Development of a Sustainable Roofing System - Spray Polyurethane Foam

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According to SPI statistics, the roofing industry used 61 million pounds of spray polyurethane foam (SPF) in 1995 and 35 million pounds in 1990. This represents a 70% increase in just five years. SPFD predicts SPF roofing applications will experience similar growth through the year 2000. Why is there such a dramatic increase in the popularity of a roofing system that has been around since the 1960s?

Sustainability may be the answer.

Dr. Rene Dupuis, Ph.D., PE. of Structural Research Center, Inc., at the National Roofing Contractors Association's 1996 convention said based on his initial findings of a jointly sponsored study of SPF roofing systems, "SPF may be one of the most sustainable roofing system to date".

Oak Ridge National Laboratories (ORNL) defines sustainable low-slope roofing as "a roofing system that addresses the issues of energy efficiency, use of materials with a lower environmental impact and embodied energy, durability with less maintenance, and reduced waste generation throughout the life cycle from design, through construction and reroofing, to reuse and final disposal".

This presentation will address each of these features as it relates to SPF roofing systems.

Knowles: I recently learned the term sustainability. However, I discovered the sustainability characteristics of SPF in 1980 when I owned an SPF contracting business on South Padre Island, Texas. Hurricane Allen, packing sustained winds over 125 miles per hour, swept into town. The eye of the storm passed over my shop. At the time of the storm, more than 100 SPF roofs and many SPF insulated cold storage facilities were within a 10 mile radius of the eye of the storm. Afterwards, only two of the SPF roofs leaked, while 3/4 of other roofing systems were blown off. Some businesses in nearby towns were without electricity for three to five days. During this time, SPF insulated freezers at a nearby meat packing plant gained only 10° F of temperature while the electricity was off, which kept the meat stored in accordance with USDA required temperatures. Meat stored in other freezers at the same location had to be thrown out because it exceeded the USDA required storage temperatures.

ENERGY EFFICIENCY

According to a report by Texas A&M University which has over 8 million square feet of new and recover SPF roofing, energy savings pay for their initial SPF roof installation costs in a little over three and one-half years.

How does SPF save energy?

According to Patrick Downey, "during the summer. black-surfaced roofs have measured [peak] temperatures of 190°F. It the interior temperature is maintained at 78°F, the resultant temperature difference is 112°F".

It's not unusual for a BUR roofs surface to reach 150°F to 180°F on hat summer days. Heat can be transferred into the building through thermal shorts. Thermal shorts are the non-insulated areas of a building system that can transfer hear more readily than the insulated areas. Thermal shorts are caused by fasteners, gaps between insulation boards and conductive materials that penetrate the roof assembly.

In the case of roofs, fasteners are one of the greatest source of thermal shorts. As shown, a 40,000 square foot roof covered with a sheet membrane requires more than 10,000 fasteners to achieve an I 60 FM wind uplift rating.

According to Mike Watts, CSI, CDT, of Styro Systems Carolinas, Inc., thermal shorts caused by fasteners can reduce roof insulation values 11.5% to 31.48% depending on the number of fasteners and the thickness of insulation. (Thermal conduction calculations are based on "isothermal planes", series-parallel path analysis, ASHRAE, 1985 Fundamentals Handbook, Chapter 23)

The same thing happens in reverse during the cold months. The same gaps and fasteners cause heat from within the building envelope to escape more easily. SPF helps stop this heat transport from within the building envelope.
SPF roofing systems have no seams, gaps or fasteners, and therefore have no thermal shorts. It has a high R-value of 5.6 to 6.2, which remains consistent at various temperatures. SPF insulates from the outside, which makes it even more effective in saving energy.

ENVIRONMENTAL IMPACT

The total Equivalent Warming Impact or TEWI of a greenhouse gas is the total effect of the combination of direct emissions and indirect emissions on global warming. Direct emissions come from the release of a greenhouse gas. Indirect emissions come from the energy consumption caused by a building product's use and manufacture.

From 1980 to 1990, carbon dioxide contributed 55% of greenhouse gases that affect future global warming. CFCs contributed 17%.

Replacing CFCs with HCFCs reduced the greenhouse contribution of fluorocarbon gases by up to 92%.

The longer it takes for a gas to be purged from the atmosphere, the worse its global warming potential. According to the Alternative Fluorocarbons Environmental Acceptability Study (AFEAS) it takes more than 500 years for carbon dioxide to be purged from the atmosphere, while most HCFC emissions are out of the atmosphere in twenty years. Burning fossil fuels to produce energy (electricity, fuel oil, natural gas, etc.) forms carbon dioxide. By saving energy, SPF roofing systems reduce the amount of fossil fuel consumed and reduce the amount of carbon dioxide (indirect emissions) produced.

Excluding performance issues, polyurethane foam takes less energy to produce than fiberglass insulation.

According to a Franklin and Associates 1991 study, polyurethane foam insulation saved 34.4 trillion BTUs in manufacturing energy over fiberglass insulation in 1990. (0ne trillion BTUs=almost 170,000 barrels of oil.) The energy savings are higher today since more polyurethane foam is used now than in 1990.

DURABILITY

The life expectancy of SPF roofing systems is not known at this time, performance studies indicate that SPF roofing systems, properly applied, can last beyond 30 years. Since the physical properties of SPF change little with age, how long the SPF roof system lasts depends primarily on the original application and long term maintenance. SPF roofing systems, like other roofing systems, should be inspected semi-annually and after events that could cause damage, such as hurricanes or hail storms.

Dr. Dean Kashiwagi, Associate Professor of Del E. Webb School of Construction at Arizona State University, has surveyed SPF and other roofing systems since 1983. Of the more than 1,600 SPF roofs he has monitored, a very high percentage of the roofs don't leak, have a high customer satisfaction rating and are NOT maintained.

SPF roofing systems typically require low maintenance. For example, Texas A&M reduced their 35 person roof maintenance crew to three people after installing SPF roofs on their campus buildings. Most repairs can be accomplished during a semi-annual inspection. Small damaged areas (less than 3 inch diameter) dents, cracks, or punctures can be repaired with an elastomeric caulking compatible with the system. Since SPF adheres to itself, more extensive damage can be repaired by removing the damage and reapplying more SPF.

According to the Building Thermal Envelope Systems and Materials Update, April, 1996, "over 13 billion dollars is spent annually for the replacement of existing roofs. The majority of these replacements are due to premature failure and high wind events...".

As mentioned previously, hail, wind driven debris and mechanical damage can cause superficial damage to SPF roofing systems. However, the damage typically does not cause leaks due to the closed cell properties of SPF. Furthermore, the damage may be repaired some time later without compromising the long term performance of the roofing system. (Dupuis, NRF Study)

According to Underwriters Laboratory tests, SPF roofing systems not only resisted high wind blow-off beyond the capabilities of the test equipment, they actually enhanced the wind uplift resistance of metal and BUR roofing systems. (UL Wind Up-lift Tests)

SPF can add structural strength to certain types of building construction. The structural properties of polyurethane foam used in building panels, boats, dome buildings, movie sets, theme parks, metal doors, etc. is well documented. Specific tests documenting SPFs structural strength in roofing applications do not exist, to date. However, case studies demonstrate this point. Before Hurricane Allen blew into South Padre Island, Texas. In 1980, my company installed a portion of a SPF application to the office section of a lumber yard's post frame construction building. The crew completed one corrugated wall and roof section before the storm hit. We discovered upon our return, that the storm carried away all of the metal except where we applied SPF.

Moisture and water cause most of the deterioration in a building. To address this issue, ORNL is developing a guide to assist roofing professionals in designing "moisture-tolerant roofing systems." According to ORNL, there are three prescriptive requirements:

a. The roofing system does not gain moisture on a yearly basis.
b. The insulation layer does not saturate.
c. After a leak occurs, the insulation directly above the deck does not saturate to prohibit, dripping.

SPF standard roofing practices reflect conventional roofing practices. Industry guidelines recommend tear-off of water-saturated roof assembly areas. However, recognizing that SPF roofing exhibits the

requirements of a moisture tolerant roof, researchers at ORNL used SPF in a test to determine if wet insulation can dry without tearoff of the existing roof covering. They found that the application of a SPF roofing system over an existing roof assembly containing wet insulation can dry successfully without a roof tear-off by using downward drying techniques. SPF's closed cell property prevents water from moving within the roofing system when damage has occurred. After a leak, the SPF does not become saturated. SPF can be designed with a "breathable" or a "Vapor retarder" covering depending on the performance criteria to help minimize vapor drive and/or condensation problems.

WASTE STREAM

According to Dr. Kashiwagi's research, more than 70% of SPF roofing is applied over existing roof coverings. By not having to remove the existing roof system. SPF saves an enormous amount of construction debris from being sent to landfills.

The actual application of a SPF roof system does not create much waste either. A typical 10,000 square foot SPF roof will produce approximately half of a pick-up truck load of debris, consisting of plastic, tape, scrap foam and from one pint to two gallons of solvent (depending on the type of covering used). Reasonably priced portable equipment can reclaim the solvent for further use.

RENEWABLE

SPF roofs typically do not require tear-off, but are recoated and/or renewed. Although most SPF roofing industry warranties range from 5 to 10 years, research shows that coated portions of SPF roofs are typically recoated every 8 to 15 years depending on a variety of factors, including thickness of coating, environment, physical properties, weathering, and warranty requirements, SPF's renewability characteristic further reduces waste stream material.

One more important fact to consider is that SPF roofs require a trained crew with the experience and knowledge to apply this system. SPFD developed a hands-on, in-the filed, applicator training program to prepare for the anticipated growth of the SPF roofing industry, a growth encouraged by the trend towards sustainable roofing systems and the recognition by specifiers of SPF's excellent field performance.

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