SAVING THE WORLD

ONE AIR BARRIER AT A TIME

BY BRIAN CAREY

Reducing dependence on fossil fuels, cutting greenhouse gas emissions, and conserving valuable energy resources – these are all hot-button issues discussed regularly over the airwaves and in publications. While virtually everyone can agree that these are important issues, there is much disagreement on which remedies to pursue. As we live and work largely in a built environment, much of the nation's energy goes toward heating, cooling, lighting, and countless other important operations within buildings. According to the Alliance to Save Energy,[1] residential and commercial buildings use 40% of U.S. energy and contribute to about 38% of carbon dioxide emissions. With this information, one can see that energy use by buildings dramatically impacts overall U.S. energy use. Reducing energy use by buildings is important, not only for the financial savings of building owners, but because it would reduce overall U.S. energy use, which in turn would reduce consumption of fossil fuels and cut greenhouse gas emissions.

Building codes impacting energy use in buildings, special programs like LEED,[2] and energy-conscious design all provide methods of constructing more energy-efficient buildings. To build a more energy-efficient building, there is usually emphasis on incorporating more insulation and using energy-efficient HVAC systems, appliances, and lighting. Many other energy-saving systems for buildings have been developed – too many to mention in this paper. An often-overlooked and highly effective way to save energy is to reduce building envelope air leakage. In typical envelope construction, where many types of materials and assemblies are joined together, countless air-leak paths exist. It has long been estimated that air leakage in typical building construction accounts for a large percentage of HVAC energy consumption. Because of this notion, model energy codes IECC[3] and ASHRAE 90.1 and 90.2[4] establish requirements for airtightness of fenestration and prescribe sealing of any direct air-leak paths through the building envelope.

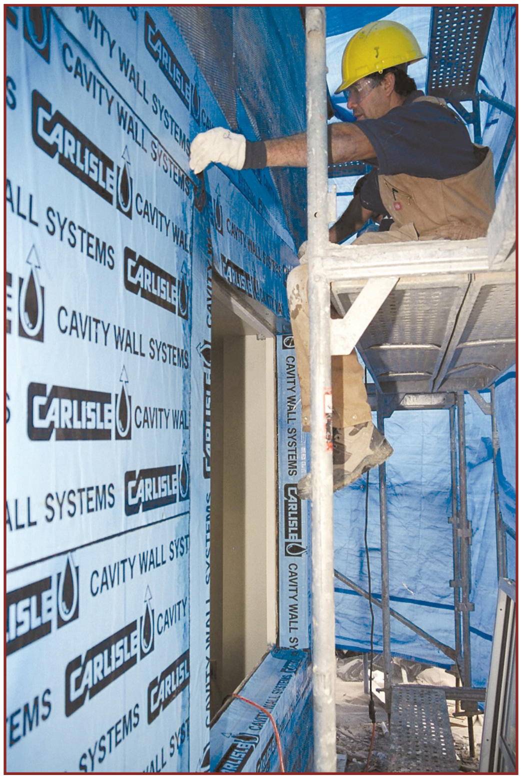

Photo 1: Carlisle Coatings and Waterproofing's 705 Self-adhering Vapor and Barrier System being applied to a new building.

Constructing more airtight buildings to save energy seems like an obvious solution. A relatively recent study by NIST entitled "NISTIR 7238, Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use,"[5] confirms that constructing a more airtight building envelope lowers energy consumption for HVAC functions. Annual energy savings approach 40%, according to the study. Although the previously mentioned IECC and ASHRAE codes indicate that airtight construction is desirable, it is not mandated by these codes. That is because the IECC and ASHRAE codes do not establish requirements for airtightness of opaque assemblies or of the building envelope.

Building code air barrier requirements take envelope construction to a higher level by mandating a minimum airtightness level and giving means and methods to achieve it. Canada's National Building Code (NBC) has required air barriers for more than a decade. The energy code for Massachusetts, entitled "780 CMR Energy Code for Commercial and High-Rise Residential New Con-

1304.3 Air Leakage

1304.3.1 Air Barriers: The building envelope shall be designed and constructed with a continuous air barrier to control air leakage into, or out of the conditioned space. An air barrier shall also be provided for interior partitions between conditioned space and space designed to maintain temperature or humidity levels which differ from those in the conditioned space by more than 50% of the difference between the conditioned space and design ambient conditions. The air barrier shall have the following characteristics:

1. It must be continuous, with all joints made air-tight.
2. It shall have an air permeability not to exceed 0.004 cfm/ft^2 under a pressure differential of 0.3 in. water. (1.57 psf.) (equal to 0.02L/s/m^2 @ 75 Pa.)
3. It shall be capable of withstanding positive and negative combined design wind, fan and stack pressures on the envelope without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
4. It shall be durable or maintainable.
5. The air barrier shall be joined in an air-tight and flexible manner to the air barrier material of adjacent systems, allowing for the relative movement of systems due to thermal and moisture variations and creep. Connection shall be made between:
   a. Foundation and walls.
   b. Walls and windows or doors.
   c. Different wall systems.
   d. Wall and roof.
   e. Wall and roof over unconditioned space.
   f. Walls, floor and roof across construction, control and expansion joints.
   g. Walls, floors and roof to utility, pipe and duct penetrations.

1304.3.2 Air barrier penetrations: All penetrations of the air barrier and paths of air infiltration/exfiltration shall be made air-tight.

Figure 1

struction,"[6] has included requirements for air barriers in Chapter 13 of the code since 2001. The air barrier language in the Massachusetts code was adopted almost directly from the language of the NBC. The air barrier requirements of 780 CMR appear as seen above (see *Figure 1*).

Air barriers have achieved national significance, even though very few jurisdictions actually require them. NBC and 780 CMR are considered established model codes for air barriers. Design professionals, product manufacturers, consultants, and spec writers use the aforementioned codes as the basis for writing air barrier guide specifications. As a result, countless projects across the U.S. have been completed with air barriers that were effectively specified with 780 CMR or NBC.

In fact, as a result of these air barrier model codes and projects, a national air barrier industry has emerged, supported by product manufacturers, design professionals, contractors, consultants, professional organizations, and others. As the use of air barriers has entered the mainstream, CSI's MasterFormat® 2004[7] has assigned a Level 2 section number, 07 27 00, for air barriers, and five Level-3 section numbers for common types of air barriers. Nationally, many building owners have embraced the benefits of air barriers and have paid for them to be installed.

Note that the established air barrier codes do not say what materials or products to use as air barriers. The codes indicate that an air barrier needs to be continuous, durable, withstand design pressures, accommodate movement, and be composed of materials having an air permeability of not more than 0.004 CFM/ft^2 at 1.57 PSF.

Air permeability, commonly measured with ASTM E 2178,[8] is used to qualify materials as air barriers by measuring the flow of air through them at a given pressure differential. A great number of materials exhibit low enough air permeability to be considered air barriers, including: half-inch drywall, glass, steel, poured concrete, plywood, extruded polystyrene insulation (XPS), spray polyurethane foam, 6-mil polyethylene sheeting, specialty sheet building wraps, modified bitumen self-adhering sheets, and certain liquid-applied membranes.

Materials that allow largely uninhibited passage of air exhibit a high level of air permeability and are NOT air barriers. Examples of these include most brick and mortar assemblies, non-glazed concrete block, batt insulation, expanded polystyrene insulation, perforated house wraps, and building paper.

When all of the provisions of the model air barrier codes are considered, the selection of air barrier materials becomes more

Photo 2: Carlisle Coatings and Waterproofing's 705 Self-adhering Vapor and Barrier System being applied to a new building.

focused. In particular, the requirement for continuity is the most difficult to achieve. For example, 6-mil polyethylene sheeting, even though it qualifies as an air barrier, generally cannot meet the provisions of the air barrier code as installed in practice. That is because it is virtually impossible to install 6-mil poly without holes or gaps in its typical location, which is on the inside surface of the wall and ceiling studs. In this location, 6-mil poly is unsupported in the span between studs, is not sealed at overlaps between sheets, and has many mechanical and electrical penetrations through it. Even if one installs the poly sheets meticulously to seal the laps and penetrations, how will it be joined to the roof and foundation, and how will it be made continuous between floors? The same problems exist when trying to use interior drywall as an air barrier. In addition to material choice, location within the building envelope and method of installation are crucial factors for delivering effective air barriers.

So, what does an air barrier look like when it is properly installed on a project? A common approach is full coverage of the walls with an airtight polymeric membrane that is fully supported by the wall surfaces and either fully adhered or securely attached by other means. Tight seals to the air barrier membrane are made around windows, doors, and mechanical and electrical penetrations. The air barrier membrane is placed on the exterior side of the structural wall and is covered by the building's exterior cladding. This is the same location where one would find building paper or house wrap as a water-resistive barrier in conventional construction. Typical air barrier membrane products employed on these projects include peel-and-stick sheets, liquid-applied coatings, mechanically attached sheets, or spray-applied polyurethane foam. The air barrier membrane on the walls either terminates onto a poured concrete footer or ties into below-grade waterproofing or dampproofing. Then the air barrier membrane on the wall is either joined directly to the roofing membrane, it is joined to a special roofing air barrier underlayment, or it terminates onto an airtight roof deck.

Not all wall assemblies require a full coverage membrane to meet the air barrier requirements. For example, walls constructed of poured concrete or air barrier type sheathing with joints securely sealed can meet the air barrier requirements as long as there are provisions made to seal the walls at openings and around penetrations to the roof and foundation.

Regardless of materials and methods selected, the greatest challenge to providing an effective air barrier is installation. With all of the common building materials that qualify as air barriers, it's easy to imagine that the challenge lies not in selecting airtight materials, but in finding a way to put all these materials together without leaving holes or having holes eventually manifest themselves. To this end, ASTM has developed a standard, designated E 2357,[9] for evaluating performance of air barrier assemblies. Another standard by the same organization, ASTM E 1186,[10] is useful for performing field inspection of air barrier assemblies. ASTM also has standards for measuring air and watertightness of field-

Photo 3: Carlisle Coatings and Waterproofing's Barriseal Liquid-Applied Air Barrier being applied to Lawrence High School in Lawrence, Massachusetts.

constructed mock-ups as well as standards for measuring whole-building airtightness. With a multitiered approach – escalating from air barrier material qualification to air barrier assembly qualification to evaluation of whole-building airtightness – a systematic and standardized method of delivering an airtight envelope can be followed.

Materials employed as air barriers can have multiple functions. Often, they are also water resistant or waterproof because of their composition and intended area of installation. In this case, they perform a dual function as an air barrier and a water-resistive barrier. Some air barriers are also vapor barriers, in which case care must be taken to locate these properly in the envelope assembly so as not to "trap" moisture.

In some regions of the country, vapor barriers are required by code in the exterior envelope assembly. A material that is both an air barrier and a vapor barrier can simultaneously perform these necessary functions. Some air barriers are vapor permeable, so they block airflow and are often water resistant, yet they allow moisture vapor to pass through. In any case, air barriers must not be confused with vapor barriers, as these two functions must be considered separately. Both systems functioning as vapor-permeable air barriers and those functioning as air and vapor barriers can be used successfully with proper envelope design and installation.

Air barriers provide benefits other than just energy savings. They also enable a more comfortable interior environment by allowing more controllability of the HVAC system. Air barriers can also provide a healthier interior environment while extending building life. Consider that a serious consequence of air leakage through the building envelope is the wetting of non-moisture-resistant materials through condensation. Free air movement through the building envelope can inadvertently move a lot of moisture. For example, heavy condensation can form as a result of movement of inside heated and humidified air toward the cold exterior in a cold climate. Conversely, in a warm climate, condensation forms from movement of hot and humid air toward the cool, air-conditioned interior. Persistent condensation can cause mold growth, decay, and corrosion, which in turn can cause health problems for occupants and premature building deterioration. Studies by the Canadian Mortgage and Housing Corporation (CMHC)[11] and Oak Ridge National Laboratories (ORNL),[12] as well as investigations performed by individual building envelope consulting firms reveal the damaging effects of moisture from condensation as a result of air leakage across building envelope assemblies.

Photo 4: Carlisle Coatings and Waterproofing's Barriseal Liquid-Applied Air Barrier being applied to Lawrence High School in Lawrence, Massachusetts.

Specifying an air barrier and assuring its proper installation can be a monumental feat. While manufacturers of air barrier materials are obvious resources for assistance with their proprietary systems, the Air Barrier Association of America (ABAA)[13] is considered the universal air barrier resource. ABAA was formed in 2001 as a group of professionals whose mission was to provide guidance on how to meet the new air barrier requirements in the Massachusetts energy code. Since then, this organization has grown, with national membership from many companies and professions. ABAA's Web site **(www.airbarrier.org)** contains guide specifications for various types of air barriers, a library of technical articles, member directory, and other important information. ABAA also trains and certifies air barrier installers and provides building owners with a quality assurance program (QAP) to assist in delivery of a quality air barrier on a specific project.

Conclusion

Air barriers in building envelope construction provide significant HVAC energy savings. Buildings consume nearly half of U.S. energy use, so installing air barriers in buildings can dramatically impact national energy consumption. Constructing buildings with barriers can contribute significantly toward efforts to reduce U.S. dependence on fossil fuels and can lower greenhouse gas emissions and lessen consumption of valuable energy resources. Air barriers also enable a more comfortable and healthy interior.

References

1 The Alliance to Save Energy charter and published information can be accessed at www.ase.org/content/article/detail/2356.
2 LEED (Leadership in Energy and Environmental Design) programs for new construction can be accessed at www.usgbc.org/DisplayPage.aspx?CMSPageID=220.
3 International Energy Conservation Code 2006.
4 American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 Energy Standard for Buildings Except Low-Rise Residential Buildings, 90.2 Energy Efficient Design of Low-Rise Residential Buildings.
5 NISTIR 7238. The full report is publicly available at www.fire.nist.gov/bfrlpubs/build05/PDF/b05007.pdf.
6 CMR 780 is accessible to the public at www.mass.gov/bbrs/energy.htm.
7 MasterFormat® 2004 is available for purchase from the Construction Specifications Institute (CSI) at www.csinet.org.
8 ASTM E 2178, Standard Test Method for Air Permeance of Building Materials.
9 ASTM E 2357, Standard Test Method for Determining Air Leakage of Air Barrier Assemblies.
10 ASTM E 1186, Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems.
11 Canadian Mortgage and Housing Corporation, www.cmhc-schl.gc.ca/.
12 Oak Ridge National Laboratories (ORNL), www.ornl.gov/sci/btc/search.shtm.
13 Air Barrier Association of America, www.airbarrier.org.

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Roofers "Least Satisfied"; Architects "Very Happy"

In a recent survey authored by Tom W. Smith of General Social Surveys, conducted by the National Opinion Research Center at the University of Chicago, roofers reported the least job satisfaction of 198 occupation classifications, with only 25.3% very satisfied. Second were food waiters and servers, with 27.0% very satisfied.

In the same survey, but rated for "general happiness," which "does not explicitly refer to work and occupations," those ranking highest were professions involving helping others, technical and scientific expertise, or creativity. The occupation with the happiest people was the clergy, with 67.2% very happy. Second were firefighters, with 57.2% very happy. Third came transportation, ticket, and reservation agents such as travel agents, with 56.5% very happy. Fourth were architects, with 53.5% very happy. Industrial engineers were in ninth place with 48.4% very happy. The occupations with the least happy people were mostly unskilled manual and service positions. At the bottom were garage and service station attendants, with 13.2% very happy. Second were roofers, with 14.2% very happy.

To read the survey report, visit **www-news.uchicago.edu/releases/07/pdf/070417.jobs.pdf**.