Highly Reflective Low Slope Roofs

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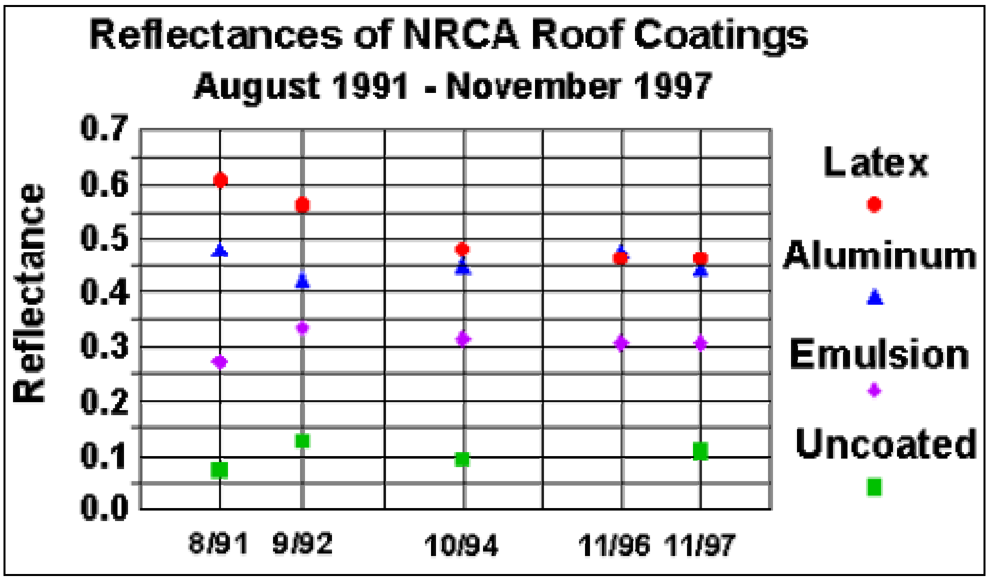
Reflective roof coatings are liquids that are brush, roller or spray applied to a surface such as a low-slope roof. They seal the surface, offer protection against degradation due to ultraviolet radiation and reflect solar radiation away from the surface before it is absorbed and heats up the surface. If initial reflectance is greater than 80%, they are called radiation control coatings. Research at ORNL on radiation control coatings has focused on the effect of weathering and substrate type on the solar reflectance. We have recently expanded our focus to include the entire range of roof coatings.

To deal with the heat load on buildings caused by solar irradiation of the exterior envelope, radiation control coatings are fundamentally appealing. Defined as coatings with initial solar reflectances greater than 80%, they reflect a large fraction of the solar irradiation away before it is absorbed in the exterior surface of the envelope. They mitigate the need to retard the rate of heat transfer through the envelope by use of insulating materials or radiation barriers. They also lessen the degradation of envelope materials caused by high temperatures and thermal stresses as well as ultraviolet radiation.

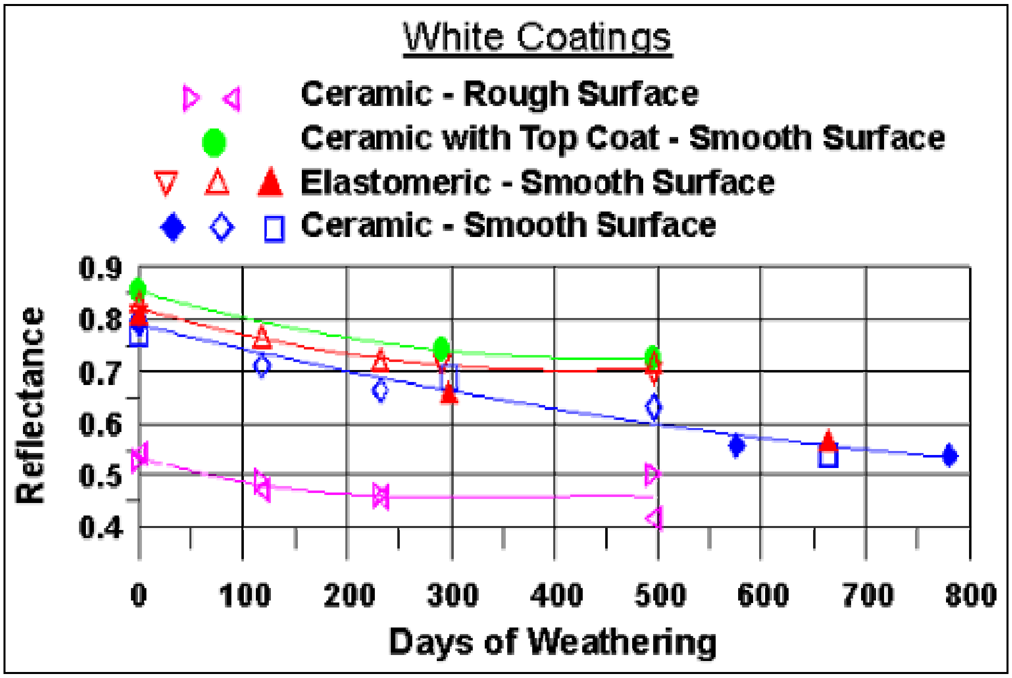
Applying white radiation control coatings to existing low-slope roofs with non-reflecting membranes has been the focus of research on roof coatings over the past 10 years at the Oak Ridge National Laboratory's Buildings Technology Center. This research focus has expanded as we enter the second year of a three-year study of 24 different coatings and coating systems with the cooperation of several coating manufacturers and the Roof Coatings Manufacturers Association (RCMA). Not only white coatings but aluminum and asphalt emulsion coating types are represented among the 24 test specimens. This is the first definitive study of coatings' long-term field performance in over 15 years, according to an August 1997 article in the roofing magazine RSI.

The RCMA study involves periodic measurement of the coatings' solar reflectances and infrared emittances and continuous measurement of the thermal performance of the coatings on instrumented test sections. Temperatures throughout insulated test sections covered with each coating, especially the temperature of the external surface, are measured as a function of weather conditions. Heat flows through the test sections are also monitored continuously to help calibrate models of each test section's thermal behavior. Calibrated models help to predict the behavior of similarly coated roofs with varying levels of insulation in different climates. Measurements of the mechanical performance of the coatings are possible with separate samples of the same coatings on uninstrumented weathering panels.

Long-term monitoring is needed to capture the effect of weathering on the coatings, especially their solar reflectance. ORNL and the National Roofing Contractors Association (NRCA) began a project in 1991 on a roof in the Chicago area. Results from it show how white latex coatings, aluminum coatings and asphalt emulsions available in 1991 have performed since the study began. The white latex coating has shown the most decrease in its reflectance.



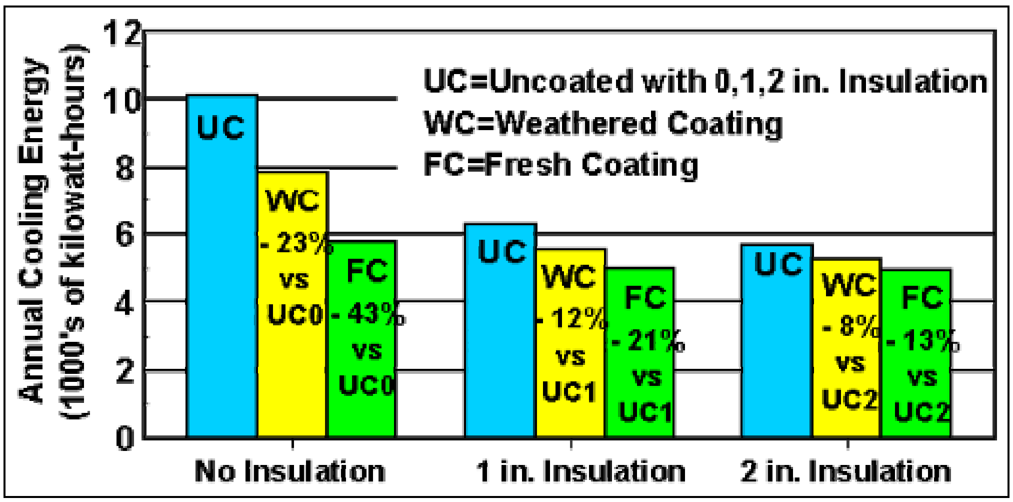
Several different white coatings have been studied in more detail over a shorter time at ORNL and at Tyndall Air Force Base in Florida. In particular, two rough-surfaced roofs were coated with a white latex-based coating with ceramic microspheres at Tyndall for comparison to the same ceramic coating and other ceramic and elastomeric coatings on smooth surfaces. The initial solar reflectance of the currently available white coatings is over 80% on smooth surfaces. Thus, the surfaces only absorb 20% of incoming solar irradiation. They remain very cool relative to uncoated surfaces. On rough surfaces, the initial reflectance is significantly lower but still much better than that of the uncoated surface shown in the NRCA data.



On a typical sunny summer day, smooth surfaces with fresh white coatings (reflectance near 80%) only heat up about 10 to 20°F above ambient temperature. Coated rough surfaces or weathered surfaces (reflectance near 55%) heat up 30 to 50°F above ambient temperatures. An uncoated surface (reflectance near 10%) can reach temperatures nearly 100°F above ambient temperatures. How much the cooling load is reduced because of the cooler temperatures depends on roof insulation, building operating conditions and other factors specific to the particular application.

An example from the summary report on the two years of monitoring buildings at Tyndall Air Force Base (ORNL/CON-439/V2) deals with a 1500 ft2 (140 m2) single-story concrete block building in the Florida Panhandle. Several modifications were proposed in a DOE 2.1E computer model of the building to predict annual energy use under different situations. The model of the existing building was calibrated against measured electrical power used by the building. To illustrate the effect of roof solar reflectance and insulation level, annual cooling energy use was estimated for the building with various roof coatings and levels of low-slope roof foam insulation. The solar reflectances varied from FC = 75% (fresh white coating on a smooth roof) to WC = 52.5% (weathered white coating on a smooth roof or fresh aluminum coating on a smooth roof or fresh white coating on a rough-surfaced roof) to UC = 20% (uncoated oxidized metal roof). Roof R-values corresponded to insulation thicknesses of 2 in. (5.1 cm), 1 in.

(2.5 cm) and none. Notice how much the annual cooling energy decreases for the uncoated roofs as insulation level is increased from none to 2 in. (5.1 cm). The same effect is obtained according to the model with a fresh white coating on the uninsulated roof, but the weathered white coating (or fresh aluminum coating or fresh white coating on a rough surface) does not do nearly as well. Starting from a roof insulated with 1 or 2 in. (2.5 or 5.1 cm) of foam insulation, the projected energy savings from coating the roof are not as impressive.



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