White roofs are certainly cool, but what about aged and dirty roofs? There is ample evidence that solar-reflective roofs can help keep a building cool, particularly in hot climates with a high level of direct sunlight. And while a number of technologies are available that can deliver a reflective roof surface, such as single-ply roof membranes, reflective aluminum-pigmented coatings, and even darker-colored coatings employing infrared-reflective pigmented coatings, the basic white reflective roof still reigned supreme as the dominant cool-roof technology.

But what about the issue of roof aging, and its effect on roof reflectivity? The factors affecting aging performance and the measurement and certification requirements for cool roof coatings has been the subject of previous JAC articles, including this Passing the Test column (JAC, January, 2006, It's a Matter of Degrees). The aging factor is taken into account in the U.S. Department of Energy's Energy Star program, which requires an initial solar reflectivity of at least 65%, with a 50% reflectivity level required after three years of outdoor weathering. The independent Cool Roof Rating Council (CRRC) has more stringent specifications, and stipulates three-year outdoor weathering in the three different climates of south Florida, Arizona, and northern Ohio as part of its rating system.

Recent revisions to the California Energy Commission's Title 24 Part 6 cool-roof provisions for residential and non-residential low-slope roofs also include aged and initial reflectivity requirements. These requirements, set forth in the California Building Standards Code, are included as part of the overall building energy-efficiency standards set by the Energy Commission. The new provisions also extend the standards to some steep-slope roofs.

Title 24, as well as CRRC certification, are based on the CRRC-1 Program Manual requirements. One important aspect for coatings, however, is that the substrate can alter a coating's performance. For example, reflectivity would be compromised if a coating delaminated from the roof substrate. A potential discrepancy within the CRRC-1 protocol is that initial reflectance measurements are made on coatings applied to standard aluminum test panels, but weather-aged performance was to be measured as applied to various actual roof substrates. This detail was initially overlooked until about two years into the initial three-year weathering requirement for certification; the exposures on standard aluminum panels were to be accepted.

Clearly, however, data are needed to answer the question of how important this matter of substrate type is, in terms of aged roof-surface reflectivity. Currently, several interested parties are working to address this need for data. The Reflective Roof Coatings Institute (RRCI), whose members consist primarily of white roof-coatings manufacturers, has launched a three-year minimum weathering study to determine how coating chemistry, film thickness, geographic location, and substrate type affect performance. Commercial formulations of acrylic, silicone, polyurethane, and acrylic/fluoropolymer coatings are being exposure tested in three separate film thicknesses. These coatings are applied to various common roof substrates, including PVC and EPDM sheet, aluminum and cold rolled steel, spray polyurethane foam (SPF), and several asphalt types.
Samples are being exposed in three locations—Florida, Arizona, and Minnesota—to determine changes in reflectivity and emissivity.

The Roof Coatings Manufacturers Association (RCMA), which represents a wider range of coatings types than the RRCI, has launched a similar but broader study to determine the effect of substrate on aged coating performance. The question is not academic; if the substrate proves to be a significant factor in rating coatings, this will necessitate much more comprehensive (and expensive) testing than currently required. At this time, both of these studies are less than one year along in their respective programs, and data is not yet available.

**Roof weathering and reflectivity loss**

Roof reflectivity also can be negatively impacted both by erosion of the coating or membrane due to weathering, and by soiling due to dirt retention or mildew growth. A research study conducted by Oak Ridge National Laboratory (ORNL) for the Single Ply Roofing Industry (SPRI) trade group compared major commercial roof membranes for aging characteristics and energy performance. It was determined that dirt and mildew were major issues for all membrane types, especially after the first three to four years of service, but that periodic maintenance cleaning usually restored reflectivity performance. Does this also hold true for roof coatings, some of which are used to rehab membrane roofs? Does it make economic sense to perform roof cleaning? And if it makes sense, how should it be done, and how often, without damaging the roof?

Typical initial solar-reflectance values for aluminized roof coatings are in the range of 0.50 to 0.60 on a scale of 1.00. Reflectance of white reflective roof coatings is typically higher, with most having values of 0.70 to 0.85, numbers that meet the standards set by the EPA Energy Star program and California Title 24. Researchers at the Lawrence Berkeley National Laboratory (U.S.) and the National Research Council (Canada) concluded that membrane roofs, on average, lost about 20% of their initial solar reflectance over the first one to three years, but that 70% to 100% of that loss could be regained through washing with water or detergents, and in some cases with an algicide.

Research by Oak Ridge National Laboratory showed that the economic benefit of washing reflective roof membranes varied, depending on the expense associated with washing and the resulting reduction in energy costs. These benefits are often location-dependent, with climate playing a major role. Reflective roof coatings, however, are often used to extend the service life of traditional built-up roofs (BURs) and membrane systems, so these positive economic and environmental impacts should also be taken into account.

**To wash or not to wash?**

So do roof coatings need washing, and is there a worthwhile economic result? The answer to those questions may be supplied in part by data generated from the RRCI and RCMA field-exposure trials. But at least anecdotal field information from current product installations appears to shed some light on the subject. Jim Leonard of elastomeric roof-coatings manufacturer ERSSystems has compiled informal data on 61 roofs where the company’s white acrylic or acrylic-polyurethane coatings were applied. These were applied to a variety of substrates, including thermoplastic, EPDM, and Hypalon membranes, granule surface-modified bitumen, smooth bitumen, smooth BUR, and SPF systems located in nine states, including Florida and Texas and locations in the Midwest and the Pacific Northwest. His field survey results for unwashed white roof coatings suggest:

- a loss of solar initial reflectivity of about 20-25% during the first few months to one year, with little change beyond that;
- a loss of solar reflectivity consistent with other reported studies; and
- generally little variation by substrate.

Leonard concludes that washing of white-coated, reflective roof surfaces as a maintenance measure does not constitute a cost-effective means of retaining or restoring solar-reflectance values, especially considering that “most solar reflectance loss will reoccur in three to six months.” He also concludes that energy calculations should be based on at least one-year aged reflectance values, which are typically 75-80% of the initial reflectance values.

A compilation of information from various studies suggests that for all reflective roofing types, about 95% of aging occurs during the first two years, and 98% occurs within the first three years of installation. Initial first-year solar reflectance losses of about 20-25% can be expected. It is important to realize that it is not the percentage loss of solar reflectivity that is significant, but rather the impact of that change on the energy efficiency of the building. Solar-reflectance changes of plus or minus 2% have a negligible on energy efficiency. While washing can usually restore most of the solar reflectivity, at least during the first several years of aging, the effects are short lived (typically three to six months), yield limited economic payback, and have the potential to damage roofs in the process.

What does it all mean? Primarily, it means...
that the actual economic benefit of washing will vary by location. Energy-efficient, reflective “cool roofs” are being used in all climates, and their use is increasing, while traditional, dark-colored, built-up roofs, though still dominant, are declining. But the energy savings attributable to cool roofs will be much different in Phoenix than in Boston.

Reflective roofs generate the greatest benefit by reducing air-conditioning costs, which are obviously higher in warmer climates with high levels of solar radiation. While reflective roofs suffer from a “heating penalty” in terms of energy-cost reductions in colder climates, this is often offset by high electricity costs due to air conditioning. The following list of cities shows EPA estimates of average annual economic savings realized by cool reflective roofs for every 1,000 square feet of air-conditioned building space.

<table>
<thead>
<tr>
<th>City</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philadelphia</td>
<td>$4</td>
</tr>
<tr>
<td>Chicago</td>
<td>$9</td>
</tr>
<tr>
<td>Dallas/Ft. Worth</td>
<td>$11</td>
</tr>
<tr>
<td>New York</td>
<td>$17</td>
</tr>
<tr>
<td>Houston</td>
<td>$18</td>
</tr>
<tr>
<td>Los Angeles</td>
<td>$20</td>
</tr>
<tr>
<td>Miami/Ft. Lauderdale</td>
<td>$21</td>
</tr>
<tr>
<td>Phoenix</td>
<td>$34</td>
</tr>
</tbody>
</table>

Energy-savings economics are a combination of local climate and the cost of electricity. Therefore, the greater the energy savings provided by a cool roof, the greater the penalty paid due to reflectivity loss with aging. For example, ORNL calculated that for San Diego, the yearly energy cooling savings per 1,000 square foot of a new reflective vs. a black roof was $72; a 20% reflectivity decrease due to roof aging reduced these savings to only $55, or a 30% decline in savings. Indianapolis, by contrast, provided a more modest initial cooling-energy savings of $6 per 1,000 square feet, but because of the cold weather heating-penalty offset, a 20% reflectivity loss due to aging resulted in no net change to overall energy savings. So energy savings alone suggested only a modest benefit from installing a reflective roof in Indianapolis, and cleaning it would provide no benefit at all. But the situation in San Diego is quite different.

Reflective roof coatings can be used to rehabilitate traditional roofing such as BURs, as well as membrane systems. The economic benefit can be determined by the overall building energy savings, but these calculations should be based on solar-reflectance estimates after at least one year of aging. Reflective roof coatings can also prolong the lifetime of existing roof systems, since thermal degradation is a major cause of roof aging. It is possible that results from the ongoing weathering field tests will provide additional guidance in the coming years.

So, the answer to the question of whether to clean or recoat cool roofs to maintain or restore solar reflectivity can basically be answered in two parts:

• in hot, high solar-load climates where air conditioning cost dominates and heating penalty-offset cost is minimal, cleaning most likely provides a benefit;
• in colder climates where the annual energy cost of air conditioning is relatively low and the cost of heating is fairly high, cleaning or recoating would not make economic sense in terms of energy cost savings

Clearly the costs and frequency of cleaning need to be carefully considered as well, as should the indirect benefit of prolonged roof life courtesy of the use of coatings, even if the energy savings decline with age.

In any case, if cleaning is warranted, the coating manufacturer should be consulted for recommendations on methods and materials to avoid damaging the coated roof surface.
G-Shield™
Graffiti and dirt protection in one coat

Clariant has developed an easy-to-use, easy-to-clean, clear solution against aggressive and damaging graffiti and unsightly dirt.

G-Shield™ is an innovative, durable coating which provides protection from graffiti and grime. Markers, paints, inks, tar, sap, grease, dirt and other stains cannot permanently adhere to the G-Shield™ protected surfaces.

Additionally, G-Shield™ will not alter the normal appearance of the substrate and is resistant to commercial cleaning solutions, and aggressive brake fluids. The protected material can be cleaned numerous times without reapplication or damage to G-Shield™.

G-Shield™ can be easily applied and because it is a thin coating, G-Shield™ is very economical – especially for large surfaces.

In addition to protection from graffiti and grime, G-Shield™ provides effective protection from UV radiation and weathering. Compared with unprotected surfaces, the G-Shield™ protected surface displayed no tarnishing, gloss reduction, scratching, or paint damage.

Did we raise your interest?

Please contact us:
KiON Specialty Polymers
A Clariant Business
4331 Chesapeake Drive
Charlotte, NC 28216
Tel: 800.585.2151
Fax: 704.395.6689
www.thegshield.com