INSULATION IS NOT ENOUGH

HOW TO IMPROVE THE ENERGY, COMFORT, COST OF OWNERSHIP AND DURABILITY OF BUILDINGS

Is YOUR project full of holes?

Unless the design and construction techniques include a continuous air barrier system, it is.

It's quite literal. The building draws unconditioned air in, then leaks conditioned air back out through holes, cracks, gaps and other leaks of varying size. It's called "uncontrolled" air leakage, and it costs a lot of money. Insulation alone cannot stop it. The United States Department of Energy estimates uncontrolled air leakage can account for 30 percent or more of a building's heating and cooling costs, and contribute to problems with moisture[1].

Most industrial, commercial and institutional buildings in the United States leak air. It is not the HVAC engineer's fault. You can design the most efficient HVAC system imaginable, and the building will still draw in air. However, a simple understanding of the interaction between the HVAC and the building envelope can help you prevent future buildings from drawing air in and leaking air out with the inclusion of a continuous air barrier system. Here's how it works…

Air leakage occurs through cracks, gaps, holes, pores in materials and other openings in the building envelope. Air flow is the result of pressure differences. When air leaks, it takes with it heat, water vapor, smoke, pollutants, dust, odors, allergens, and anything else it can find and carry. Energy moves from regions of high to regions of lesser potential: hot and cold, high pressure to low, and so on.

There are three major sources of pressure that cause air to leak: wind pressure, stack pressure and HVAC fan pressure. Of the three, wind is usually the greatest. When averaged out over the course of a year, it is about 10-15 mph (0.2-0.3psf or 10-14Pa) in most locations in North America[2]. If it hits the building straight on, air enters the envelope on the windward side and exits on the other three sides and at the top, through the roof. If the wind hits at an angle, air exits the building on the two leeward sides and the roof.

Stack effect, also sometimes referred to as chimney effect, is caused by buoyancy or the simple physics lesson that hot air rises. The weight of the column of conditioned air inside the building compared with that outside creates a pressure difference across the building envelope. The taller the building is, the greater the stack pressure will be. Warm, conditioned air escapes through holes at the top of the building and at the roof. The resulting lower pressure at the bottom of the building draws in air from the surrounding environment.

The third pressure comes from the mechanical system itself. Mechanical engineers and on-site managers often choose to bring in makeup air to increase pressure and overcome the infiltration at the base of the building. Unfortunately, this increases pressure at the top, causing more exfiltration problems in that area.

HOW DOES AN AIR BARRIER SYSTEM INCREASE ENERGY EFFICIENCY?

When uncontrolled air leakage occurs, the HVAC system has to work harder to maintain the indoor environment. An effective air barrier system, quite simply, controls air movement into and out of the building. This allows the HVAC system to do its job uncompromised by having to make up for a disproportionately large amount of the air it is conditioning leaving the building.

And of course, increasing the operating efficiency of the HVAC system reduces energy consumption and, therefore, operating costs. In fact, the inclusion of an effective air barrier system may allow the HVAC system to be downsized at the design stage – in some cases by a substantial amount.

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The times – and the Codes – they are a-changin'

Provisional changes to ASHRAE Standard 90.1-2004 will mean big opportunities in the non-residential air barrier market

For the first time, continuous air barrier systems will be required by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) under Addendum z to Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings.

This proposed new standard has been in public review since November 2005 and is expected to be published early in 2006. Although previous ASHRAE standards contained performance requirements for fenestration and door products, this is the first ASHRAE standard to establish performance requirements for air leakage of the opaque building envelope.

Why the change? It's all thanks to a ground-breaking report that confirmed that air barrier systems can reduce air leakage by up to 83 percent and energy consumption by up to 40 percent. The report, Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use, was performed in part to provide input to ASHRAE 90.1 Envelope Subcommittee in its consideration of potential energy savings and cost effectiveness of an air barrier requirement and issued in June 2005 by the National Institute of Standards and Technology (NIST).

Why do HVAC engineers care about air leakage? Because insulation by itself is not enough to make a building truly energy efficient. Without an effective, continuous air barrier system, conditioned air escapes through the building envelope, and the HVAC system has to work harder to keep the indoor environment comfortable. And as the NIST report proved, a hard working HVAC means higher energy bills.

Within a few years, most new construction projects in the United States—with the exception of low-rise residential buildings—will have to have a continuous air barrier to meet Code.

That's where the opportunity comes in. Qualified applicators know that the BASF WALLTITE® insulating air barrier system meets and exceeds all of the requirements outlined in the proposed new ASHRAE standard. It's already approved by the Air Barrier Association of America (ABBA) to meet or exceed the Commercial Energy Codes of Massachusetts, Michigan and Wisconsin. Many additional states are using the current ASHRAE 90.1 standard in lieu of developing their own State Commercial Energy Codes. When ASHRAE 90.1-2004 is adopted, these states can be expected to upgrade their Codes to the new standard, including the air barrier requirement.

The WALLTITE system is a monolithic, self-adhering, air barrier that also offers superior effective insulation R-value. By combining insulation with total air leakage control, the WALLTITE engineered air barrier allows HVAC requirements to be reduced at the design phase of the development. In addition, third-party testing has shown that spray-applied polyurethane foam air barriers actually add structural strength, while offering long-term durability greater than or equal to the building's expected life span.

BASF Polyurethane Foam Enterprises LLC offers applicator training for those interested in taking advantage of this business opportunity.

For more information, visit www.basf.com/ici.

THE NEW ASHRAE STANDARD OUTLINES ITS AIR BARRIER REQUIREMENT AS:

- continuous throughout the envelope (at the lowest floor, exterior walls, and ceiling or roof), with all joints and seams sealed and with sealed connections between all transitions in planes and changes in materials and at all penetrations
- joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components
- capable of withstanding positive and negative combined design wind, fan and stack pressures on the air barrier without damage or displacement, and shall transfer the load to the structure; not to displace adjacent materials under full load
- installed in accordance with the manufacturer's instructions and in such a manner as to achieve the performance requirements
- lighting fixtures with ventilation holes or other similar objects are to be installed in such a way as to penetrate the continuous air barrier, provisions shall be made to maintain the integrity of the continuous air barrier

COMPLIANCE OPTIONS FOR ASHRAE 90.1-2004 INCLUDE:

- using individual materials that have an air permeance not exceeding 0.004 cfm/ft^2 under a pressure differential of 0.3" w.g. (1.57psf) (0.02 L/s.m^2 @ 75 Pa) when tested in accordance with ASTM E 2178; or
- using assemblies of materials and components that have an average air leakage not to exceed 0.04 cfm/ft^2 under a pressure differential of 0.3" w.g. (1.57psf) (0.2 L/s.m^2 @ 75 Pa) when tested in accordance with ASTM E 1677; or
- testing the completed building and demonstrating that the air leakage rate of the building envelope does not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3" w.g. (1.57 psf) (2.0 L/s.m^2 @75 Pa) in accordance with ASTM E 779 or an equivalent approved method

Learn more about air barrier standards at www.airbarrier.org

It takes more than reflectivity to be a cool roof

What image comes to mind when someone says the phrase, "cool roofing?" A white EPDM membrane instead of traditional black? A roll-on coating on an otherwise ordinary roof?

Texas A&M University thinks chemistry. The main campus boasts over 7 million square feet of spray-applied polyurethane foam (SPF) roofing – almost no other system has been installed for more than 30 years. Why? Proven energy efficiency, waste reduction and environmental responsibility, as well as long-term performance.

It all started in 1974. Dissatisfied with the performance of their traditional tar and gravel built-up roofing (BUR) systems, the Physical Plant Department at Texas A&M began looking for alternatives. The BURs were leaking constantly after an average of five years of service, and isolating the sources of the leaks was next to impossible. The University selected SPF because it is seamless, monolithic and fully adhered. And because it is lightweight, a complete tear-off of the existing BUR could be avoided.

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"We sprayed over the failing BUR for a number of years, mainly due to budgetary constraints," says Sam Cohen, Construction Project Manager, Engineering Design Services at Texas A&M. "That's one of the advantages to SPF. And environmentally, it means all that material doesn't end up in the landfill."

In 1985, Gerald Scott P.E., then in charge of roofing and energy conservation within the Physical Plant Department, announced another benefit the university had been receiving from the SPF roofs: energy savings.

Scott monitored energy savings on 27 different buildings on the campus that had received an SPF roof from 1980 to 1984. The results showed the university was able to cover the complete cost of the roof application through energy savings in an average of 4.5 years.

Surprised? You shouldn't be. All spray-applied polyurethane foam roofing systems require a coating to protect the foam from UV degradation and weathering. Many of the coatings used for this purpose are ENERGY STAR®-rated to be reflective and utilize the albedo effect to reduce rooftop temperatures, just like white membranes or roll-on coatings.

But as the Texas A&M story shows, SPF brings more energy efficiency benefits to the table than simple reflectivity. For one thing, it offers an effective insulation R-value of 6 per inch (remember: the thicker the foam application, the higher the R-value). And because SPF is self-adhering and spray applied, it requires no fasteners and eliminates thermal bridging by providing a continuous layer of insulation over existing thermal bridges in the roof deck and assembly.

WASTE REDUCTION AND ENVIRONMENTAL RESPONSIBILITY

According to the National Roofing Contractors Association (NRCA) 1999 survey, more than 68.5 percent of the $11.3 billion low-slope roofing market includes tear-off and replacement of the existing roof. SPF is lightweight and can be applied to a variety of substrates including BUR, modified bitumen, concrete, wood, asphalt shingles, clay tile and metal as a recover system over existing roofs without tear-off in most retrofit cases. As noted by Mr. Cohen, that means significantly reducing the installation cost and diverting thousands of pounds of waste from the landfill on every re-roofing project. It also means the building interior is never exposed to the elements.

The Spray Polyurethane Foam Alliance (SPFA) reports that SPF's on-site manufacture and application generates very little debris and waste. A typical 10,000 ft^2 roofing project produces less than ½ cubic yard of scrap, tape and plastic, and from one pint to three gallons of waste solvent.

SPF is a two-component product that is manufactured on-site, but engineered on the molecular level to optimize performance for a specific application. Some SPF manufacturers are engineering those molecules to optimize lifecycle performance, maintenance cost and ecological footprint (includes energy and raw material consumption, health effect potential, risk potential, emissions, and evaluation of land use and transportation fuel usage[1]). A commitment to R&D for environmental stewardship has resulted in superior formulations. For example, BASF Polyurethane Foam Enterprises LLC has developed zero-ozone-depleting, VOC-free foams incorporating ZONE3® technology.

LONG-TERM PERFORMANCE

The National Roofing Foundation commissioned Structural Research Inc. of Middleton, Wisconsin, to perform independent field and laboratory assessments of SPF roof systems to establish and verify existing performance attributes. The published reports[2] of the findings show that the physical properties of the 140 evaluated roofs (ranging in age from six months to 27 years in four climatic zones) were positive regardless of the age of the installation and that these properties point to the durability of SPF.

SPF offers a lifespan of 20 to 30 years with minimal maintenance. It is also a renewable system. While BUR and single-ply membrane systems must be removed and replaced after their usable service, SPF systems can be scarfed down and recoated.

A primary cause of roof failure during severe weather is flying debris or hail actually puncturing the roof. SPF systems have proven to offer unparalleled resistance to impact. Documentation gathered by Thomas L. Smith of TLSmith Consulting after Hurricane Andrew decimated Dade County, Florida, shows that even if debris punctures the foam straight down to the metal deck, the roof will not leak, and can remain un-repaired indefinitely without developing leak problems. Independent studies from the Performance Based Research Group (www.pbsrg.com) at Arizona State University show SPF systems also perform in severe hail zones.

1 BASF Eco-Efficiency Analysis for ELASTOSPRAY® Spray-Applied Polyurethane Foam Roofing Systems

2 *Field and Laboratory Assessment of SPF Roof Systems*, Dupuis, R.M., Proceedings of the 4th International Symposium on Roofing Technology, 1996

WALLTITE® Insulating Air Barrier

Outperforms on Eco-Efficiency Analysis

The WALLTITE® Insulating Air Barrier System from BASF Polyurethane Foam Enterprises LLC outperforms traditional insulation materials in eco-efficiency, according to a recent study conducted by BASF's lifecycle assessment group. The system—consisting of spray polyurethane foam (SPF) in combination with appropriate primers, transition membranes, other sealants and an optional vapor barrier—delivers a unique combination of properties to a highly functional building envelope.

The BASF Eco-Efficiency Analysis uses an award-winning methodology to measure the lifecycle performance[1], cost, ecological footprint, including energy and raw material consumption, health effect potential, risk potential, emissions, and evaluation of land use and transportation fuel usage for a set customer benefit (CB)[2] for WALLTITE technology compared with extruded polystyrene (XPS), expanded polystyrene (EPS), glass fiber board and mineral fiber board.

In 2005, the BASF Eco-Efficiency Analysis process won three major awards of interest to the building and construction industry: the Design for Sustainability Award (Society of Plastics Engineers), the Presidential Green Chemistry Challenge Award (U.S. Environmental Protection Agency) and the Best Sustainable Practice Award in the Sustainable Research, Development, Construction Process and Demonstration (Sustainable Buildings Industry Council).

The aim of the eco-efficiency analysis is to compare similar products or processes. This involves carrying out an overall study of alternative solutions to include a total cost determination and the calculation of ecological impact over the entire lifecycle. Holding sustainability to be part of its global mission, BASF Corporation is committed to constant improvements in safety, protection of health and environmental conservation.

In addition to its eco-efficiency performance, the WALLTITE Insulating Air Barrier System can help reduce air leakage by up to 80 percent and improve energy efficiency by up to 40 percent for industrial, commercial and institutional buildings[3].

The WALLTITE Insulating Air Barrier System is approved by the Air Barrier Association of

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Is YOUR Project Full of Holes?

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According to the National Institute of Standards and Technology (NIST) report, Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use, the inclusion of an air barrier system in four sampled types and sizes of building can reduce air leakage by up to 83 percent. This represents a large reduction in current and future energy consumption and operating costs: potential gas savings of greater than 40 percent and electrical savings of greater than 25 percent.

The study evaluated the energy savings of an effective air barrier requirement for non-residential buildings in five cities representing different climate zones. The methodology included blended national average heating and cooling energy prices and cost effectiveness calculations matching the scalar ratio employed by ASHRAE SSPC 90.1. Energy simulations were performed using TRNSYS (Klein 2000). Simulations of annual energy use were run using TMY2 files (Marion and Urban 1995).

The research team selected whole building airtightness levels that were judged to be readily achievable and used these as the whole building target used in the energy modeling. The baseline buildings used in the comparison were modeled with leakage levels based on a database of commercial building leakage measurements.

FOR THE FUTURE

Although the idea of mandating air barrier systems for new commercial construction is a relatively new phenomenon in the United States, Canada has included air barriers in its National Building Code for over two decades. In recent years, Massachusetts, Wisconsin and Michigan have begun mandating air barrier systems as part of their Commercial Energy Codes. Although air barrier systems are now required by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE's) Advanced Energy Design Guide: Small Office Buildings, and the New Building Institute's Benchmark™ for Advanced Buildings, for the first time continuous air barrier systems may become a requirement by the ASHRAE under Addendum z to Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential Buildings; at the time of writing, this Addendum was in public review.

1 Air Sealing Fact Sheet, www.eere.energy.gov/buildings/info/homes/sealingair.html
2 Air Barrier Systems in Buildings, Anis, Wagdy AIA, Whole Building Design Guide, www.wbdg.org, a program of the National Institute of Building Sciences (NIBS)

WALLTITE® Insulating Air Barrier

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America (ABAA www.airbarrier.org) and eliminates uncontrolled air leakage by providing seamless, monolithic construction, complete system continuity, superior effective insulation R value and virtual air impermeability. Our closed-cell polyurethane technology is unique in the way that it allows design professionals and building owners to specify a material that is engineered to meet and exceed required performance criteria for every code and climate.

These factors combine to increase building energy efficiency and significantly reduce operating cost, while improving occupant comfort, health and safety. The WALLTITE spray-applied system provides the design flexibility to address high-performance building envelope challenges in all types of buildings, including those with unusual shapes and contours.

1 Lifecycle analysis calculations set up according to rules and principles of the ISO 14040 ff.
2 Customer benefit = insulation of the exterior of 9 m^2 wall surface for a commercial building, with one 0.6 x 1.2 m window, and R-value of 20 ft^2*h*F/ (BTU*in) over a period of 25 years.
3 Investigation of the Impact of Commercial Building Envelope Airtightness on HVAC Energy Use, Emmerich, McDowell and Anis. 2005, National Institute of Standards and Technology (NIST).

Chemistry 101:

are all foams created equal?

You probably don't spend a lot of time thinking about chemistry when you consider adding insulation to improve energy efficiency. Yet one popular insulation material—spray-applied polyurethane foam (SPF)—relies entirely on chemical cleverness.

ARE ALL FOAMS CREATED EQUAL?

Quite simply, the answer is no. Spray-applied polyurethane foam is a two-component product that is manufactured on-site, but engineered in the molecular level to optimize performance for a specific application. By varying key components, the finished product can be modified to meet specific performance requirements for roofing applications, insulating air barrier systems, adhesive applications or wall insulation.

Currently, three types of SPF are commonly used within the construction industry:

- medium-density (MD) 24 kg/m^3 to 48 kg/m^3 (1.5 pcf to 3 pcf)
- low-density (LD) 8 kg/m^3 to 12 kg/m^3 (0.5 to 0.7 pcf)
- sealant foams

The most important distinction is whether the formulation produces an open-cell or closed-cell foam. MD foams are formulated to have a closed-cell content of greater than 90 percent, combined with an effective R-value of over 6.0 per inch. LD, open-cell foams have approximately 60 percent open-cell content and offer an R-value between 3.0 and 3.6 per inch.

But R-values are only the beginning when it comes to energy efficiency. It is the air permeability capabilities that are the true differentiator.

Yes, you need insulation. But in order to make a building truly energy efficient, you need an effective, continuous air barrier system. Without it conditioned air escapes through the building envelope, and the HVAC system has to work harder to keep the indoor environment comfortable.

Most open-cell foams have not been tested and, therefore, do not qualify as air barrier systems in 'typical thickness' of less than four inches. One open-cell foam manufacturer's product requires an application of 5.5 inches (its maximum allowable thickness) to pass the minimum requirements of ASTM International E 2178, Standard Test Method for Air Permeance of Building Materials (air leakage rate of 0.005 $L/s/m^2$ @ 75 Pa). Compare this with closed-cell foams, some of which provide air leakage rates of <0.001 $L/s/m^2$ @ 75 Pa at 1.5-inch thickness.

Open-cell foams offer a slight cost advantage when compared on an equal-thickness basis, and in general they provide greater sound control. On the other hand, closed-cell formulations can actually improve building durability and structural strength. Testing conducted by the National Association of Home Builders (NAHB) Research Center shows closed-cell SPF insulation between wood- and steel-stud wall panels increased rack and shear two to three times over standard stick-built components and glass fiber insulation when sprayed onto gypsum wallboard and vinyl siding, and increased racking strength by 50 percent when sprayed onto oriented strandboard (OSB)[1].

1 Canadian Construction Materials Centre (CCMC), Evaluation Report 12932-R, National Research Council (NRC) of Canada.

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