The Impact of Air Barriers on the Thermal Performance of the Building Envelope

By Laverne Dalgleish

The use of air barriers in buildings is a relatively activity in the United States. Air barrier requirements have just recently been included in energy codes. Design professions, contractors and installers are just starting to acquire the expertise for the proper installation. There has been a lot of discussion on how tight building should be, how effective air barriers actually are and what the energy savings will be when an air barrier is used in the building envelope.

For years the US Department of Energy advised consumers that 30-40% of the energy used in a building was due to air leaking in and out of a building. People generally accepted that air leakage did result in heat loss and that the gaps and cracks needed to be sealed to provide comfort for the occupants.

In 2001, the Commonwealth of Massachusetts, included requirements for air barriers in buildings. [1] Other states such as California, District of Columbia, Georgia, Illinois, Maryland, Minnesota, New York, Oregon, Rhode Island and Washington State[2] followed suit and proposals were made to the International Code Council to include air barrier requirements in the International Energy Conservation Code. During all of these Code discussions, the impact on the energy use of using an air barrier in a building was at the center.

To determine the impact on energy use, the National Institute for Science and Technology undertook an investigation of the impact of commercial building envelope airtightness on HVAC energy use. Their investigation showed that air leakage accounted for up to 40% in heating climates and up to 15% in cooling climates.[3] During these Code hearings, Mr. Christopher Mathis stated that including requirements for air barriers is the single most significant opportunity available to reduce energy use. He also stated that most of the proposals will results in less than 1% of total energy savings whereas including air barriers provide double digits of energy reduction.

If we are looking at energy savings of anywhere from 5% to 40%, why isn't everyone scrambling to include in their projects? The answer is that many people are doing just that. However for the majority of people, air barriers are very confusing.

To reduce the confusion, it is important to understand that the term "air barrier" should be used a verb and not as a noun. To be used as a noun, it needs to be an "air barrier something". The air barrier industry has defined air barriers as;

air barrier material, n - building material that is designated and constructed to provide the primary resistance to airflow through an air barrier assembly

air barrier accessory, n – products designated to maintain air tightness between air barrier materials, air barrier assemblies and air barrier components, to fasten them to the structure of the building, or both (e.g. sealants, tapes, backer rods, transition membranes, fasteners, strapping/furring strips, primers)

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[1] XXXXXX

[2] http://www.airbarrier.org/codes/index_e.php

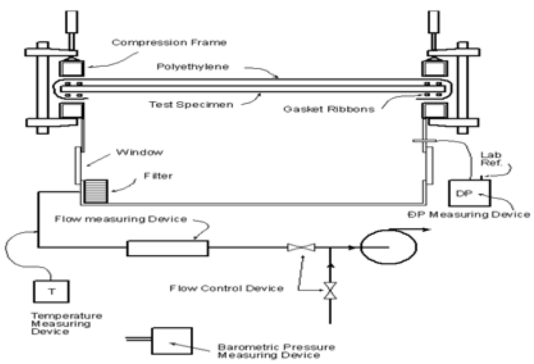
[3] NISTIR 7238 Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use Steven J. Emmerich - *Building and Fire Research Laboratory,* Timothy P. McDowell - *TESS, Inc.,* Wagdy Anis - *Shepley Bulfinch Richardson and Abbott* Prepared for: U.S. Department of Energy Office of Building Technologies June2005

air barrier component, n – manufactured elements such as windows, doors and service elements that are installed in the environmental separator

air barrier assembly, n – combination of air barrier materials and air barrier accessories that are designated within the environmental separator to act as a continuous barrier to the movement of air through the environmental separator

air barrier system, n – combination of air barrier assemblies and air barrier components connected by air barrier accessories that are designated to provide a continuous barrier to the movement of air through an environmental separator.

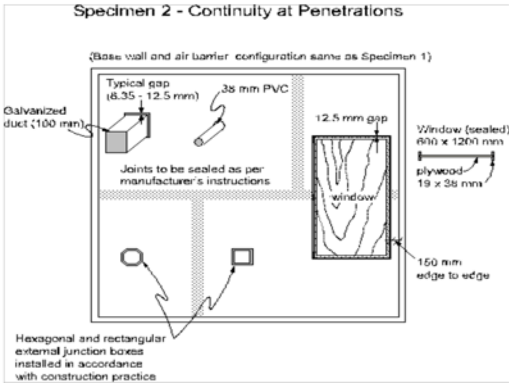
You start with the air barrier material. The air barrier industry has developed a test method for determining the air leakage rate of air barrier materials and has set a maximum rate of air leakage. The test method is ASTM E 2178 Standard Test Method for Air Permeance of Building Materials. The maximum air leakage rate allowed is 0.004 cubic feet per minute per square foot at a pressure difference of 1.56 lbs/ft^2 (0.02 L/(s·m^2) at a pressure difference of 75 Pa). This happens to be the approximate air leakage rate of gypsum board and this also happens to be where this number has come from.



You then combine the air barrier material (the "big" pieces) with materials that will seal joints between air barrier materials, seal air barrier materials to penetrations, fasten the air barrier material to the substrate, etc. These materials are air barrier accessories.

Within the building envelope you will have doors, windows, skylights and other service elements which provide a plane of air tightness which we define as air barrier components. These air barrier components need to be connected to the air barrier material using air barrier accessories.

By combining air barrier materials with air barrier components and air barrier accessories you produce an air barrier assembly. They will also be a building assembly – roof assembly, wall assembly, foundation assembly, floor assembly, etc. The air barrier industry has developed a test method for air barrier assemblies. It is ASTM E 2357 Standard Test Method for Determining Air Leakage of Air Barrier Assemblies. In this test method the proponent develops an eight (8) foot by eight (8) foot building assembly. If the specimen happens to be a wall assembly, this wall specimen needs to have a mock window, a round penetration, a square penetration, octagon electrical box, square electrical box and brick ties. During the test procedure, the rate of air leakage is determined and then the specimen is subjected to loads. These loads include a stepped positive pressure, a stepped negative pressure, positive cycles, negative cycles, a positive wind gust and then a negative wind gust. These wind gusts are 1200 Pa positive and then 1200 Pa negative. In testing that I have seen, the middle of an eight (8) foot wall has moved between ½ to 5/8 of an inch, positive and then negative. When this conditioning is complete the wall is tested again to determine the air leakage rate. If the rate is within 10% of the air leakage rate that was tested first, then the first number is used. If the air leakage rate is greater than 10% then the higher number is used.



The difference between testing an air barrier material and an air barrier assembly is significant. We do want to separate materials that have a high air leakage rate from the materials that have a low air leakage rate. You do need to understand that materials such as dense packed cellulose, thin plywood/OSB and thin expanded polystyrene, etc. are not classified as air barrier materials. The most important information gained by conducting this test is that the installer now has a list of materials that will work together to create a plane of airtightness. If you are using such air barrier accessory products such as tape, you can have a level of confidence that that specific product will work in the field if it has withstood the loads imposed upon it during the test. Some manufacturers are reluctant to identify air barrier accessories that they do not manufacturer and therefore do not control. However the installer needs to know what works and what does not. The installer cannot practically do this type of testing in the field to determine this.

What really counts in the air leakage rate of the whole building? We call this the air barrier system. It is all six (6) sides of the building. During construction, the building assemblies (which contain the air barrier) are connected together using air barrier accessories. This includes roof to walls, walls, to floors, walls to foundations, floors to foundations, etc. The air barrier assemblies are also connected to the air barrier components (doors, windows, skylights, etc.). When completed you have a complete building envelope which has a continuous plane of airtightness. This means the building will not use the energy that a non-airtight building would. To conduct a test on a whole building, currently people are using ASTM E 779 Standard Test Method for Determining Air Leakage Rate by Fan Pressurization or ISO 9972 Thermal performance of buildings -- Determination of air permeability of buildings -- Fan pressurization method. Currently the Air Barrier Association of America is working on a test method which is more geared to testing large whole buildings. The work is almost complete and a round robin is being organized to determine the precision and bias.

In addition to the building envelope which separates the interior environment from the exterior environment, there may be different environments within a building that also needs to have an air barrier. In a hotel you would want to separate the swimming pool from the guest rooms. In a hospital you would want to separate the ICU from the balance of the hospital rooms. The Commonwealth of Massachusetts has identified that if the temperate or humidity requirements are different by 50% or more, then an air barrier is required. Other buildings may want to block smells and pollutants from transferring from one unit to another. Cigarette smoke from one apartment needs to be confined to that apartment and not transfer to other apartments. In one case the air from a beauty salon containing VOC's was leaking into a pet store next door and disturbing the animals.

Tightening up buildings can have a significant impact on energy use. Some buildings are seeing the up to 40% energy reduction along with peak reduction. An airtight building will also be much quieter as most of the sound we head is transported by air. The HVAC equipment will work much better and provided the ducts are also sealed, will deliver the proper amount of air to the proper location. Many times an airtight building can result in significant reduction in equipment size and reduced capital costs. The comfort of airtight building is greatly increased as the occupants are not affected by drafts.

The performance of installed thermal insulation will also greatly increase. If a fibrous insulation is used, the material counts on still air to provide the thermal resistance required. If air moves through a fibrous insulation it greatly decreases the thermal insulation's performance. Having a properly installed air barrier system can improve the performance. Even with cellular plastics, which may be an air barrier material, an air barrier system greatly increases the performance of the cellular plastic material as the joins, penetrations, termination, etc. are then dealt with.

The impact of an air barrier system properly installed in a building improves the thermal performance not simply by stopping air leakage but also improving the performance of the thermal insulation and the HVAC system.