REFLECTIVE ROOF COATINGS RETAIN THEIR RADIATIVE PROPERTIES

BY JIM LEONARD

Within the roofing industry, it is generally accepted that white, highly reflective coatings can cool and protect the roof surface to which they are applied. It is also recognized that coated roof surfaces may pick up dirt and lose some of their solar reflectance with time. The CRRC (Cool Roof Rating Council) recently questioned whether the radiative properties and cool roof benefits of field-applied coatings are substrate- and coating-thickness dependent. Some consultants have suggested that coated roof surfaces may not be economically justifiable due to maintenance costs associated with washing the white surfaces on a regular basis or potentially requiring recoating to maintain an acceptable level of solar reflectance. At what rate does dirt pickup occur? What factors impact the rate of dirt pickup? How much solar reflectance is lost over time? And what are the economic implications of this dirty little problem?

Very little research specific to these issues has been done. Akbari and associates reported, "Light-colored roof surfaces may expect a 20-25 percent reduction in solar reflectance over time, with most occurring in the first year," as one conclusion within a much broader study.

Photo 1 – Metal R-panel in North Carolina, three years old, acrylic coating.

In an effort to address these questions, a study of 40 white, field-coated roofs was conducted to measure solar reflectance as a function of substrate and duration of exposure. An Eppley Albedometer was used following a procedure similar to ASTM E-1918 (see *Photo 1*). Roofs in states across the country were tested, including Washington, Minnesota, Iowa, Illinois, Ohio, Texas, Georgia, North Carolina, and Florida. Substrates included metal, single-ply membrane (thermoplastic, EPDM, and Hypalon), granule-surfaced modified bitumen, smooth modified bitumen, smooth BUR, and spray polyurethane foam (SPF). The coatings applied to the various substrates were either white, water-based acrylics or acrylic-polyurethane copolymer (see *Photos 2, 3, and 4*).

The procedure followed was to take ten readings from each roof at test points selected in a totally arbitrary fashion (see *Chart 1*). The surfaces were not cleaned or prepared in any way. The high and low readings were eliminated and the remaining eight values were averaged for a final reported result. See *Chart 2* for solar reflectance data points by substrate and age of exposure. Where multiple data points are reported for a particular substrate and age, one can see the range of results is reasonably tight, considering expected variability from different locations.

The average values of multiple test points demonstrate a trend for loss of solar reflectance with time of exposure.

Rearranging the average values of solar reflectance with age and substrate, as reported in *Chart 3*, provides a clearer picture. Loss of solar reflectance is calculated from the initial solar reflectance value of 0.84. Since this is a study without controls for comparison, we are looking for trends. Following the horizontal line of "3 - 6 months exposure," one sees little variation by substrate and a loss of 11 percent on average from the initial solar reflectance of 0.84. At exposure levels of one year, two years, and three-plus years, there is a range of approximately 10 percent from the average value, which is reasonably consistent for field data.

Conclusions from this limited study are:

1. Nearly half of the loss of solar reflectance occurs in the first three to six months, and 75 percent of the loss occurs within the first year of exposure. After two years, there is very little further loss in solar reflectance, independent of the sub-

Photo 2 – EPDM in Minnesota, 1.5 years old, acrylic coating.

Photo 3 – Granular modified bitumen in Washington, 2.75 years old, acrylic coating.

Photo 4 – SPF in Iowa, 3 years old, urethane/acrylic coating.

strate.

2. This limited field study reinforces the indication that total loss of solar reflectance may be expected to be 20-25 percent from the initial reflectance value.
3. There is no definitive or substantial substrate dependence observed in the loss of solar reflectance.

A limited literature review was conducted from studies that were designed for other purposes. Byerly and Christian, 1994; Bretz and Akbari, 1997; and Mellott and Portfolio, 2005, conducted studies in which solar reflectance of a variety of roof coatings was measured at various time intervals. These studies provided no definitive or substantial trend of solar reflectance loss being substrate-dependent over time.

Based on this study, an approximation of a cost/benefit ratio for cleaning to retain solar reflectance and corresponding energy savings may be made utilizing the Oak Ridge Energy Calculator to estimate energy savings. Consider a 100,000-square-foot roof in Dallas, Texas, with a reflective-coated, EPDM membrane with R = 10 insulation and electrical cost at $.07/kwh. *Chart 4* shows the projected energy savings from turning a membrane with initial solar reflectance of 0.10 into a white-coated

Roof/Building Name	**Leith Honda**	**Coating Applied**	Eraguard 1000
		(ie - EG1000, Erlastic, etc.)	
Address	Captial Blvd	**Size of Roof**	14,043
	Raleigh, NC		
		Type of Substrate	Metal r-panel
Contractor Involved	**Yes**	**Ambient T**	66
Warranted	Yes	**Time of Day**	9:15 AM
Date Installed	11/5/2003	**Description of Sky Cond.**	Clear
Date of SR Test	**9/15/2006**	**Person Performing Test**	Lippman

Trial	Incoming (Up) Intensity	Reflected (Down) Intensity	Solar Reflectance (Down) / (Up)	Roof T at Point of SR Measure	Coating Thickness
1	374	238	63.6	70	18 mil
2	358	244	68.1	71	19 mils
3	381	252	66.1	75	16 mil
4	401	259	64.5	72	16 mils
5	393	262	66.7	74	17 mil
6	403	272	67.5	71	16 mil
7	354	270	76.2	74	16 mil
8	443	275	62.1	74	17 mil
9	464	256	55.1	72	16 mil
10	447	290	64.8	78	16 mil

If mil thickness of the general field of the roof can be determined please measure. On metal, measure thickness right under the albedometer position.

Please take at least one photo of the roof with the Albedometer Test in process.

Chart 1 – Sample field data report.

Substrates	# of Roofs		Average Value	Range
Metal	8 Roofs	2 @ 3 Months	0.769	.766 - .772
		2 @ 1 Year	0.635	.613 - .651
		4 @ 3 Years +	0.662	.566 - .720
Thermoplastic	5 Roofs	1 @ 5 Months	0.751	
		4 @ 3 Years +	0.652	.556 - .762
EPDM	6 Roofs	5 @ 1 Year	0.716	.597 - .774
		1 @ 2 Years	0.598	
Hypalon	5 Roofs	2 @ 6 Months	0.768	.765 - .772
		1 @ 1 Year	0.720	
		1 @ 2 Years	0.643	
		1 @ 3 Years +	0.584	
Gran Surface MB	6 Roofs	1 @ 2 Weeks	0.753	
		1 @ 2 Years	0.710	
		4 @ 3 Years +	0.682	.655 - .698
Smooth BUR	2 Roofs	1 @ 2 Years	0.648	
		1 @ 3 Years +	0.573	
SPF	7 Roofs	2 @ 3 Months	0.730	.692 -.770
		3 @ 2 Years	0.645	.600 - .677
		2 @ 3 Years +	0.614	.558 - .670

Chart 2 – Data points by substrate and age.

Age	Metal	Thermoplastic	EPDM	Hypalon	Gran MB	Smooth BUR	SPF	Average	Range	% Loss from .840
3 to 6 Months	0.769	0.751		0.768	0.753		0.730	0.75	.73 - .77	11%
1 Year	0.635		0.716	0.720				0.68	.63 - .72	19%
2 Years			0.598	0.643	0.710	0.648	0.645	0.65	.60 - .71	23%
3 Years +	0.662	0.652		0.584	0.682	0.573	0.614	0.63	.57 - .68	25%

Chart 3 – Average solar reflectance by age and substrate.

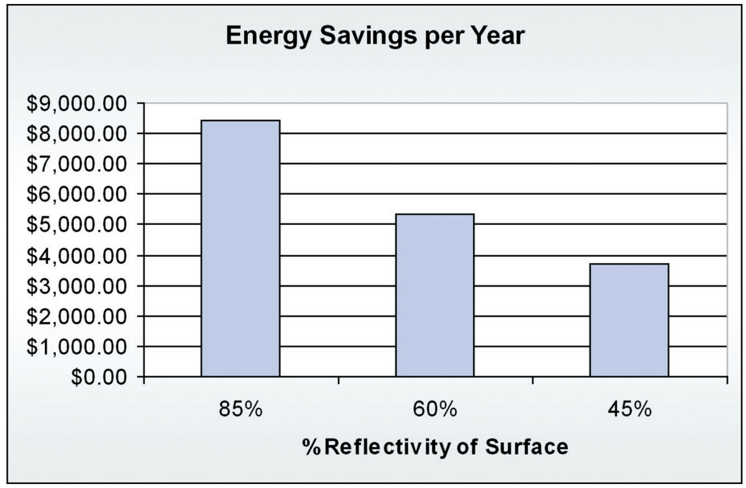


Chart 4 – Savings comparison to black EPDM at 10 percent reflectivity.

- **85% SR = $8300 saved**
  $3,100 difference
- **60% SR = $5200 saved**
  $4,500 difference
- **45% SR = $3800 saved**
- **Cost to wash, coatings=5cents=$5,000.**
- **Cost to wash, single-ply=10cents=$10,000**
- **EVALUATE EACH SITUATION-Energy cost, environment.**

Chart 5 – Savings comparisons to solar reflectance levels.

membrane surface at solar reflectance values of 0.85, 0.60, and 0.45. *Chart 5* compares savings at various levels of solar reflectance.

Assuming a cost of $.05/sf to wash the coated roof, it is clear that washing the roof at any time interval to maximize the energy savings is not an economically justifiable procedure, especially considering that most solar reflectance loss will reoccur in three to six months. Similar estimations can be made for other roof surfaces utilizing the data from *Chart 3* above. One may also conclude that aged solar reflectance values of at least one year in duration should be used in estimating long-term energy savings resulting from white, reflective coatings.

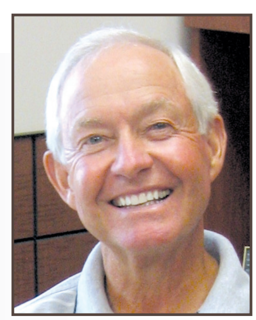
While this study indicates that loss of radiative properties due to dirt pickup is generally independent of the type of roof surface to which it is applied, it is important to note there are several factors that are known to impact dirt pickup. Rough and textured surfaces, surfaces that contain sticky degradation residue, roofs that pond some water, and those located in environments that are uniquely dirty may not follow the general trends identified above.

This field study was expanded in the summer of 2007 to add approximately 100 additional data points to the study. Specific data points are being gathered to fill in the blank boxes of *Chart 3*.

The RRCI (Reflective Roof Coatings Institute) has also commissioned a study to determine the change in solar reflectance and thermal emittance of elastomeric coatings as a function of coating chemistry, film thickness, geographic location, and roof substrate and as a function of exposure time. This will be the first controlled study in the roofing industry to measure and quantify the relative significance of those factors that influence loss of radiative properties with time. Samples were placed into exposure in May 2007 in Florida, Arizona, and Minnesota, and data will be collected over the next three years, if not longer.

In summary, white reflective coated roof substrates may be expected to retain 75-80 percent of their initial solar reflectance over time, independent of the type of roof surface to which they are applied. Washing white reflective surfaces to maximize the solar reflectance is typically not cost justifiable. And finally, when estimating long-term energy savings due to white reflective coating installations, one should use a value of approximately 75-80 percent of the initial solar reflectance.

Jim Leonard



Jim Leonard received degrees in chemistry from the University of Wisconsin and the University of South Dakota. He taught college chemistry for ten years. Jim has over 30 years experience in development and marketing of roof coatings and adhesives and holds two patents. In 1993, he founded Elastomeric Roofing Systems, Inc., and in 2004 was a co-founder of Prairie Technologies, Inc. Leonard is past president of the Reflective Roof Coatings Institute and a member of NRCA, RCI, CSI, SPFA, and CRRC. He has written numerous articles for publication. ERSystems' manufacturing plant in Rockford, Minnesota, is built to LEED standards with a roof that serves research and demonstration functions for garden roofing, solar and wind study, and roof-mounted energy generation.