REFLECTIVE COATINGS: Looking Beyond Energy Savings

By Matthew Lendzinski

For many years, reflective coatings have been promoted as a way to transform an energy-consuming, dark-colored roof into a more environmentally friendly cool roof. With the increasing trend toward the use of highly reflective roofing products such as white thermoplastic polyolefin (TPO) and polyvinyl chloride (PVC) rolled roofs, many industry watchers believed that roof coatings would no longer have a place in the roofer's toolbox. However, the reduction of energy costs related to air-conditioner usage should not be the main driver to utilize a reflective coating. These products can be used in other ways beyond the traditional black-to-white conversion.

HISTORY

Elastomeric roof coatings were put into wide use during the early 1980s as a maintenance product for aging roofs. The original purpose of elastomeric roof coatings was not to provide reflectivity for the purposes of energy savings, but to protect the surface that was being coated. This extends the life of the underlying roof surface in several ways:

1. By blocking ultraviolet radiation from breaking down the membrane,
2. By protecting the roofing assembly from liquid water flowing over the roof surface, and
3. By reducing the temperature of the roof membrane, in many cases.

In the early years of elastomeric roof coatings, a large fraction of the coatings were used to protect sprayed-in-place polyurethane foam (SPF) roofs. SPF roofs are common in the southwestern United States because of their inherent insulation performance, but they are not stable when exposed to ultraviolet radiation from the sun. Reflective coatings were, therefore, used to protect the foam, and many polyurethane foam roofs have lasted several decades with proper maintenance. However, it is a misconception to think that reflective coatings provide value only on this type of roof.

Another misconception about reflective coatings cropped up during their early years – the perception that they were a cure-all for every roof problem. Reflective coatings can provide value in many ways, but they are not an appropriate choice for every troubled roof. A coating by itself is typically not a remedy for a leaking roof or one with severe water damage.

ENERGY SAVINGS FROM REFLECTIVE COATINGS

There is no question that reflective coatings can lower roof temperatures when compared to nonreflective alternatives. In some cases, these lower temperatures have been shown to reduce the overall energy loads of the entire building. For example, the Florida Solar Energy Center published a study in 1995 that showed the energy savings from its test roofs in Florida "averaged 19%, ranging from a low of 2% to a high of 43%."[1]

Energy savings, however, are the most difficult impacts to estimate and the most highly debated. There are currently three competing energy calculators available to the public. Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and the National Roofing Contractors Association have each developed a calculator based on a different set of assumptions, and they request varying degrees of information about the roof being modeled. *Figure 1* shows an example of two hypothetical 20,000-sq-ft roofs, one in Phoenix and one in Minneapolis. These roofs were modeled using each of the three calculators to determine the cost difference between a reflective and nonreflective roof. As the table shows, the results vary – widely in some cases – between the three models.

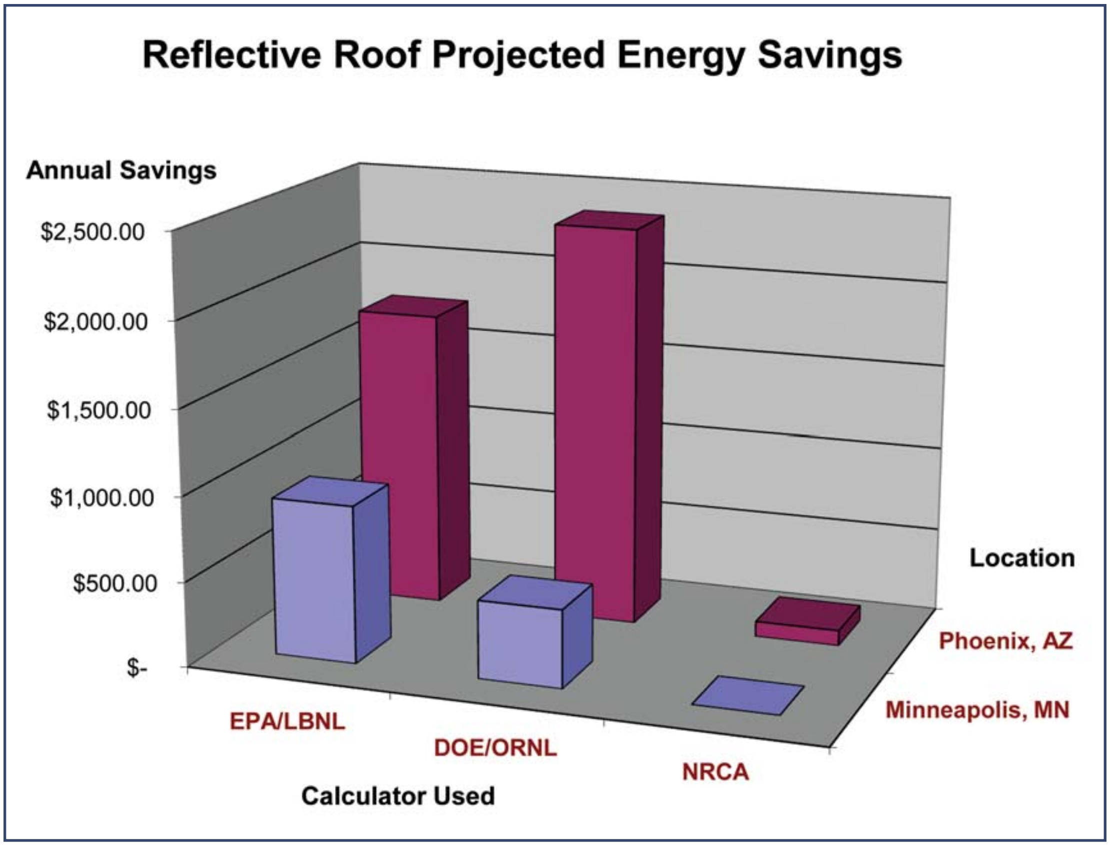

Figure 1 – This chart reports the energy savings estimated using each of the three calculators listed. The calculation is based on a 20,000-sq-ft office building located in either Phoenix, AZ, or Minneapolis, MN, with R-19 insulation in the roofing assembly and assuming a constant energy cost of $0.10 per kilowatt-hour.

Another common question about the energy savings of roof coatings revolves around the heating penalty that these coatings incur due to loss of heat gain in the winter months. Several papers have been written over the last few years about choosing the "right" system for the roof. These papers have even gone so far as to show maps of the United States with a line snaking across the country as a demarcation of where the transition occurs between a benefit and a penalty for using a reflective roof. However, most of these studies are based on modeled energy-usage data for hypothetical buildings, not actual data. No conclusive, real-world studies have been conducted to measure actual increases in energy usage by buildings that employ highly reflective roofing systems.

For all of these reasons, the projected energy savings of a roofing system should not be the sole factor in the selection process.

ROOF LIFE EXTENSION

In many building codes, the standard requirement is for a maximum of two installed roofs on a building. This imposes an additional cost burden on building owners who have reached the end of the service life on their second roof. Removal and disposal of the existing roof alone can cost more than $2 per sq ft, according to the 2007 edition of RS Means. This is in addition to the cost of installing the new roofing membrane.

By providing a barrier to both liquid water and ultraviolet radiation from the sun, the coating provides a sacrificial layer of protection for the roof membrane. This layer does erode over time because the ultraviolet radiation is breaking down the coating. But in this case, the damage is at a fairly slow rate, and the waterproofing membrane underneath is unaffected.

Several exposure studies have been conducted in Spring House, PA, to quantify this effect. The studies have found that in commercial and laboratory-produced acrylic coatings, the actual erosion rate is typically well under 1 mil (0.001 in) per year when put on an exterior horizontal exposure.

The coating is delivering value by preserving the initial roofing investment that the building owner has made. A roof originally estimated to last 10 years when exposed to the sun might last almost indefinitely if continuously coated and kept protected from the sun's destructive UV rays. In the case of a metal roof, protection from thermal shock and temperature cycling can also help to extend the life of the roof assembly. This should not imply that every roof's life could be extended. In the case of a roof where the deck has become rotted, the insulation has become saturated, or there is significant trapped water, the use of coatings can never be a substitute for an appropriate roof repair.

GREEN ASPECTS OF REFLECTIVE COATINGS

Sustainability

Sustainability is commonly described as the ability of industries to operate without depleting valuable natural resources. As an example, the Rohm and Haas company described sustainability by noting "The design of our businesses, processes, and products will consider the needs of the present global community and the impact the designs will have on future generations' ability to meet their needs." To reduce this broad statement into concrete actions, there are several routes to accomplish the goal of a more sustainable building. Following are two examples.

First, we will examine the life cycle of a building. If a building lasts 100 years and the roof is replaced every 10 years, the roof will go through 10 life cycles during the life of the building. If, however, a roof can be supplied that takes no additional resources to manufacture but lasts 20 years, it has reduced the number of life cycles to five. This means that only five roofing assemblies will need to be produced, installed, and disposed of during the 100-year period in question.

Another approach to making a more sustainable product is to make a similar product with a smaller environmental impact. An example of this would be producing aluminum cans with recycled aluminum. While consumers are still using the same number of cans for the same period of

This large retail property had an asphalt-based roof system that leaked extensively. Tearing off and replacing the existing roof was not only a business interruption, but involved the environmental concern of disposing of the old roofing material. The owner avoided both of these issues by having a white, reflective, elastomeric coating applied directly to the existing roof. By doing so, he solved his leak issues, extended the service life of the roof, and reduced his energy costs. Photo by Aldo Products.

time, the impact each can has on the environment has been reduced because less new aluminum is needed to produce them.

In both of these examples, real economic value has been created for the end user, in addition to the obvious environmental benefits. In the roofing example, the building owner has fewer life cycles to manage as far as business interruption and project management are concerned, and in the can example, there is a quantifiable cost involved with disposing of aluminum and producing virgin material. This shows that environmental benefits do not have to be gained to the exclusion of economic ones.

Recycled Raw Materials

To make coatings more sustainable than they are today, one route could be to produce them with recycled material as described above. Research is already being conducted by several organizations on the feasibility of using bio-based and recycled raw materials to manufacture reflective coatings. In the near future, coatings may be available with 20% or more recycled content based on total product weight (40% of solid content weight). This recycled content is likely to come from fly ash or other industrial byproducts that are used in place of a more traditional extender, such as calcium carbonate. In testing conducted at Dow's Spring House Technical Center, fly ash was found to be the most compatible extender replacement for calcium carbonate. The only major downsides to its use have been the gray color it imparts to the coating and the possibility of mercury contamination inherent in fly-ash generation.

Reduced Landfill Waste

The other route to a more sustainable product can be taken through a reduction in waste generation. In the case of coatings, the main environmental benefit is derived from their ability to extend the lives of existing roofing systems. It is estimated that between nine and 10 million tons of asphalt roofing materials are sent to landfills each year.[2] This figure does not even include other roofing materials, such as single-ply membranes.

Imagine a roof that was built with a single-ply membrane. The owner can probably expect a service life of 10 to 20 years, depending on the specific material and grade installed. What happens at the end of that time? The roof will be removed, sent to a landfill, and a new roof will be installed in its place. This process would be repeated every 10 to 20 years, with a large fraction of the roof assembly being removed and disposed of once a major failure has occurred.

How do coatings differ? Reflective coatings are different because they can extend the life of that membrane. In the example in which coatings are used, assume the membrane has a coating applied seven years after the roof is initially installed. Now that the roof is being protected from the effects of weathering and harmful ultraviolet radiation, the underlying membrane should last well beyond its original service life. Instead of the roof's life cycle being 10 to 20 years, it can be extended to 30+ years. In examining a 100-year time span, our average building may only go through two complete roof replacements with the use of coatings, compared to five to 10 without. That is 40% to 80% less waste entering a landfill.

Reduction in the Urban Heat Island Effect

Anyone who lives in or near a major city can bear witness to the urban heat island effect. During hot summer days, urban areas tend to hold onto the accumulated heat they have absorbed more than the surrounding suburbs. This is mainly caused by the heavy use of man-made surfaces such as concrete and asphalt that absorb more heat than natural surfaces such as grass. The net effects in urban environments are warmer temperatures and increased electricity usage. These effects have an impact on all urbanized areas, even those in more northern climates, such as Toronto and Chicago.

In Philadelphia, the Energy Coordinating Agency[3] helps to install reflective coatings in highly urbanized residential neighborhoods to reduce the temperatures inside the homes. This effort is partly about reducing air conditioning costs, but many of the homes have no air conditioning. In these instances, the agency's efforts are driven by the dozens of people who die during Philadelphia heat waves each summer. The reflective coatings can help to keep individual homes and entire blocks cooler during hot summer months. Since 2001, over 550 homes in Philadelphia have had their built-up asphalt roofs coated with a reflective coating to reduce the interior temperatures.

The Heat Island Group at the Lawrence Berkeley National Laboratory has been a key researcher in this area. In a June 1998 report, the group demonstrated that installing a reflective coating on a roof could significantly reduce the heat island effect. In its experiments, asphalt-based roofs that were approximately 170˚F in the middle of the day could be reduced to 120˚F with the application of reflective coatings.[4] Data such as these are what led the Leadership in Energy and Environmental Design (LEED®) program to designate a credit specifically for the installation of high Solar Reflectance Index (SRI) roofing systems.

BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Test your knowledge of building envelope consulting with the following questions developed by Donald E. Bush, Sr., RRC, FRCI, PE, chairman of RCI's RRC Examination Development Subcommittee.

1. **What are two performance attributes required of waterproofing?**
2. **What specific condition must exist before damp proofing can be used on the exterior (earth) side of the waterproofing system?**
3. **When backfilling earth against a below-grade waterproofed substrate, how far (above or below) should the fill be from the top of the liquid-applied waterproofing system?**
4. **What is tuckpointing?**
5. **When replacing deteriorated mortar, how deep should the old mortar be removed?**
6. **How does the SWRI glossary define a cold joint?**
7. **What is the consequence of cold joints in concrete?**
8. **What are the four forces that move water through masonry walls?**
9. **What are the two major movements that occur in a newly laid brick veneer?**
10. **What are the minimum width and depth of a proper sealant joint?**

Answers on page 44

BUILDING ENVELOPE KNOWLEDGE ASSESSMENT

Answers to questions from page 43:

1. **Must perform for the life of the building. Must perform in a constantly wet environment.**
2. **Where a hydrostatic pressure-relief system has been employed.**
3. **Earth fill should be a minimum of three inches below the top of the waterproofing.**
4. **The removal of deteriorated mortar from points of a masonry wall and replacing it with new mortar.**
5. **A minimum depth of one inch.**
6. **A plane of weakness in concrete caused by an interruption or delay in the pouring operation, permitting the first batch to start setting before the next batch is added.**
7. **Lack of adhesion (bond) between the batches of concrete.**
8. **Gravity, kinetic energy, capillary action, and air pressure difference.**
9. **Thermal movement – brick can expand and contract approximately 0.4 inch per 100°F temperature swing.**
   Moisture movement – initial moisture expansion of dry/new brick may last up to 18 months before a relative degree of stability is found to occur.
10. **One-fourth-inch width, one-fourth-inch depth.**

REFERENCES:

SWRI Manual* and *NRCA Roofing and Waterproofing Manual, Third Edition

CONCLUSION

As with most professions, roofing specifiers have a broad array of tools at their disposal. Most of the tools in the toolbox can be beneficial when used at the proper time and place, and reflective coatings are no different. Since the claims of energy savings or costs are difficult to estimate, they should not be the primary driver for the selection of a roofing product in more moderate climates. Reflective coatings have many other benefits that are more clearly measurable, such as their ability to extend the life of a roofing membrane. Considerations around life-cycle cost, sustainability, and the protection of the roof assembly should be the paramount factors in making a product decision.

REFERENCES

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Vertical Roof Installation

The eight buildings that create the Smith and Mohawk residences at the State University of New York (SUNY) campus in Canton, NY, cause most observers to tilt their heads. That's because the structures feature unique mansard "roofs" that reach from the top of the buildings down more than four stories to the lawn below.

Originally built in 1968, the dormitories, temporary home to 850 students, were reroofed this summer while school was out. Mid-State Industries, Ltd. removed the existing concrete shingle roofs and replaced them with 352 squares of DaVinci Slate synthetic roofing tiles in a European Blend color. The almost straight vertical application required special scaffolding for installation. An additional challenge was the adjacent "steep landscaping" and minimal access.

The specifying architect, Jenny Schumaker of C Companies®, chose the synthetic tiles because of their resistance to curling and insects, durability, reinforced ribbed backing, variety of colors, and 50-year warranty.