**by Mason Knowles**
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# Save energy and $ with SPF

## SPF (Sprayed polyurethane foam's) advantages—over and above high aged R-values—mean cost savings for owners

Sprayed polyurethane foam (SPF) has been used in the building envelope for many years—and with good reason. SPF has proven aged R-values that are quite high compared to other types of insulations. However, contractors and owners have observed that SPF insulated or roofed buildings consume far less energy than calculated projections based solely on R-values.

This report explains how and why this happens by examining recent research, articles and studies obtained from several sources.

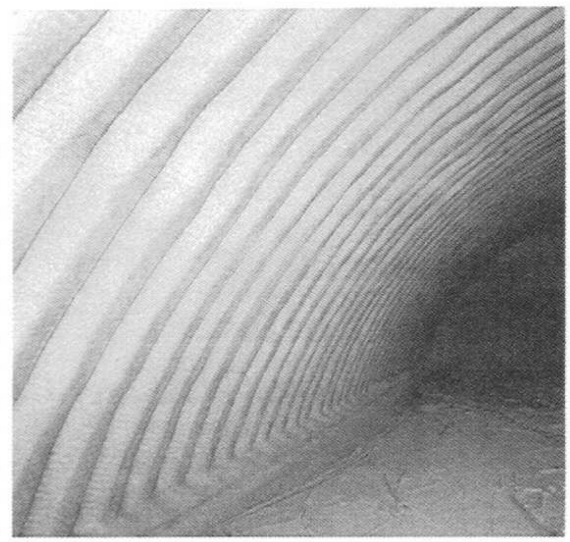
A recent series of articles published in the National Research Council of Canada's magazine, Construction Practice, by M.T. Bomberg, M.K. Kumaran and W.C. Brown, observed that "environmental control within a building envelope depends on strong interactions between heat, air and moisture transport . . . To ensure that all aspects of the building envelope perform effectively, we must deal with heat, air and moisture transport collectively." [1]

The articles state that in order to control these factors, there must be effective air barriers, rain screens, weather barriers, and thermal insulation of a continuous nature so that gaps do not compromise the climate control design. [2]

SPF can be applied within a building envelope to control heat, air and moisture transport by providing continuous and effective air barriers, rain screens, weather barriers, and thermal insulation. (The SPF discussed in this article is a closed cell foam with densities ranging from 1.5 to 3 lbs/ft$^3$. Performance characteristics of lower density, open cell SPF systems are not addressed in this report.)

### *SPF: An air/ weather barrier*

Bomberg and Brown state that SPF is an effective air barrier and weather barrier because of "its ability to seamlessly fill irregular spaces and provide water resistance."[3] Independent tests by Metrotec Inc. of a house in Quebec, Canada insulated with SPF showed that the application of SPF within a two-inch by four-inch stud-framed construction provides a continuous air barrier for houses. Furthermore, the tested building envelope was 4.4 times tighter than the requirements proposed by the Canadian Building Energy Code of 1995. In fact, the house was rated as the best sealed house tested in Quebec to date. [4]



**Sprayed polyurethane foam provides a continuous air seal, weather barrier and insulation in this metal project. The next step would be the application of a 15-minute thermal barrier.**

Air seal problems can occur when wet lumber is used for framing purposes. If the wet studs dry out with non-uniform shrinkage, gaps can occur in the air seal. In their report, "Air Tightness of Two Walls Sprayed with Polyurethane Foam Insulation," published in the April 1992 issue of The Journal of Thermal Insulation, Researchers D.M. Onysko and S.K. Jones showed that only a small change in airtightness occurred in walls insulated with SPF when wet frame studs dried out.[5] Other insulations had much higher losses of air seal under the same conditions. (Note: Caution should be used when applying SPF to wet stud walls because SPF covered-walls inhibit the drying process. Wood decay can occur when foam insulation is applied to the cold side of wet wood.)

SPF is an excellent weather barrier, as evidenced by its ability to resist water in SPF roofing systems. While coating and coverings are used in these applications to protect the SPF against the sun, they are not needed to prevent water from saturating the SPF and leaking into the building. SPF also limits water movement within the building envelope since the water cannot flow within the SPF's closed cells, even if a hole is made in the SPF.

### *SPF and thermal bridging*

Thermal bridging is another notorious energy thief. When insulation is not continuous, and the building components are very conductive, substantial reductions in performance R-values are observed. The March/April 1995 issue of Drexel Insulation Report presented a table that showed heat transfer through metal studs can lower the effective R-value of some insulation from an R-25 to an R-9.6.

The report further states that "a far better way of increasing the R-value of

## Advantages of SPF

SPF reduces energy use in buildings beyond its stated R value because SPF:

- provides a continuous air barrier.
- prevents moisture infiltration through air leakage.
- minimizes dew point problems and condensation.
- avoids thermal bridging.
- resists heat movement in all directions.
- provides reliable performance under varying conditions.

steel stud walls is to add rigid foam insulation that covers the stud, either on the outside or on the inside, to effect a thermal break." [6]

A related study sponsored by the American Iron and Steel Institute and conducted by researchers at the National Association of Home Builders (NAHB) Research Center, Oak Ridge National Laboratory, and Holometrix Laboratory concluded that sheets of insulation added to the exterior of the wall increase the R-value of the insulation by more than the R-value of the added layer. "This occurs because the added insulation makes the heat flow through the wall assume a more nearly parallel path through the wall reducing the fraction of heat that is lost through the metal studs," the report states. [7]

The tests show that foam sheathing helps to reduce the thermal bridge effect within the framed portion of the wall. Though sprayed polyurethane foam was not tested in either of these studies, it can be reasonably assumed, considering the seamless, monolithic properties of SPF, that it would perform particularly well to reduce thermal bridging in stud wall insulation, if applied in a continuous manner to the exterior or interior of the building. Plus it will also serve as an air and weather barrier.

Patrick Downey's article, "Energy Efficient Roof Design" published in The Roof Consultants Institute's May 1995 Interface magazine, addressed the problems of controlling a desired interior temperature by considering factors that influence the ability of a roof to help control thermal transfer within and outside the building envelope.

Downey considered thermal bridging, color and surface profile causing high or low albedo effects, radiation, convection, conduction, thermal shock, thermal gain and thermal loss when evaluating energy-efficient roof systems.

To gain the maximum energy efficiency of a roof system, he provided the following observations/recommendations:

1. Insulation is more effective above the roof deck.
2. Thermal bridging problems occur when insulation is not continuous. Layers with staggered joints should be used to eliminate thermal shorts.
3. Moisture condensation can occur between joints of insulation. Double layers should be used to minimize this possibility.
4. Increased insulation R-value is favored where energy costs are primarily for heating.
5. Dark-colored roofs can have surface temperatures 90 F higher than ambient temperature. High albedo (heat reflective) surfaces are favored where energy costs are primarily for cooling.

Although Downey never mentions SPF roofing systems in his report, his observations and recommendations highly favor the application of SPF roofing systems for the following reasons:

1. SPF roofing systems are applied above the roof deck. In fact, the roofing system and insulation system are one and the same.
2. SPF eliminates thermal bridging problems since it is continuous, seamless, and monolithic with no gaps or thermal bridges.
3. SPF is water resistant, and has no seams that water can travel through. SPF's high perm rating allows moisture vapor to travel within the building envelope. As long as the dew point is not reached within the building materials, condensation will not occur. SPF's high R-value, air seal and weather barrier help to keep building envelope temperatures within the desired range to prevent condensation.
4. SPF has an aged, R-value averaging a very high 6.2. [9]
5. SPF on roofs are protected from UV with a covering system. Installing a protective covering to achieve a de-

sired reflectivity does not add to the SPF roof system's cost.

Materials specified for building envelopes must perform well in the environment where they will be used. Some insulation material's performance varies with temperature and humidity level. Also, for some materials, small-scale tests results do not correlate with full scale testing.

One recent report from Oak Ridge National Laboratory noted that the thermal resistance of one type of insulation product was as much as 30 percent lower in full-scale tests, than in corresponding small scale tests. [10]

Mark Bomberg and Robert Alumbaugh's research paper "Evaluation of Thermal Performance of the Building Envelope," presented at Spray Foam '93, showed that SPF has a consistent R-value in varying temperatures and humidities. Additionally, small-scale testing reliably predicted thermal performance of SPF in full-scale tests.

Bomberg and Alumbaugh concluded that SPF's long-term thermal performance (from five to 100 years) can be accurately predicted in three to six months of testing,11 and that, "The difference between the thermal conductivity coefficient predicted from (the) aging curve, . . . and that calculated from wall R-value measurements is less than 3.5 percent difference . . ." [6]

Bomberg and Alumbaugh address the thermal, air barrier and weather barrier performance of walls and roofs containing SPF. The paper describes their methodology and test procedures to predict the initial thermal performance, calculate the initial and long-term thermal performance, determine the air barrier performance and study the moisture absorption of SPF in a variety of designs and environments.[6]

Bomberg and Alumbaugh's research is significant because it shows how thermal performance of an insulation system can be calculated considering factors other than the R-values of the respective building envelope components. **RSI**

## References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