Do We Need Walls That "Breathe"?

By Richard Kadulski

There is much misunderstanding about the purpose of various components in the building envelope. We use terms such as air barriers and vapour barriers to define functions for some components. The building envelope must keep the weather out, keep the heat in (or out, in hot summer weather), and take structural loads that may be imposed (wind pressures and other physical forces). To do their job, materials must be put together properly to form a complete whole.

What we forget at times is that we create buildings to make spaces habitable for human occupancy by separating its occupants from harsh natural environments.

The recent building envelope failures in coastal BC have brought out many traditional myths about today's construction practices and the need for walls to "breathe." These failures have also focused attention on how we look at building practices. The problems have been blamed on the increased levels of insulation being used today and the greater attention given to air sealing. The thinking goes that if we just built the way we used to, all will be well.

However, there are many reasons why we do not build today like we did in the past. We use materials that did not exist 30 or 40 years ago. We insulate buildings for increased comfort; we build more air tight buildings to reduce uncontrolled drafts; and we use more efficient mechanical equipment to condition our buildings. All these factors have contributed to changing building dynamics. Going back to the way buildings were constructed two or three generations ago is just not acceptable. We simply have to learn how to build properly.

Physical Principles

First let's look at how the basic laws of physics apply. Regardless of the climate conditions, the heating systems, or construction materials used, the basic laws of physics are always the same: heat goes from hot to cold; water vapour flows from areas of high vapour pressure to low vapour pressure; gravity pulls water down; porous materials absorb moisture. However, the appropriate details differ from location to location because the conditions each faces will be different in each climate zone.

Moisture in Building Envelopes

Moisture is by far the biggest cause of problems in buildings. When it is warm and wet, biological activity can lead to damage. When it is cold, frozen water can trigger structural damage as ice expands. An area that receives high rainfall, has warm temperatures year round and receives few hours of sunshine will require different details than one that has cold, sunny winters with little precipitation.

Most materials have a capacity to absorb moisture - in fact even when "dry" most materials have a certain amount of moisture stored in pores and fibres. Each material has its own critical conditions for moisture content. Some materials can store more moisture than others. The absolute moisture content will vary based on temperature, relative humidity, the material's capacity to store , moisture and degree of exposure to direct wetting. It is important to remember that moisture absorption and drying is a two-way process.

Two main sources of water are bulk moisture and water vapour. Bulk water is visible. Whether it is poor detailing and construction practices or material deterioration that leads to water leaks, bulk water is relatively easy to deal with simply because it is visible and obvious. Water vapour is less noticeable and its flow is often misunderstood.

Water Vapour

Water vapour has a vapour pressure that depends on temperature, moisture content and atmospheric pressure. Differences in vapour pressure create a driving force to move moisture from an area of high vapour pressure to an area of low vapour pressure.

We are not sensitive to water vapour except in extreme conditions, whether it be on a cold Canadian winter day when the indoor air is drier than in the Sahara desert, or on a hot humid summer day when humidity levels exceed the comfort range.

Indoor vapour pressures in a building are higher than outdoor pressures most of the time, so there is a force driving water vapour toward the outdoors which is at a lower pressure. However, the direction of the vapour pressure is not always uniform. During some periods of the year, and in some climate zones the pressures can be from the outside in. The important point is that water vapour flows are dynamic. Thus, there no one single way to deal with water vapour.

Vapour Diffusion

The building code uses the term *vapour barrier*, which implies a perfect elimination of vapour diffusion. In reality, with a few exceptions like sheet metals and glass, all materials allow a certain amount of water vapour to diffuse through them. Vapour diffusion, which vapour barriers (or vapour diffusion retarders) are intended to resist, is a weak force that can easily be controlled, even by the limited vapour resistance of many types of paints. A better, more accurate term to use is vapour diffusion retarder.

The forces of vapour diffusion are often misunderstood, and have received much scrutiny lately, especially in the analysis of the building envelope failures on the West Coast. When some suggest we need to allow our walls to "breathe" like in the old days, they are often confusing air leakage with vapour diffusion. In part this confusion may have been created when polyethylene was introduced as an "air-vapour barrier" and little else was considered acceptable to meet the functional requirements.

Much of our understanding of building science has come from the pioneering work done by the National Research Council's work in Saskatoon, and therefore has a bias toward a cold dry continental climate. This is where the "poly air vapour barrier" was strongly promoted because it was an appropriate way to address the issues in that climate zone. However, Canada has other climatic zones as well. We are only now becoming aware of the importance of looking at these other conditions, and realizing that they have an impact on the best details and building approaches to use in those climate zones.

In a cold, dry climate like that of the Prairies, at winter design conditions there is a big temperature difference between indoors and outdoors. However, with an indoor relative humidity of 20 to 30% the vapour pressure differential is modest. On the mild West Coast, monitored results have shown that winter indoor RH is typically above 55%. Although there is a relatively small temperature difference between inside and outside, the vapour pressure difference is significant.

On the West Coast (and in other mild, wet climate zones) materials often become saturated and little drying takes place. Because temperatures are warm, conditions are ideal for biological deterioration. In a cold dry climate like the Prairies, even if some moisture condenses and freezes, it tends to dry quickly - a kind of natural freeze drying.

Air Barriers

Air barriers resist the flow of air through the building envelope. They do not have to meet the vapour diffusion requirements of vapour diffusion retarders, and can be located at any point in the envelope. To be effective, air barriers must be applied properly, and joints sealed. Building materials such as drywall, concrete, or spun olefin sheets (such as 'Tyvek') may be poor vapour diffusion retarders, but, installed correctly, they can be used as air barriers.

Vapour Diffusion Retarders

A vapour diffusion retarder controls moisture transfer by slowing the rate of water vapour transmission through the pores of a material. It is intended to avoid the accumulation of moisture as a result of condensation on colder surfaces. Any low-permeance material can serve as a vapour diffusion retarder, including polyethylene, foils, vapour retardant paints, foil faced rigid foam insulation boards, some closed cell insulation boards, plywood, and vinyl wall papers. It is important to remember that different materials allow vapour diffusion at different rates, so some materials are better diffusion retarders than others.

Vapour diffusion retarders must always be on the warmer side of the wall, otherwise condensation can occur on the colder surface. However, vapour flow can go in both directions in some climate conditions. Solar heating of a wet wall surface can drive water vapour into the building assembly because the interior of the wall may be cooler and at a lower vapour pressure. Therefore, careful analysis is required to decide the optimum location of a vapour diffusion retarder. It will be different in different climatic zones.

Polyethylene is a very effective vapour diffusion retarder. However, there are times when allowing small quantities of water vapour to diffuse through an assembly may be acceptable. The moisture content of building materials and absolute quantities of vapour diffusion will determine whether there is going to be a problem or not. If the moisture content remains below saturation conditions, or if quick drying can take place, there will be no problems related to moisture.

Vapour diffusion retarders do not deal with bulk water movement, resulting from water leakage.

Typical Air Barrier Materials	
Materials with negligible air leakage	*Water vapour permeance (ng/Pa.s.m²)*
torch-on roof membrane	
½" gypsum board	1373
¼" plywood	23 - 74
½" OSB	44
1" extruded styrofoam	23 - 92
1" foil faced urethane	negligible
aluminum foil	negligible
6 mil polyethylene	1.6 - 5.8
spun bonded polyolefin	3646
breather type membrane	170 - 1400
	A vapour diffusion retarder must have an initial permeance no greater than 45 (ng/Pa.s.m²)

Direction of Vapour Diffusion

Vapour can diffuse inward or outward. Inward diffusion problems may arise in construction assemblies that can store moisture or that use vapour permeable materials in wall construction. This means that, under certain weather conditions, south side exposed walls could have moisture problems. The moisture source will be water from driving rain, rain penetration or, in the case of new buildings, built-in construction moisture.

For example, a stucco or brick veneer wall has a very large moisture storage capacity. After a heavy rain, the moisture can move into the wall or outward. When the sun heats the wall, the driving force may move the moisture inward, rather than drying to the outside, because the vapour pressure difference favours vapour diffusion inward toward a cooler interior. If the design does not allow adequate venting and moisture drainage, the water can start to accumulate inside the wall.

Summertime inward vapour pressure forces can be two to four times larger than outward winter forces, but are of short duration. However, condensation is more critical in warm weather because conditions are ideal for corrosion and fungal growth. The increased use of air conditioning in homes increases the problem because the interior surface temperatures are lower. This means that the design of building envelopes must balance winter drying to the exterior with summer wetting and drying to the interior.

Suggestions have been made that walls be built without any poly, to allow vapour to flow through the assembly and dry the wall. This is a strategy that may be acceptable for certain conditions in the mild West Coast climate. In a cold climate, the vapour diffusion retarder is still critical.

Although elimination of the vapour diffusion retarder may be acceptable under some conditions, it will not deal with moisture problems that are the result of rain penetration from the exterior. It is also important to remember that vapour resistant interior finishes, such as paint, vinyl wallpaper and many wood panel products also restrict vapour movement and contribute to vapour resistance.

Air leakage

Airtight construction practices became a significant feature of house construction in the mid 1970s as an energy conservation issue. At the time, it was realized that air leakage was one of the largest factors in house heat loss. This is especially the case in cold climates where the temperature difference between inside and outside can exceed 50°C (more than 100°F).

Loose, leaky construction does not only mean cold drafts into the house. Air leakage is also the driving mechanism for the movement of moist, warm indoor air to cold areas where damage to the structure can occur when the moisture condenses on cold surfaces. Air movement in and out of a building will take place through holes or gaps in

"Breathing" Walls

There is no such thing as a "breathing" wall. When people refer to walls that "breathe" it is typically to a construction assembly that has a less than perfect vapour diffusion retarder that allows water vapour to move through the construction assembly. It must still have an effective air barrier. This may seem like a very subtle difference, but it is perhaps a key to avoiding moisture problems.

Proper building envelope design should still provide control from the elements, keeping the outer layers of the cladding dry, reduce inward moisture movement (e.g., by using heavy building paper, extruded polystyrene insulation, etc.), and control of vapour diffusion. Interior moisture levels have a big impact on the performance of materials in the wall.

the construction, for example, around window and door frames, electrical outlets, between wall/floor plates, plumbing or service stacks. In a wall, wet materials provide ideal conditions for fungus and rot to attack structural wood.

Air movement is responsible for moving most of the moisture through the building envelope. The driving force can be a pressure difference between the inside and outside created by wind acting on the building envelope, and by the stack effect created by a temperature difference. Thus the need for an air barrier is not just an energy conservation issue, but an important consideration for the durability of the structure. ☼

Heating Cost Guarantee

For information: Enbridge Consumers Gas New Construction Hot Line: 416-495-5371

Enbridge Consumers Gas launched its "Ultimate Comfort Guarantee" at the Ontario Builder Forum in January. It provides homeowners a three-year comfort and heating cost guarantee.

This is a pilot program being done as a utility demand management project, so it is not subject to vagaries of a deregulated marketplace. Program costs will be monitored against energy savings.

Each house participating in the program must have a heat loss simulation performed, forced warm air heating systems must have all ductwork sealed, and the house has to meet minimum air tightness criteria (2.5 ACH). In addition, two inspections will be done: one before drywall, and one before occupancy, when the blower door test will be done and heating distribution balance verified. The program guarantees that the temperature in all rooms will be ± 1.5°C from the mean temperature.

The program criteria are meant to be achievable by mainstream builders. The intent is to ensure that homes are built with properly sized and laid out heating systems. Gas fired hydronic heating systems are also covered in the guarantee.

This guarantee program does not set out an energy consumption target (as in the R-2000 program) so that standard code construction is acceptable. However, if a builder wishes to build to R-2000 standards, that is also acceptable. The bottom line in the guarantee is determined by the heat loss calculation, so builders could use the guarantee to push the energy efficiency envelope as far as they wish to go.

Is it possible we will see builders promoting how little it costs to heat their house with a written guarantee to prove it? ☼

Health Canada Issues Advisory on Ozone Generators

Health Canada is working on a voluntary recall of ozone generators sold for household use. For more information: call 1-800-267-3364 (Monday to Friday 9:00 a.m. to 5:00 p.m. EST).

Health Canada is advising the public not to use ozone generators in their homes. The concern is with the adverse health effects that may result from exposure to ozone from air cleaners that generate ozone gas. Ozone is an irritant that can cause coughs, chest discomfort, and irritation of the nose and throat. The direct and purposeful generation of ozone indoors should be avoided.

Following a review of current information, the Canadian Standards Association (CSA) recently decided not to certify ozone generators for household use and issued new interim requirements for commercial units.

Health Canada advises all owners of ozone generators to stop using them in their homes. Owners of commercial ozone generators are advised to either stop use or have their devices tested to ensure that recommended exposure levels for ozone are not exceeded. Commercial ozone generators should never be used in homes.

Products affected include portable, breadbox sized units that plug into the wall, and some smaller units that may be battery-powered. Most devices of this kind have been sold door-to-door, and not in retail outlets. ☼