THE DOLLAR$ AND Common Sense OF AIR BARRIERS

BY RYAN DALGLEISH AND LAVERNE DALGLEISH

Air barriers are a relatively new term to most individuals in the U.S. market, even though the materials and technology have been around for decades. Actually, air barriers have been used since the very first building was constructed.

The purpose of the building enclosure (commonly known as the building envelope) is to separate two different environments. Whether they are at work, at home, or anywhere else, people want the environmental conditions around them at levels where they feel comfortable and can be productive. They want it warm enough but not too warm; cool enough but not too cool. Also, the environment should not be too humid or too dry.

Air barriers and building airtightness must be viewed in a "building as a system" approach and in consideration with the other functions of the building enclosure. This includes the use and function of liquid water barriers, water vapor barriers, and heat barriers (thermal insulation). Liquid water must be the design professional's first concern. In order to facilitate this, we must install roofs, eaves, flashings, water-resistive barriers, etc. All these components are designed to keep liquid water out of the building.

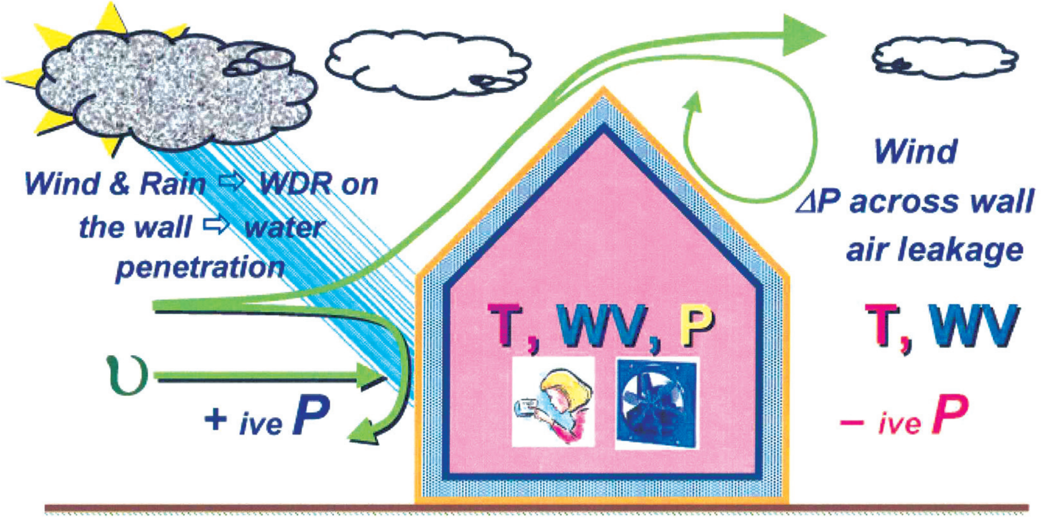
Once liquid water is addressed, the next concern for the design professional should be air barriers. Air barriers are more important than vapor barriers or heat barriers. Common sense calls for designers to address water, water vapor, air, and heat transfer all at once.

Design professionals who incorporate air barriers into their building must keep in mind that many materials provide more than one function. You could have a material that provides an air barrier function, a vapor retarder function, a radiant heat barrier, a water-resistive barrier, or combinations of these functions.

The exterior enclosure (envelope) separates the exterior environment from the internal environment.

The Building Science of Air Barriers

Nature wants everything to be balanced. Heat flows from hot to cold, moisture from wet to dry, and air from high pressure to low pressure, until everything is balanced or has equalized. When we put up a barrier in the building enclosure to create a different environment, nature exerts a force on the building enclosure. We then put mechanical equipment and occupants into the building. This adds an additional level of force or pressure exerted to the building enclosure.

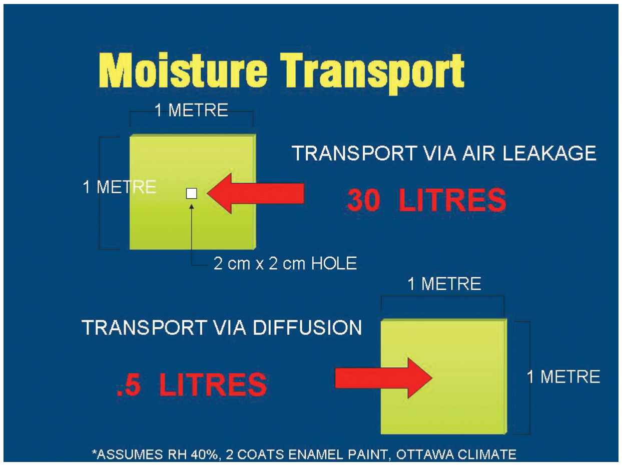


The building enclosure must resist the pressures exerted by both the exterior and interior environment. (Courtesy of the National Research Council.)

The building enclosure must be designed to resist the forces generated on it from both the exterior and the interior. Wind, solar radiation, night sky radiation, and rain all exert forces against the building enclosure from the outside. People, mechanical equipment, stack effect, flue effect, and ventilation effect all exert forces from the interior. The interior forces can either act against or act with the exterior forces. These forces vary from day to day, hour to hour, and in some cases, minute by minute.

There currently is a lot of confusion relating to the function of air and vapor barriers. Simply put, a vapor barrier is intended to stop moisture transport by diffusion; that is, moisture movement of water molecules physically working their way through a material. For the most part, this is a slow and tedious process. An air barrier, on the other hand, is intended to stop or retard air flow. Where some of the confusion may lie is in the fact that air has the ability to carry water vapor and transport it through holes, cracks, and so forth in the building. Estimates on the relationship of water transport by diffusion vs. air transport have indicated that air transport can carry between 60 to 100 times more moisture than by diffusion alone.

Many times, individuals will discuss the need for a vapor barrier, but as soon as someone starts to talk about holes, sealing, or anything along that line, typically they are no longer talking about a vapor barrier, but rather an air barrier. When a vapor barrier is damaged, repairs are needed, but typically this is not as much of a concern as having a hole or defect in the air barrier. As one increases or decreases the size of a hole in a vapor barrier, one simply has a different water vapor transmission rate for the area of the hole. Conversely, in an air barrier, as the size of the hole is decreased, the velocity of the air passing through that hole increases. This is due to the fact that the air is moving the same amount of volume through a now smaller hole. Therefore, having a hole in a vapor barrier does not have the same impact as a hole in an air barrier.



Example of moisture transport by air vs. moisture transport by diffusion over a heating season.

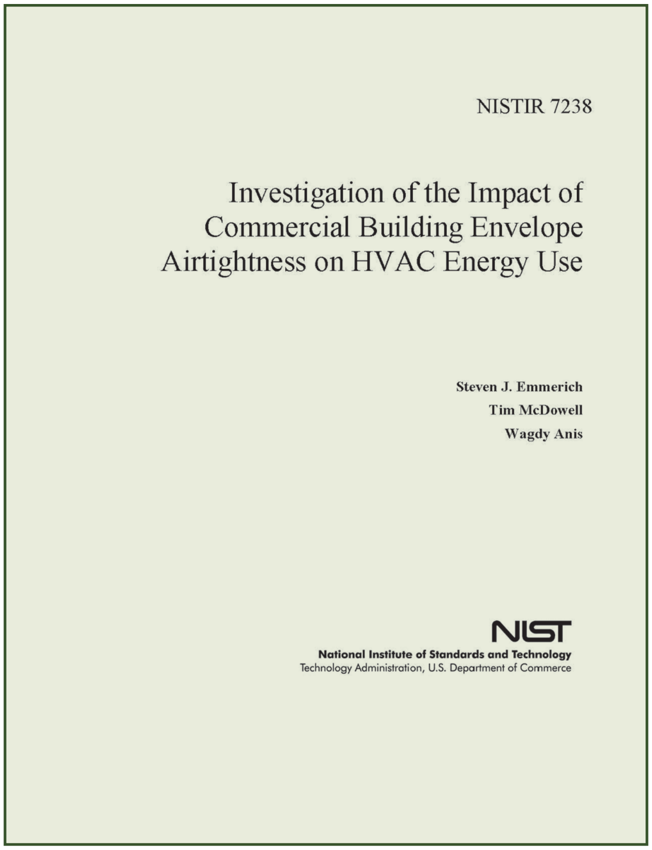
Also adding to the confusion is that many materials can provide more than one function in the building enclosure. There are materials that are air barriers; air and vapor barriers; and air, vapor, and heat barriers. Sometimes, materials used with the building enclosure may possess these characteristics but actually are not intended nor designed to provide more than one function. For example, drywall is an air barrier and can be used within a wall assembly. Although it is an air barrier, it may serve no other purpose than to provide a substrate for other materials on the exterior or a surface that can be used to provide interior finishing on the inside of a building. The designer needs to identify which materials provide the air barrier function in their wall assembly and ensure that he or she can trace a line of airtightness through the assembly.

It is recommended that when a building is designed, the design professional should first go back to the basics of understanding heat flow, water flow, and air flow in their simplest form. Once that is achieved, a designer can move onto looking at the composite effect of these dynamic flows. If the designer understands the basics, then combining the functions becomes much easier and much more practical.

The physics and science of buildings and building enclosures do not change, no matter where the building is constructed. The climate may be dry and cold, hot and humid, or anywhere in between. The details of what materials to use, how to install them, and where they are installed within the building enclosure need to be carefully reviewed based on the environment in which the building will ultimately operate.

Energy Savings

It takes energy to condition the air in buildings, whether heating or cooling is taking place. Most individuals are aware of the increase in the cost of oil. Although oil is not a major energy source for the heating or cooling of buildings, the cost of natural gas and electricity has historically followed the cost of oil. Most electricity comes from coal, but the majority of the new generation of electricity is using natural gas as the fuel source. No matter what the energy source, most people agree that energy costs will be increasing and will remain high.


NISTIR 7238

Investigation of the Impact of
Commercial Building Envelope
Airtightness on HVAC Energy Use

Steven J. Emmerich
Tim McDowell
Wagdy Anis

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Cost/benefit analysis study on the cost effectiveness of including air barriers in building enclosure systems.

The National Institute of Standards and Technology (NIST) has completed a study to determine the cost effectiveness of installing air barriers in buildings. The study can be found at http://fire.nist.gov/bfrlpubs/ build05/ PDF/b05007.pdf. The report states, "Despite common assumptions that envelope air leakage is not significant in office and other commercial buildings, measurements have shown that these buildings are subject to larger infiltration rates than commonly believed. Infiltration in commercial buildings can have many negative consequences, including reduced thermal comfort, interference with the proper operation of mechanical ventilation systems, degraded indoor air quality, moisture damage of building envelope components, and increased energy consumption." The report goes on to say that the reduction in energy consumption and operating costs has a potential gas savings of greater than 40% and potential electrical savings of greater than 25% compared to a baseline case.

Very simply, for the energy savings alone, it is cost effective to install an air barrier into a building.


Building façade distress due to uncontrolled air leakage from the interior of a building in a cold climate.


Exterior sheathing damage from excess moisture in wall assembly.

Complete Building Performance

The benefits of including an air barrier in a building go beyond simply saving money. By having an airtight building enclosure, the sizing of the mechanical equipment can be reduced, as the equipment will not have to make up for air that has infiltrated or exfiltrated the building. In some cases, the cost savings on the equipment side alone can offset the cost of adding an air barrier system to a building.

With an airtight building, the mechanical equipment can work as intended and deliver the conditioned air to where the occupants are, resulting in making the occupants more comfortable. Indoor air quality will also be improved as the exchange of air in the building will be more precise. The bottom line is that an air barrier helps the building to perform as intended.

If the thermal insulation used in a building is not in itself an air barrier, then the air barrier will help the thermal insulation perform better. When air leakage occurs through an air permeable insulation, the value of the insulation may be severely reduced.

Moisture and Durability Issues

In climates where there is a difference in temperature between the two environments, there is the possibility of moist warm air moving by air transport through the building enclosure, which would cause the moist air temperature to drop to its dewpoint.

This can be warm, humid air from the outside infiltrating into the building from the exterior. It could also be warm, moist air inside the building exfiltrating from the interior to the exterior.

In either case, when water vapor turns to liquid, there is a potential for problems to develop. Building materials have varying ability to absorb moisture and then release it. This is referred to as the "wetting" and "drying" of the building enclosure. When the "wetting" of the building enclosure lasts for a limited time and then the materials dry out, it may not produce problems or degradation to the materials. Most buildings are constructed to withstand this as a temporary occurrence. When the "wetting" continues for a period of time or when there is limited drying potential, air leakage through the building enclosure can cause considerable damage.

Installed Performance is Critical

It is important that materials used for airtightness in a building enclosure have low air permeance. Materials considered to be air barriers have a maximum air permeance of 0.02 L/(s·m^2) when tested in accordance with ASTM E-2178.

The installer takes air barrier materials and components and installs them in a building to form an air barrier assembly. These assemblies (wall assembly, roof assembly, door/window assembly) all have to be connected together to form an air barrier system that completely wraps the entire building on all sides.

However, if the material has a very low air permeance and then holes are subsequently put through the material, then the air will travel through the path of least resistance, which in this case will be through the holes. As no material can cover all six sides of a building without any penetrations, it is very important how these penetrations, terminations, and the connections are made. Whether it is from one material to another material or assembly to assembly, these are critical areas that must be addressed in both the design and installation of the air barrier assembly.

There is no easy way around this. The skill level of the installer of the air barrier materials and components is extremely important. This includes constructing the air barrier assembly and then the connections of the different air barrier assemblies together. As air barriers are required on all six sides of the building, the air barrier installation will be done by a number of trades. In addition to each installer having the proper skills, the different groups of air barrier installers, general contractors, and others involved in the construction process need to keep lines of communication open to determine who is responsible for what connections and so forth. For example, which trade is responsible to connect from the roof to the wall, from the wall to the window, and so on. Continuity of the system is critical, and individuals involved in the construction process need to be aware of the sequence of construction so proper and durable connections can be achieved.

Quality assurance programs for the site installation of air barrier assemblies have been developed and are being delivered across the U.S. Key principles of the program include defining what a proper installation should be; the training of the installer on how to achieve a proper installation; then verifying on-site that the installer is actually implementing what he or she has been trained to do. The biggest issue and a key reason for improper installation can be attributed to not defining, in advance, how the installation should be completed. There

Air barrier installers attending ABAA training in both the theory of building science and hands-on application of various air barrier materials.

should be no surprises, and there should be no requirements that the installer does not know in advance.

Air Barrier Standards

Air barrier standards are required to provide a balanced approach and to remove bias from the project. For standards to be developed, agreement must be reached on terminology. As an example, discussion over the years has included the term air barrier vs. air retarder.

Today the term "barrier" is accepted as not meaning absolute, but providing the function that is anticipated. Therefore, an air barrier is not an air impermeable material, but rather any material that has a maximum air permeance based on a specific test procedure.

New terminology has been developed for air barrier materials, components, assemblies, and systems. In short, air barrier materials are the main material used – the "big" pieces so to speak.

Air barrier components are any materials used to join materials or assemblies together.

Air barrier assemblies are defined as a combination of air barrier materials and air barrier components joined together. Current construction terminology uses the term "assembly" when describing parts of the building (wall assembly, roof assembly, door assembly, etc). All of these assemblies come together to provide the airtightness of a building, so they must be considered by a designer. There needs to be consideration given to all of the assemblies, with the ultimate goal an airtight building. Air moves through the path of least resistance, so when the wall assembly is extremely airtight, but the windows have an extremely high air leakage rate, the air will travel through the window, bypassing the wall.

The air barrier system is the airtightness plane defined throughout the complete building enclosure.

There have been two ASTM test methods published to date for the air barrier industry. The first standard developed was ASTM E-2178 – Standard Test Method for Air Permeance of Building Materials. The second standard developed was ASTM E-2357 – Standard Test Method for Determining Air Leakage of Air Barrier Assemblies.

Work is continuing to develop a com-

ROOF KNOWLEDGE ASSESSMENT

Test your knowledge of roofing with the following metal roofing questions, developed by Donald E. Bush Sr., RRC, FRCI, chairman of the RRC Examination Development Subcommittee.

The sources for this month's column are *NRCA Roofing and Waterproofing Manual*, 5th Edition, Volume 3

1. **How is Waterproofing defined by the *NRCA Roofing and Waterproofing Manual*?**
2. **How much hydrostatic pressure does water exert?**
3. **What is a Hydrostatic Pressure Relief System?**
4. **Built-up roofing membrane is typically defined by headlap, endlap, and sidelap. Where are each of these laps located in a BUR cross-section?**
5. **When a properly shingled BUR membrane is showing a lap exposure of 9 inches, how many plies of roofing are present?**

Answers on page 18

plete family of standards, including such things as components, installation, inspection, and a standard for air barrier systems.

The Future of Air Barriers

Building airtightness, performance, and more energy-efficient buildings are here to stay. As we move into the future, the issue of effective air leakage control will continue to be at the forefront. The move to energy efficiency and green buildings will continue to embrace the common-sense approach of using an air barrier to reduce energy use while reducing the building owner's cost to operate the building.

References

Steven J. Emmerich, Tim McDowell, and Wagdy Anis. "Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use." National Institute of Standards and Technology. June 2005.

Ryan Dalgleish

Ryan Dalgleish, vice president of bpc Building Professionals Consortium, has been involved in the building envelope industry for over 10 years in the areas of research, training, and quality assurance. He earned a certificate in adult education from the University of Manitoba and is working towards a master's degree in this field at the same university. Ryan is currently involved in both the development and delivery of training programs on air barriers and related building envelope products for both the commercial and residential industries. He is the current chair of the Manitoba Building Envelope Council (MBEC), a director of the National Building Envelope Council (NBEC), serves on various technical committees in regards to building performance/green building practice, and is a frequent speaker across North America on air barriers. Ryan also forms part of the quality assurance management and training team for the Air Barrier Association of America's on-site quality assurance and training programs on air barriers.

Laverne Dalgleish

Laverne Dalgleish is president 0f bpc Building Professionals Consortium, which designs, develops, and delivers site quality assurance programs for the construction industry. Laverne has been actively involved in the construction industry for over 32 years and has specialized in building envelopes, energy efficiency, and building performance for over 20 years. Laverne is a frequent presenter across North America on a variety of topics as they relate to building envelopes, energy efficiency, green building practices, standards, and quality of construction. He is actively involved in the standards development process and is currently the chairman of ULC's Thermal Insulating Systems and Standards. He is also an active member in ASTM, CSA, CGSB, and is secretary of two ISO standard development committees. Laverne is the executive director of the Air Barrier Association of America.

NRCA To Host ROOFPAC Auction

The NRCA's political action committee, ROOFPAC, will host a silent and live auction to raise money during NRCA's annual convention in Las Vegas on February 14. All proceeds from the auction will go to support pro-business candidates for the U.S. Senate and House of Representatives.

For more information, contact Leah McKnight, NRCA's manager of public affairs, at 847-299-9070, Ext. 7599, or e-mail lmcknight@nrca.net.

ROOF KNOWLEDGE ASSESSMENT

Answers to questions on page 17:

1. **The treatment of a surface or structure to prevent the passage of water under hydrostatic pressure.**
2. **Water exerts a pressure of 62.4 pounds per foot of depth. Therefore, water lying against a barrier exerts a steadily increasing pressure as the depth of water increases.**
3. **A system of perimeter and/or under-slab drains used to regulate the hydrostatic pressure in the earth surrounding a below-grade structure.**
4. **Endlap – the overlap distance that is measured from where one roll of felt ends to where another begins.**

   Sidelap – the overlap distance along the length of the felt where one roll of felts overlaps the adjacent underlying felt.

   Headlap – the distance of the overlap that exists between the lowermost and uppermost plies of a shingled portion of a roof membrane when measured perpendicular to the long dimension of the membrane.
5. **FOUR (4)**

NRCA Roofing and Waterproofing Manual,
5th Edition, Volume 3