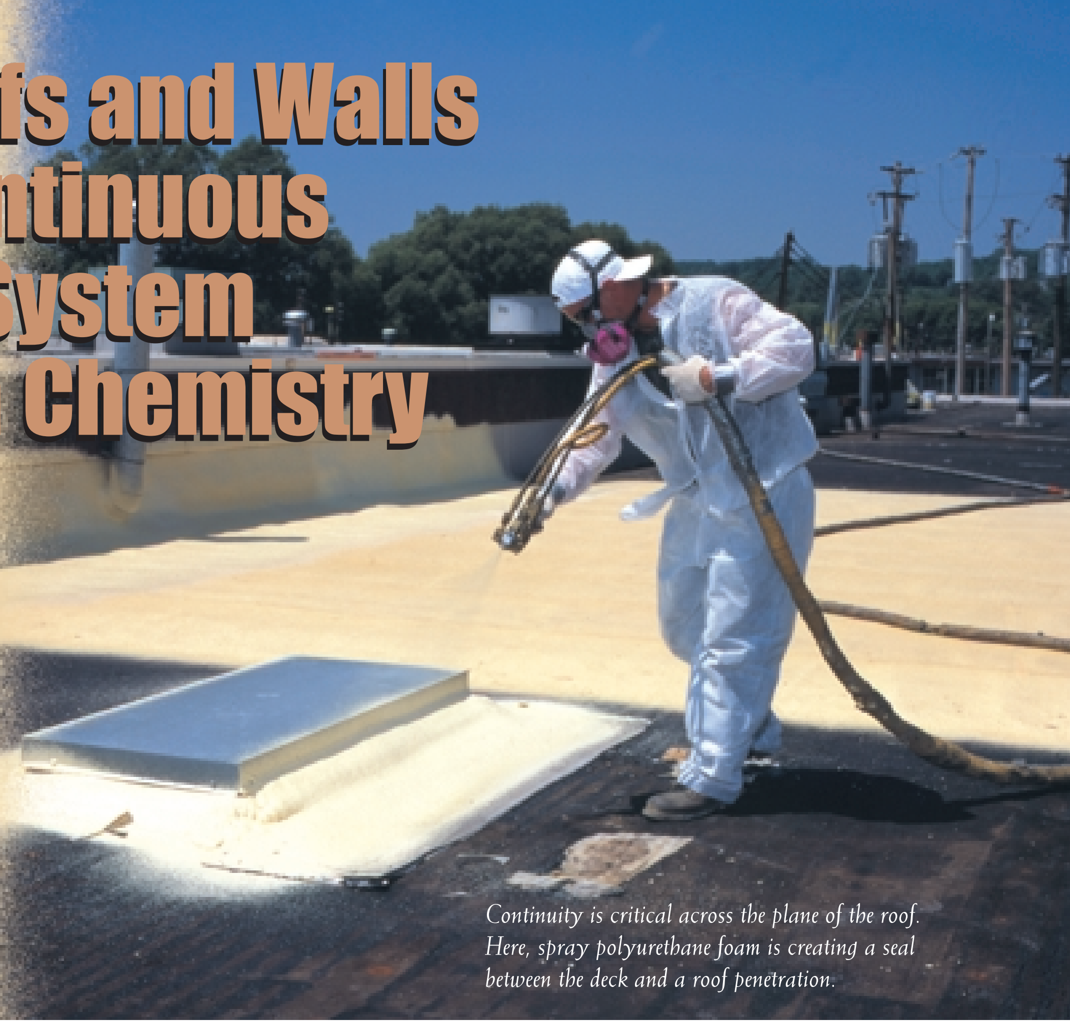
Making Roofs and Walls Join in a Continuous Air Barrier System Depends on Chemistry

By Tom Harris
and Tony Woods

In this article, the authors describe why Codes are starting to mandate a continuous air barrier system, how polyurethane chemistry creates a material that delivers the required properties, and why a roof must be a component of the system.



Continuity is critical across the plane of the roof. Here, spray polyurethane foam is creating a seal between the deck and a roof penetration.

Air barriers were a curious Canadian obsession just a few years ago but are now mandated in at least one state energy code and are predicted to spread quickly. The primary reason is energy efficiency, but the goal of durable buildings with healthier indoor environments is driving more and more professionals to consider the "total building envelope." The continuous air barrier system (CABS) is a key element of this new approach.

Why a Continuous Air Barrier System?

The total building envelope is a system of construction components that controls the movement of air, moisture, and thermal energy in and out of the building. Simply put, air barrier, vapor barrier, and insulation work together to create a more comfortable and healthier indoor environment and to protect the building from premature deterioration.

Architects in the Northeast are in the vanguard of change. The Boston Society of Architects has formed a Building Envelope Committee, chaired by Wagdy Anis, Director of Technical Resources at Shepley Bulfinch Richardson and Abbott, a leading New England firm. This is one of several related developments, including the formation of the American Air Barrier Association (AABA), also headquartered in Boston.

In a recent issue of *ASHRAE Journal*, Mr. Anis described how air pressure acting on the building envelope, if not properly understood and adequately designed for, can wreak havoc on building performance.

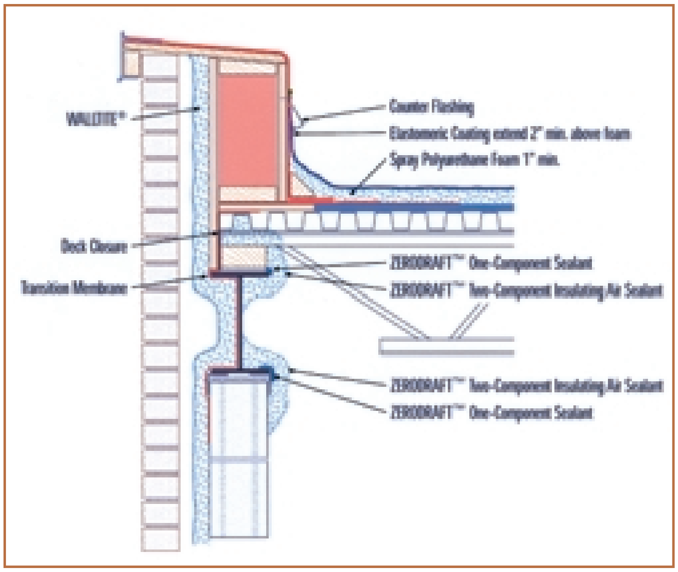
He wrote that uncontrolled air pressure across the envelope and within the building itself can cause infiltration and exfiltration that overpower HVAC systems. By disrupting mechanical design, uncontrolled air movement can result in occupant discomfort and create serious indoor air quality problems. An architect designing the building envelope may not consider the interaction between the envelope and the mechanical system. Various contracting trades then build the envelope to what they think is required by the design, without particular concern for airtightness.

There are three primary sources of air pressure differential on a building envelope: wind, mechanical systems themselves, and the very important stack effect. Stack or chimney effect is the tendency of warmer air to rise through buildings and escape through available openings at the top. Air finds any way it can to travel through the building. Vertical pathways in high-rise buildings include elevator shafts, garbage chutes, stairwells, and a variety of electrical, plumbing, and communications penetrations between floors. Just as important are the openings at the bottom of the building that make the airflow possible. In a high-rise structure these could be ground level entrance doors, or even the ramp to the underground parking.

Levels of airtightness have not been mandated by the building codes. An increased level of understanding will result in the inclusion of minimum building tightness in future codes.

What Makes an Air Barrier System Effective?

First, an air barrier system (assembly) is not to be confused with air barrier materials (components). An air barrier system may consist of many different components linked together for continuity.



Typical Roof/Wall Intersection Continuity Detail.

An air barrier system must control air infiltration and exfiltration through the building envelope. To do this it must:

- Be virtually impermeable to air.
- Achieve airtight continuity across all joints, construction material changes, seams, and laps.
- Provide flexibility to allow for creep and relative movement of materials caused by thermal expansion and contraction, moisture absorption, and retention.

An air barrier material (component) must:

- Be virtually impermeable to air.
- Withstand wind, mechanical, and stack pressures without damage or displacement.
- Be able to transfer these loads to the structure.
- Not displace adjacent materials under full load.
- Be durable.
- Be serviceable.

Polyurethane Chemistry Delivers the "Insulating Air Barrier"

Which material, then, can satisfy all these requirements? Spray and injected rigid polyurethane foams are airtight, structurally sound, durable, and repairable. Cellular chemistry provides virtual air impermeability and a relatively high degree of thermal insulation.

Rigid urethane foams are available in two- and one-component formulations. Both contain two main ingredients: polyisocyanate and polyglycol. Two-component foams are chemically cured and may be used in both spray and injection applications. One-component foams are air cured and can only be used for smaller cracks and voids.

Sprayed polyurethane foam (SPF) is already well known in the roofing industry. It is also becoming equally well known as an insulating air barrier component in cavity wall construction.

In a recent article in *Construction Specifier*, Leonard Anastasi, CSI, referred to the growing role of SPF: "SPF products have piqued the curiosity of many experts and designers as an air barrier material due to their ability to serve as both an air and vapor barrier, a drainage surface, and an insulation layer. They are also seamless and can be applied over exceptionally large areas in a single workday. Among the leaders in the manufacture and technology of these products is BASF."

In industrial, commercial, and institutional buildings, polyurethane foam is frequently being sprayed onto roofs and walls and injected into roof/wall intersections and every crack, gap, void, and hole where the various components in the air barrier system can't achieve continuity.

Where the steel deck runs perpendicular to the wall, two-component polyurethane foam is injected into the gaps between the steel deck flutes and into specially drilled holes in the deck itself in order to ensure continuity of the air barrier system.

In residential buildings, it is being sprayed between studs, onto walls of basements, crawl spaces, and on the floors of attics. It is injected into the gap between window openings and frames and at every service penetration to create a continuously sealed and insulated building envelope.

In all types of buildings, polyurethane foam plays the role of maintaining continuity of the air barrier plane across the roof and walls and through the transition between these major components of the building envelope.

SPF suppliers stress the importance of using certified applicators to install this "sprayed-in-place" material, reference the Canadian application standard CAN/ULC S107.2. RCI members are encouraged to investigate various air barrier systems and components as they seek to incorporate the most cost-effective, continuous air barrier system.

Continuity Alternatives

Accepting that a continuous air barrier system is desirable even when not mandated by the building Codes, are there other design and construction alternatives to polyurethane foams that can deliver the required performance?

There are many conventional techniques that strive to achieve continuity. Most of these involve overlapping, fastening, gluing, and/or nailing. This is often followed by a further sealing or caulking process to stop air leakage through the holes caused by fastening, stapling, or nailing. The advantage of foam is that it simultaneously performs as an all-in-one structurally integral air barrier and sealant.

How Does This Affect Roofing Consultants?

As experienced professionals in the continuous air barrier system discipline often say, "It's time the roofer and the mason started talking to each other."

At roof level changes, and at roof/wall joints, the air barrier system can fail to achieve continuity. Every penetration through the roof itself creates discontinuity, whether HVAC systems, mechanical penthouses, electrical services, or antennae. All of these gaps in the air barrier system can be successfully bridged with polyurethane foam. Spray applied polyurethane has been evaluated by the Canadian Construction Materials Centre (CCMC) for use in this application.

A common problem for air barrier continuity is a typical low-rise industrial roof/wall joint where a steel deck sits on a masonry wall. Different methods of foam application are used, depending on whether the deck flutes run perpendicular or parallel to the wall.

The Future

The incorporation of air barrier materials into a continuous air barrier system will help make buildings more energy-efficient and durable, and provide a healthier, safer, and more comfortable indoor environment. ■

Typical Properties of Polyurethane Foam Used as an Insulating Air Barrier System Component

Density			
(ASTM D-1622): core			
lb/ft³ (kgm³)		1.90	(30.4)
Thermal Resistance			
(ASTM C-518)			
After 2 days at 73°F			
	[ft²●hr●˚F/Btu]/in	8.29	
	[m²●˚C/W]/25mm	1.46	
After 90 days at 73°F, 50% RH			
	[ft²●hr●˚F/Btu]/in	6.47	
	[m²●˚C/W]/25mm	1.14	
Thermal Conductivity			
(ASTM C-518):			
After 2 days at 73°F			
	Btu●in/ft²●hr●˚F	0.118	
	W/m●˚C	0.017	
After 90 days at 73°F, 50% RH			
	Btu●in/ft²●hr●˚F	0.159	
	W/m●˚C	0.023	
Water Vapor Permeance			
(ASTM E-96):			
	U.S. Perms	2.18	
	ng/Pa●s●m²	125	

About the Authors

Tom Harris

Currently the Product Manager for BASF's Spray Foam Group in the US, **Tom Harris** is originally from Canada and is a chemical engineering graduate of Ryerson Polytechnical University currently completing his MBA. Over his 20-year career within the polyurethane systems business, he has chaired eight Technical Committees within the SPI, Canadian General Standards Board, National Research Council of Canada, and the Canadian Urethane Foam Contractors Association. Tom is currently contributing to two ASTM committees, an NRCA committee, and the SPFA's Building Envelope Committee. Tom also represents BASF as a founding member of the Air Barrier Association of America.

Anthony A. "Tony" Woods is President of CanAm Building Envelope Specialists Inc. , a company he co-founded in 1980. He is a physicist, having graduated from the University of Hull, England, in 1959. Woods is a member of nine Standards committees covering airtightness, testing, ventilation, combustion safety, window installation, and sealants. He has participated in many utility development and demonstration programs, including several air leakage control projects, U.F.F.I. remedial measure development, national moisture studies, the Ontario Hydro 1000 House Audit Program, House as a System, and Retail Training Programs. He has been a regular presenter at Affordable Comfort and E.E.B.A. conferences in the U.S. and is continually involved in training of weatherization organizations across North America. Woods is a past president of the Ontario Building Envelope Council, and Executive Vice-President of the National Energy Conservation Association and the Contractors Warranty Corporation. He is a member of H.R.A.I. Toronto Chapter, the Construction Specification Writers Association, and the Ontario Association of Home Inspectors. Tony was a member of the Advisory Committee for the Condominium Guide developed by the Ontario New Home Warranty Corporation and has just completed the development of a *Practical Guide for Designers and Contractors for Air Leakage Control Measures in High Rise Commercial Buildings* on behalf of Public Works Canada.

Tony Woods