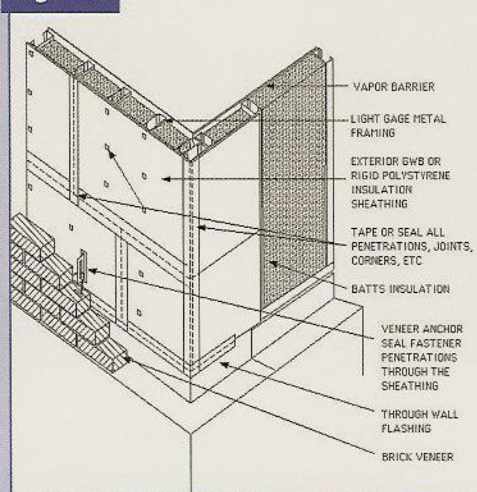


Figure 3

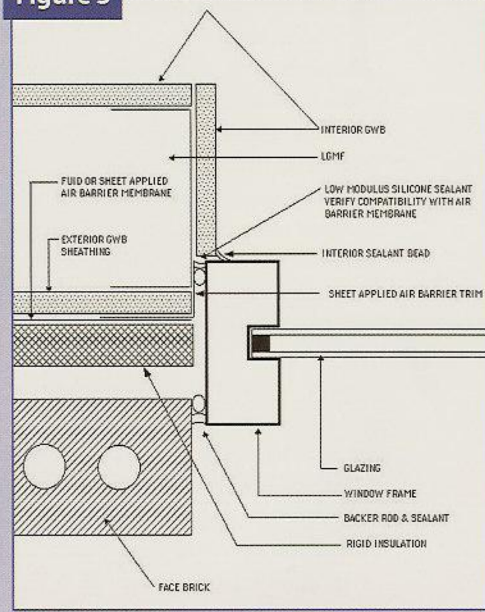


Figure 4

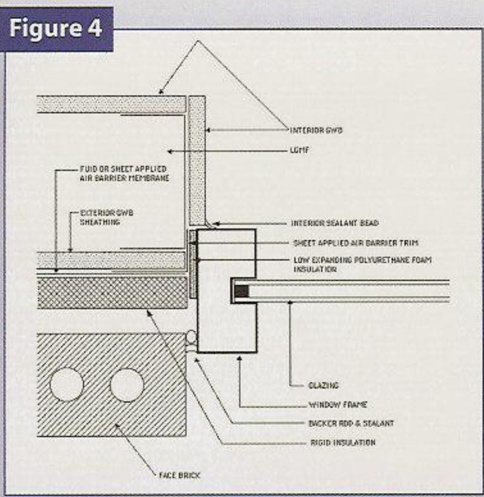


Figure 5

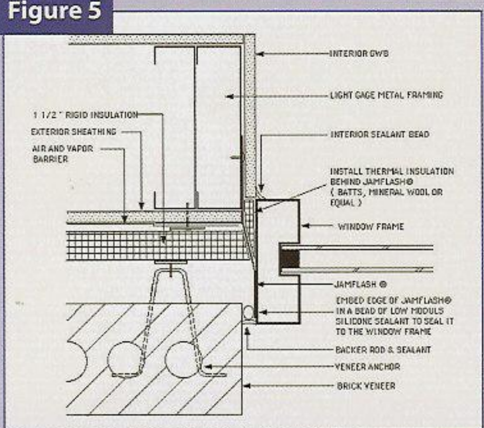


Figure 6

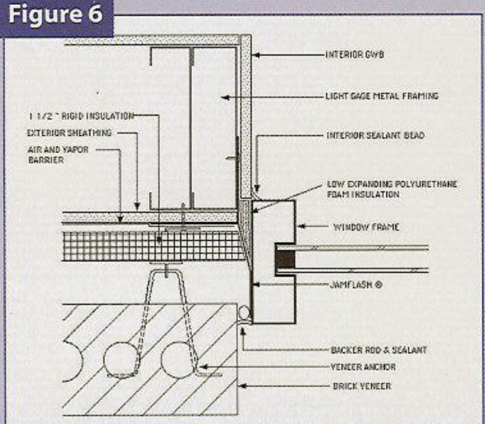
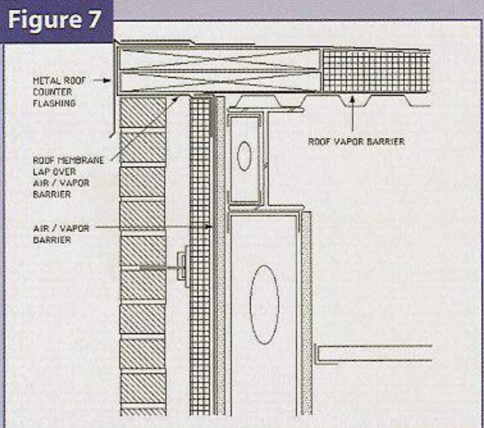


Figure 7



polyurethane foams (SPFs) can also be effective air barriers. While providing a superior bond to substrates, torch-applied membranes have not gained significant market share in the industry. According to sources in Canada, this is due to a lack of certified installers and industry's unwillingness to accept the dangers of open flame installations.

SPF products have piqued the curiosity of many experts and designers as an air barrier material due to its ability to serve as both an air and vapor barrier, a drainage surface, and an insulation layer. They are also seamless and can be applied over exceptionally large areas in a single work day. Among the leaders in the manufacture and technology of these products is BASF.

A negative for every positive

Above-grade

Every air barrier product comes with its own inherent problems when detailing the ABS. For instance, none of these products provides for the effective continuation of the ABS at doors and windows in exterior walls. Remember, ABSs must be complete and continuous.

Flanged frames have been installed prior to the veneer so the air barrier material can be lapped over the flange, but this practice can result in irreparable damage to frames and glass in buildings under construction—particularly those with masonry veneers. Canadians have dealt with this issue using sealants (Figure 3) and low expanding polyurethane foam insulation (Figure 4). While sealants are less costly, only a few low modulus silicone sealants are able to adequately adhere to the polyethylene film in self-adhering membranes.

The longevity of these sealants is questionable because manufacturers do not warrant their materials will last the expected life of the building. Also, sealant joints can allow cavity moisture to saturate the insulation at window perimeters, thereby degrading its effectiveness.

Low expanding polyurethane foams adhere well to the polyethylene used in self-adhering membranes, but they are costly and must be applied in a slow, controlled manner to avoid contact with exposed portions of door and window frames (the solvents required to remove overspray will damage the finish). Another concern with these foams is they are much more dimensionally stable under varying temperatures than the metals commonly used in door and window frames, which can lead to adhesive or cohesive failure of foam adhered to a frame that is exposed to temperature extremes.

Another option is to use a semi-rigid flashing material called Jamflash® (Figures 5 and 6) in conjunction with sealants and insulation. The issue of sealant longevity still exists, only now the sealant joints can be located where they are maintainable. This jamb flashing can also be used in details to protect fiber-based insulation from moisture, as well as provide a flexible adhering surface for low expanding polyurethane foams that will accommodate thermal movement of substrate materials.

There has been much discussion in this country over which veneer anchor system to use in conjunction with light-gage metal framing back-up systems. An acceptable veneer anchor must be able to create an airtight seal, and facilitate the installation of insulation on the outer side of the barrier for air and vapor barrier systems.

Most veneer anchors available here can be made airtight in vapor permeable ABSs by either embedding them in the liquid- or sheet-applied air barrier materials, or coating the base plates with them. This is not the case with air and vapor barrier systems, where veneer anchor systems with prongs penetrate the materials and and cause leaks. Locating the metal studs to which these anchors must be fastened can prove a tedious task, not to mention a source of unwanted penetrations in both the insulation and air and vapor barrier.

Another anchor promoted for this application comprises a unitized screw and base structure. The base structure is fabricated with prongs that "chew" through the air barrier membrane and exterior sheathing until the prongs come into contact with the metal stud.

Figure 8

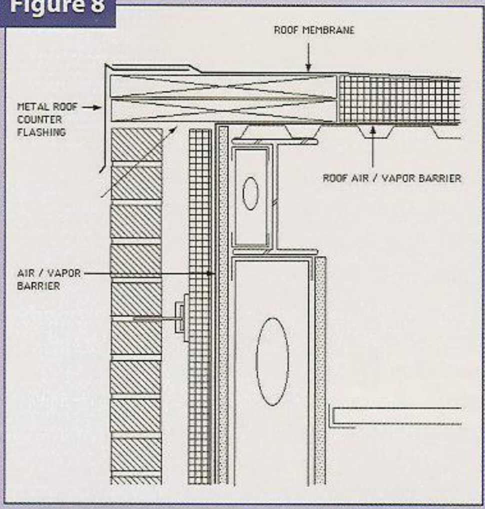


Figure 9

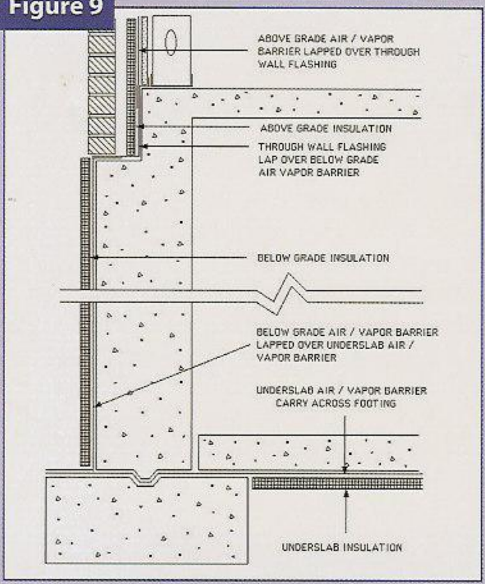
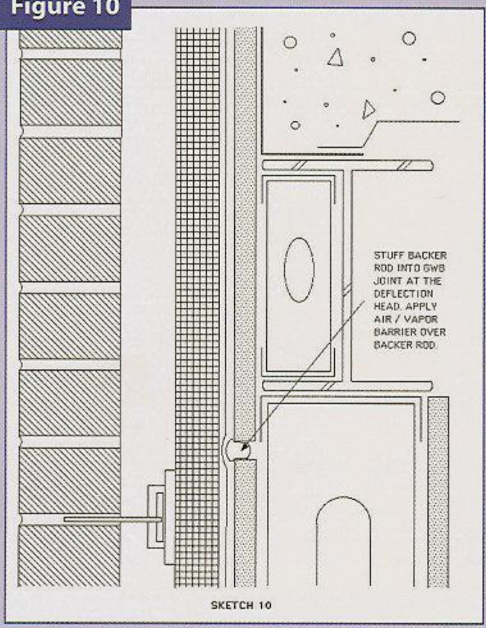


Figure 10



Examination of these anchors after installation reveals they can pull and tear at the air and vapor barrier and cause air leaks. These types of anchors also result in the same locating problems, only with less holes to repair. (Canadians have been using anchor systems manufactured by Fero Corp., but these systems are manufactured to meet different criteria than those of the United States.)

Roofs

The wall and roof junction is another area of concern. While many roofing materials meet the air permeability requirements of an air barrier material, there are compatibility issues between them and wall air barrier materials. Also, while the wall ABS is intended to last the life of the building, roof systems are not, which raises the question of where the junction of these two materials should occur.

Roofing manufacturers would like to see this junction at a location where they feel comfortable enough to offer their warranty, but this may create a condition where other building components must be dismantled to replace the roof (Figure 7). Some experts will install an air and vapor barrier on top of the roof decking, followed by the roofing system (Figure 8). This simplifies system details and resolves both compatibility and contractor responsibility issues. It does, however, raise issues such as roof leak detection, moisture retention below the roof membrane, and fastener penetrations through the air and vapor barrier.

On roofing systems without parapets, collected moisture can be drained and resulting vapor can be vented into the cavity or out through a drainage and venting system at the façade of a building. For roof systems with a parapet, a two-tier roof drain can be used to drain moisture and vent vapor. Self-adhering and certain fluid-applied air and vapor barrier membranes have been shown to "self-seal" around roofing system fasteners (provided, or course, that misplaced fasteners are left in place).

Corrugated steel roof decks create yet another problem. While some manufacturers of sheet-applied membranes claim their products effectively bridge flutes in metal decking, many experts are reluctant to use them in this capacity. They feel the polyethylene carrier film of the membrane will break down over time, and the heat created in the roof system will cause the rubberized asphalt to sag and fail. In this situation, a gypsum-based material is usually installed on top of the metal decking, followed by the air barrier membrane.

Neither of these types of membranes will suffice due to the heat of the roofing membrane used in hot-applied roof systems. On concrete roof decks, a layer of hot-applied roofing membrane applied directly to the deck should suffice as the air barrier (depending on the manufacturer and/or material). For both hot-applied roofing and corrugated metal decking, W. R. Meadows' self-sealing Mel-Gard® will bridge deck flutes without failure, and stand up to the heat of hot-applied roof materials because of its 163 C (325 F) melting point.

Below-grade

In considering below-grade details, some designers have relied on concrete meeting the air permeability requirements of an air barrier material. However, concrete cracks and usually contains control and expansion joints—conditions that result in system failure. Waterproofing membranes, on the other hand, are an excellent air barrier for below-grade, vertical ABSs. Extruded polystyrene can result in the above-grade problems already discussed, and dampproofing mastic will not suffice because it dries out and cracks over time.

While below-slab waterproofing systems suffice as air barriers, some have yet to show they can withstand the test of time as a waterproofing barrier, let alone an air barrier. Not all materials adhering to the bottom side of concrete may possess the elongation capability to withstand movement caused by concrete shrinkage and creep. Those systems that do account for such slab movement may not be able to withstand high hydrostatic head pressure without a drain tile system.

Other below-slab ABSs, such as polyethylene and polyolefin films, fail due to punctures caused by substrate materials, despite the sand layers protecting them. Also, moisture in the soil can deteriorate adhesive bonds at joint and lap treatments. None of these materials are effectively detailed to carry through footing tops, around pipe and conduit clusters, to provide a complete ABS.

The use of extruded polystyrene with taped joints has been used in Massachusetts with the requirement of R-5 insulation under the slabs of many types of buildings under the new Commercial Energy Code. This ABS is unable to withstand construction site traffic, or remain in place when exposed to high winds prior to concrete placement. Also of concern is the longevity of the bond of the joint sealing tape when exposed to the constant moisture and vapor pressure created by ground water.

One system that has worked in the State of Massachusetts is W. R. Meadows' Premoulded® Membrane with Plasmatic Core® (PMPC) on top of rigid polystyrene insulation (Figure 9). This membrane is manufactured to withstand job site foot traffic and has even withstood vehicular traffic. It is heavy enough to hold itself and the rigid insulation in place in high winds. The joints and laps are sealed with rubberized asphalt materials that withstand exposure to ground water, and enable the air barrier system to compensate for material, substrate, and slab movement. W. R. Meadows also provides details for footings and pipe cluster penetrations. One drawback is that PMPC is only rated to withstand an 18-m (60-ft) hydrostatic head.

Deflection heads

Fortunately, there appears to consensus among experts as to how to deal with deflection heads. Basically, a sealant backer rod that is wider than the deflection head gypsum sheathing joint is forced into the joint. The air barrier membrane is applied over the backer rod material to form bellow (Figure 10), which accommodates deflection head movement without excessively stretching the membrane during elongation. It will also protect the membrane from being pinched and damaged in the joint.

Conclusion

In spite of all these nuances, the overwhelming cause of ABS failures is improper installation. Failures can result in near catastrophes, as building veneers must be stripped in order to repair and/or replace the air barrier system in most cases. Installers of air barrier systems proved to be the hardest group upon which to impress the importance of quality installations. Furthermore, field testing and inspection measures were not developed enough to be able to discover installation errors, nor were the providers of such services adept in identifying possible failures before the systems were covered.

These problems helped prompt the founding of the National Air Barrier Association (NABA) in Canada, whose quality assurance program calls for licensed installers, NABA field audits, a demerit system for poor installations, and daily field reports prepared by installers. (This program has drastically reduced the amount of problems with air barrier installations in Canada.)

The Air Barrier Association of America (ABAA) has adopted a similar quality assurance program. Designers employing the use of air barrier systems can use ABAA specifications or require the use of ABAA-licensed installers in their specifications.

Building envelopes that include air barrier systems are becoming a national trend, and with the knowledge coming out of Canada and the United States, the industry can move forward into a future of better performing building envelope systems.

Resources

National Air Barrier Association
www.naba.ca

Air Barrier Association of America
www.airbarrier.org

Oak Ridge National Laboratories, Building Technology Center
www.ornl.gov/ORNL/BTC

WUFI-ORNL/IBP Dew Point Analysis Tool Download Page
www.ornl.gov/ORNL/BTC/moisture.index.html

Building Science Corp.
www.buildingscience.com

The Boston Society of Architects Building Envelope Committee
www.architects.org

Canada Mortgage and Housing Corp.
www.cmhc-schl.gc.ca

Canadian Construction Materials Corp.
(613) 993-6189

ADDITIONAL INFORMATION

Author

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MasterFormat No.

07050—Basic Thermal and Moisture Protection Materials and Methods
07270—Air Barriers

Key words

Division 7
Air Barrier Association of America
Air barriers
Canada Mortgage and Housing Corp.
Canadian Construction Materials Corp.
Indoor air quality
National Air Barrier Association
U.S. Department of Energy

Abstract

In the past decade, the use of air barrier systems (ABSs) in the building envelope has been steadily increasing, and research into ABSs has reached the point where their advantages are significant in virtually all buildings. In this article, the author discusses air barrier systems and materials, as well as those engaged in their manufacture.