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Air Barrier Materials and Systems: What is the Difference? Is There a Difference?

Remember the old TV ad showing two piles of clean towels, each washed with a different detergent? We were supposed to guess what made these two piles different: the quantity or type of detergent? The fabric softener? The price? Were these piles of towels in fact different in any way?

There may be an analogy regarding the perennial questions about the characteristics of air barrier materials and air barrier systems intended to constitute the primary line of defence against air leakage across the building envelope. This article highlights commonalities and differences of air barrier materials and air barrier systems, and introduces the challenges of integrating notions of durability in the design.

Materials with Low Air Permeance

How is "low air permeance" of a material defined? Article 5.4.1.2 of the National Building Code (1995) and the assessment documentation of the Canadian Construction Materials Centre (CCMC) at NRC, rate low air permeance at a maximum value of 0.02 $L/(s \cdot m^2)$ at a pressure differential of 75 Pa. This property can be found in several different materials. A 1988 study carried out by Air-Ins Laboratories Inc. demonstrated the low air permeance of various materials. Here are some examples: oriented strand board (11 mm and up); plywood (8 mm and up); gypsum board (12 mm); extruded polystyrene (38 mm); polyethylene sheet (0.15 mm or 6 mil); and cement board (12 mm), without mentioning materials such as metals, plastics and glass. The list of materials that did not meet this requirement included No. 15 building paper, type 1 and 2 expanded polystyrene (25 mm), asphalt-coated fibreboard (11 mm), and perforated polyethylene wrap.

Since that study in 1988, several product manufacturers have been granted CCMC evaluation reports for Air Barrier Materials, i.e., materials with air permeance equal to or lower than 0.02 $L/(s \cdot m^2)$ at 75 Pa.. These are:

- Tyvek HomeWrap® from DuPont Canada. Spun-bonded olefin membrane made by combining continuous fibres of high-density polyethylene into a sheet, through a process using heat and pressure. CCMC 12857-R
- Typar® II from BBA Materials Technology. Membrane of polypropylene, spun-bonded olefin fabric made from oriented polypropylene filaments thermally bonded. CCMC 12884-R
- Airmetic® 0223/Heatlok®0240 from Demilec Inc. Two-components spray urethane foam insulation. CCMC 12893R
- Isoclad® from Les produits Isolofoam inc. Type II preformed expanded polystyrene rigid insulation panel plant-laminated to a spun-bonded olefin sheathing membrane (Tyvek® grade) made by DuPont Canada. CCMC 12981R
- Styrofoam™ Weathermate Plus™ from Dow Chemical Canada Inc. Polypropylene-based, non-woven membrane. CCMC 13013R
- GreenGuard® Ultra Wrap from Pactiv Building Products. Non-perforated and non-woven polyolefin membrane made by combining an open polyethylene fabric with a polyethylene sheet. CCMC 13075R
- Walltite® /Thermal Tech® from BASF Canada Inc. Two-component spray urethane foam insulation. CCMC 12877 R
- Sto Gold Fill® from Sto Corp. Coating to spray or trowel at the joints of a low air permeance sheathing board, as part of the Sto Guard™ system. CCMC 13120R

These evaluation reports are posted on the CCMC Web site http://irc.nrc-cnrc.gc.ca/ccmc under Master Format Division 07273 of the Registry of Product Evaluations. Information on limitations and uses presented in the reports can be quite useful to designers and building officials. Other design criteria of an air barrier system, such as structural performance, deflection and continuity at fasteners and other junctions were not included in that type of material-only evaluation.

Air Barrier Systems

In order to ensure the airtightness of a building envelope, it is not only important to install materials with low air permeance, but most of all to integrate all these different materials and components in a continuous assembly that is designed and built to withstand the differential air pressure to which the building is subjected during its useful life (5, 10, 25, 50 or 100 years?). Wind loads exercise undoubtedly the highest pressure on walls in comparison to that imposed by the stack effect or mechanical ventilation systems.

An air barrier system (ABS) must:

- have the required structural capacity to transfer wind loads without undue deflection (this calls for rigidity or support) without altering its air permeance
- be continuous over the entire envelope
- be durable.

The system's continuity is undoubtedly the most challenging characteristic to achieve as it requires superior design, execution and quality control. The joints between the airtight elements (such as two panels), the joints between two components (such as interfaces between walls and balconies, windows, ducts and roofs), and the penetrations made in the air barrier system for fastening to other components (such as the outside cladding), are challenges stemming from the building details.

Some manufacturers developed an air barrier system for the exterior walls of low-rise buildings based on all of the above-mentioned requirements. To learn more about those evaluation criteria, consult Construction Technology Update No. 46 posted at http://irc.nrc-cnrc.gc.ca/ctus/46.html

CCMC lists two evaluation reports on ABS (see MasterFormat Division 07272 of the CCMC Registry of Product Evaluations:

- Walltite® - Air Barrier System from BASF Canada Inc. A system based on a urethane foam insulation to spray on the exterior face of a substrate, with accessories for continuity such as Blue Skin SA®, a modified bituminous membrane manufactured by Monsey Bakor and used as a transition membrane over construction joints. CCMC 12932R (Note the difference with Report 12877-R for air barrier material)
- CodeBord® Air Barrier System from Owens Corning Canada Inc. An air barrier system, based on extruded polystyrene material, with accessories comprising foamed polyethylene sealing gasket and one-component spray-in-place foam sealant applied on joints. CCMC 12935R

CCMC evaluations also include the following polyurethane foam sealants applied to several appropriate substrates to maintain the continuity of an air barrier system at penetrations such as window and door frames:

- Froth-Pak, Enerfoam, Great Stuff, Great Stuff Pro Gaps & Cracks, Great Stuff Pro 10/16/23 Pound Gaps & Cracks, Great Stuff Window and Door, Great Stuff Pro Window & Door, from The Dow Chemical Company. One-component post expanding foam or two-component polyurethane foam. The allowable air leakage rate for this foam sealant (after accelerated aging) is 0.25 m^3/h per metre of joint at 75 Pa (criteria for a fixed window). CCMC 13074R

During NRC's Building Science Insight 2003 Seminars, many industry representatives pointed out that low air permeance sheathing membranes form the basis of the air barrier system in their low-rise residential projects. At present, no air barrier system using flexible membranes has been evaluated by CCMC. The issues of maximum deflection and air leakage at fasteners and junctions as a result of wind load pressures are crucial with regard to the use of flexible membranes for air leakage control purposes.

Maximum Air Leakage Rate for Wall ABS

In 1986, IRC scientists reviewed the existing literature and applicable standards and proposed for discussion a relationship of the permissible air leakage rate for the building envelope and the indoor relative humidity level. This was based on airtightness levels specified for metal or glass curtain walls at the time, and on needs being expressed about reducing the risk of interstitial condensation forming within the envelope. The higher the indoor relative humidity would be, the tighter the ABS had to be (Table 1).

Table 1 Maximum Air Leakage Rate Proposed in 1986

Indoor Relative humidity at 21°C	Permissible air leakage rate (L/s·m^2 at 75 Pa)
<27%	0.15
27-55%	0.10
>55%	0.05

Ten years later, with the advancement of numerical modelling capabilities, IRC researchers explored the hygrothermal response of virtual wall assemblies exposed to a variety of conditions. Based on such studies, they developed a relationship between the maximum air leakage rate for a wall air barrier system and the vapour permeance and the temperature of the outermost non-vented layer of the wall assembly (for indoor conditions of 36% RH) (Table 2). The lower the vapour permeance of the outermost non-vented layer of the wall, the higher the required airtightness of the air barrier system. Requirements for maximum air leakage – and minimum risk of interstitial condensation – were more stringent in situations where the wall assembly exhibited a lower drying potential by moisture diffusion to the exterior (due to the low vapour permeance of the outmost non-vented layer).

Table 2 Current Maximum Air Leakage Rate of Walls

Water vapour permeance (WVP) of outermost non-vented layer of the wall assembly (ng/Pa s·m^2)	Maximum permissible air leakage rate for Wall ABS (L/s·m^2) at 75 Pa
15 <WVP <60	0.05
60 <WVP <170	0.10
170 <WVP <800	0.15
>800	0.20

In addition, when the temperature of this low vapour permeance element located toward the outside of exterior walls would be maintained above the dew-point temperature of the surrounding air most of the time in winter conditions, very little condensation would be likely to accumulate on its interior face. Adding thermal insulation to the exterior face of an element of low vapour permeance resulted in an increased tolerance for a higher air leakage rate without increasing the risk of condensation accumulation within the wall. Based on its numerical modelling studies, IRC proposed a minimum ratio of outboard to inboard thermal resistance for low vapour and air permeance materials for various climate severity conditions expressed in heating degree-days (see Construction Technology Update No. 41 at http://irc.nrc-cnrc.gc.ca/ctus/41.html.

Durability and Location of Air Barrier Systems

The durability of a material or an assembly (let's not forget the junctions) is determined not only by the selection of properties but also by the severity of the climate to which it is subjected during its service life. If the odds of the ABS becoming exposed to rainwater loads during the construction process or during its service life are high, then its resistance to moisture attack should be higher than if it is sheltered on the inner side of the walls. For example, an ABS assembly installed in a warm dry place would be subjected to less differential movement and wetting than an ABS placed immediately behind the exterior cladding. Therefore, the climatic exposure of the ABS should be acknowledged and integrated in the decision-making process for the selection of suitable materials to be used in the ABS assembly for a given construction project.

When a sheathing membrane constitutes the principal element of a wall ABS, it is expected that the air pressure drop across this membrane would be large in relation to the total air pressure difference across the wall assembly. As this membrane also performs the function of a second layer of protection against rain penetration, it is conceivable that the wall ABS could get wet at times. Deficiencies in the installation of the ABS-sheathing membrane, e.g., tears or punctures by the cladding fasteners, could allow rainwater to infiltrate inwards where moisture-sensitive elements are located because the three conditions for water ingress would be present (i.e., a hole, a force and some water). Risks of rainwater ingress are lower when the materials exposed to the highest air pressure drops (i.e., the ABS) are kept dry. If the ABS is likely to be wetted, special measures should be taken to ensure that its continuity is not compromised during its service life.

Don't Throw the Towel!

Going back to our introduction about the piles of towels, remember that there are important differences between air barrier materials and air barrier systems, even though they may appear to be all the same to the uninformed. Selecting a material is only a small part of the work involved in constructing and installing an effective air barrier system.

Additional Reading

- Air Barrier Systems for Walls of Low-rise Buildings: Performance and Assessment, NRCC. http://irc.nrc-cnrc.gc.ca/catalogue/40635.html
- The Difference between a Vapour Barrier and an Air Barrier, NRCC, http://irc.nrc-cnrc.gc.ca/catalogue/bpn54.html
- An Air Barrier for the Building Envelope, NRCC, http://irc.nrc-cnrc.gc.ca/catalogue/29943.html
- Registry of Product Evaluations, CCMC, http://irc.nrc-cnrc.gc.ca/ccmc/home_e.shtml. See Divisions 7272 and 7273 for air barrier systems and air barrier materials.

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