Highlights of NRF's SPF roof system study released

Roofing professional provides insight into SPF research project

by **Rene M. Dupuis**

In 1995, the National Roofing Foundation (NRF) undertook a large field research program to assess the impact of changes in sprayed polyurethane foam (SPF) roof system technology in the United States. The study was initiated after a number of material and system suppliers and roofing contractors determined an independent field evaluation was needed.

NRF contracted with Structural Research Inc., Middleton, Wis., to conduct the research effort, which was performed in cooperation with NRCA and the Spray Polyurethane Foam Division of The Society of the Plastics Industry. Field work began in late 1995 and was completed early this year.

As previously reported in the March 1996 issue of *Professional Roofing*, the research was geared toward the performance of aged SPF roof systems in a variety of U.S. climates. The effects of surface texture, ponded water, uncured coatings, mechanical damage, foam blisters and coating blisters were examined. Each roof system was core-sampled; additionally, slit samples were taken for measuring coating thicknesses.

To the extent possible, equal numbers of coating types from the East, Midwest, West and Gulf Coast states were inspected. Acrylic, polyurethane and silicone coatings, as well as aggregate-surfaced SPF roof systems, were evaluated.

This article presents highlights of the NRF study.

Photo 1: *A view of a slit sample through an area that was struck by hail; the coating had ruptured. An electrical capacitance meter detected moisture in this area, but it was not visible and did not extend far from the impact area. The hail damage probably occurred a year or more before the photo was taken in 1996. SPF was applied over an aggregate-surfaced BUR in 1989.*

Field protocol

Roofing contractors and manufacturers were asked to submit for review a list of aged SPF roof systems. The author then randomly selected SPF roof systems. In total, 140 SPF systems were evaluated, varying from three months to 27 years old. More than 5 million square feet (450000 m^2) of SPF roof systems were surveyed, ranging from 8 to 2,200 squares (75 to 20500 m^2).

All common types of building structures were surveyed, with heights ranging from single story to a 19-story high-rise. Most of the SPF roof systems were applied over existing roof systems, such as built-up roofing (BUR), metal panels, modified bitumen and single-ply systems. Several different deck types were

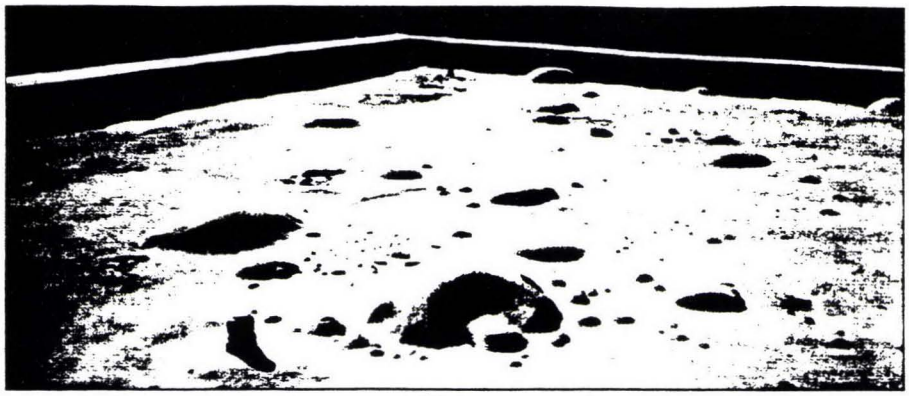

Photo 2: *This roof system has several blisters, some of which are relatively large. Most of them have not ruptured. Although this is not an attractive roof system, it still is functional. SPF was applied over an aggregate-surfaced BUR.*

encountered, including steel, structural and lightweight insulating concrete, gypsum, wood plank and plywood.

The number of roof systems surveyed in each region is as follows: East (Connecticut, New Jersey and New York)—32; West (California)—24; Midwest (Illinois and Wisconsin)—47; and Gulf Coast (Texas)—37.

The types of SPF roof surfacings encountered were: 37 acrylic-coated, 41 polyurethane-coated and 42 silicone-coated. In addition, 19 aggregate-surfaced SPF roof systems were audited, as well as one uncoated SPF roof system that had been installed in 1983 (i.e., the foam was left exposed).

Table 1 lists the oldest audited SPF roof system by surfacing type and indicates whether the system has been recoated.

The oldest acrylic-coated SPF roof system was on an office in California; it was a 43-square (400-m²) roof system that had poor drainage. The oldest polyurethane-coated SPF roof system was in Texas on a 19-story office tower. This roof system experienced high winds and suffered damage from baseball-sized hail, which led to recoating in 1995.

The oldest SPF roof system found was on a factory in upstate New York—it had been coated with silicone in 1969 and, at the time of auditing, had not been recoated. This roof had 5 mils (0.13 mm) of silicone coating left at the time of the study. The oldest aggregate-surfaced SPF roof system was located on a New Jersey manufacturing plant.

The one uncoated foam job was a 100-square (930-m²) roof system on a plant in New Jersey. Since its installation in 1983, on average, it has been losing 60 to 70 mils (1.5 to 1.8 mm) of thickness per year because of weathering and ultraviolet degradation. Although uncoated foam is not recommended for a variety of reasons (e.g., lack of fire rating and ultraviolet and mechanical protection), this SPF roof system exhibited remarkably good performance.

Spec requirements

During 1975-85, specifications typically required 15 to 20 mils (0.4 to 0.5 mm) depending on coating typ Today the coatings are thicker—25 to 35 mils (0.6 to 0.9 mm).

Granule surfacings now often are included at the rate of 40 pounds per square (2 kg/m²). They vastly diminish bird damage problems and improve a roof system's appearance (see Photo 3). Aggregate-surfaced SPF roof systems use 400 to 500 pounds per square (20 to 24 kg/m²) of aggregate laid over uncoated foam.

A relatively new, high-end specification for coated SPF roof systems has been developed that includes 100 pounds per square (5 kg/m²) of chipped aggregate to be broadcast into a 40-mil (1-mm) polyurethane coating. The aggregate was a minimal ⅜-inch (9.5-mm) chipped stone. This type of finish has a tough surface that appears similar to an aggregate-surfaced BUR.

An SPF roof system's surface texture is important; this study found that newer SPF roof systems typically are much smoother, especially when using the hydrochlorofluorocarbon blowing agent, which was introduc in 1992.

Problems encountered

Hail damage was seen on some roof systems, especially in Texas. Signs of water penetration generally were found to be ⅛ to ¼ of an inch (3 to 6 mm) below the hail impact site (see Photo 1). However, moisture

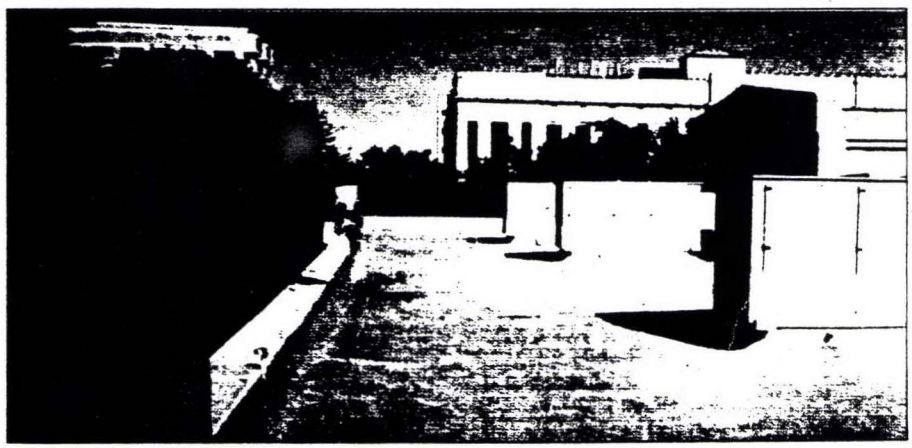

Photo 3: *This SPF roof system is surfaced with light-brown granules, which present a relatively attractive appearance. SPF was applied over a smooth-surfaced BUR i 1978; in 1995, the SPF was scarfed and recoated. This photo was taken in 1996.*

typically was not detected when checked with an electrical capacitance meter. With respect to mechanical damage, the unique aspect of SPF roof systems is that they are not in imminent danger of leaking, provided the penetration does not extend all the way through the foam.

Foam blisters were observed on a number of SPF roof systems (see Photo 2). Similar to small blisters found on BURs, they typically are left alone. If they are cracked or ruptured, they eventually should be repaired.

However, as with mechanical damage, upon rupturing, a roof system typically is not vulnerable to leakage for a substantial length of time. Blisters typically occur between lifts (applications) of foam; therefore, if the blister ruptures, leakage protection is provided by the lower lift(s) of foam. Blisters also may occur between the coating and foam.

Coating/ surfacing	Year of oldest installation	Year of recoating
Acrylic	1978	1987
Polyurethane	1976	1995
Silicone	1969	not recoated
Aggregate	1980	not applicable

Table 1

Aesthetics

One interesting field observation was that many people unfamiliar with SPF tend to reject SPF roof systems based on their finished appearance and lack of aesthetics. This is because many believe a good visual appearance translates to good workmanship and leak-free performance. This study has shown that some SPF roof systems, especially older ones, may have been watertight for years but are visually displeasing.

Although not all building managers were available for interviews, plant maintenance staff said they were not concerned with the aesthetics of their old SPF roof systems. This is because of SPF's ability to flash tightly around a myriad of penetrations and resist leakage even when damaged by heavy rooftop maintenance activity.

Undamaged foam surrounding damaged areas was found to limit water migration because of SPF's closed cell structure and ability to adhere tightly to the substrate. Three of the SPF roof systems surveyed did have active leaks reported; the cause of leakage was not investigated.

SPF roof systems do have limitations—application is critical to their success. Wet substrates cannot be tolerated; overspray can be a large problem if cars are parked around the building being roofed. Dry and wet bulb temperatures need to be at least 5 F (3 C) apart.

Laboratory analysis

A laboratory analysis of the foam cores has shown that densities ranged from 1.9 to 4.9 pounds per cubic foot (pcf) (30 to 78 kg/m^3), with an average of 3.2 pcf (51 kg/m^3). This is above the industry recommendation of 2.8 pcf (45 kg/m^3). Compression strengths ranged from 22.8 to 99.3 pounds per square inch (psi) (157 to 685 kPa), with the average being 58.6 psi (404 kPa). This also is above the industry recommendation of 40 psi (276 kPa).

The coated roof systems' moisture contents ranged from zero to 166.5 percent by weight, with an average of 3 percent. The 166.5 percent by weight moisture content came from a sample taken over a built-in freezer; the sample's upper half was dry, and the lower half had a moisture content of 166.5 percent. Aggregate-surfaced roof systems had higher moisture contents. In some cases, ponded water and moisture vapor drive combined to increase their moisture contents.

More work is needed to define the design parameters for aggregate-surfaced SPF roof systems. SPF roof systems' moisture contents will vary somewhat depending on a roof's design, location and building function.

Summary

This study has shown that a number of parameters are important to an SPF roof system's service life. The installation procedures are most critical. The mechanical properties of the aged foam core samples have shown that the average densities and compressive strengths were higher than industry specifications. The moisture content of the foam core materials generally was found to be low, with the coated SPF roof systems' average moisture content being 3 percent. The aesthetics of the newer SPF roof systems have improved significantly. The use of granule, aggregate or chip aggregate surfacings has added to the design parameters now available with SPF roof systems.

Overall, the survey results were positive. SPF roof system technology has made significant improvements, as found in the physical property test results.

This will allow future recoating work to take place on many of these roof systems—leading to long system service lives.

A report detailing this research will be issued later this year. PR

Rene Dupuis is president of Structural Research Inc., Middleton, Wis.

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	AY-128	Documents to Disk (*Docs. included on 3.5 IBM Disk)
	AY-129	SPF Roofing "Tomorrow's Roofing Today"
	AY-130	SPF Roofing "Sustainable Roofing"
	AY-131	Whole Wall Testing Study performed by Oak Ridge National Laboratory for SPI/SPFD
	AX-171	Spray Foam Course 101 Chapter 12: Health, Safety and Environmental Aspects of Spray Polyurethane Foam and Coating. Video and test.

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February 19, 1998