ACRYLIC ROOF COATINGS:

MAXIMIZE Roof Life, *LOWER* Energy Costs, AND *GET* LEED Points!

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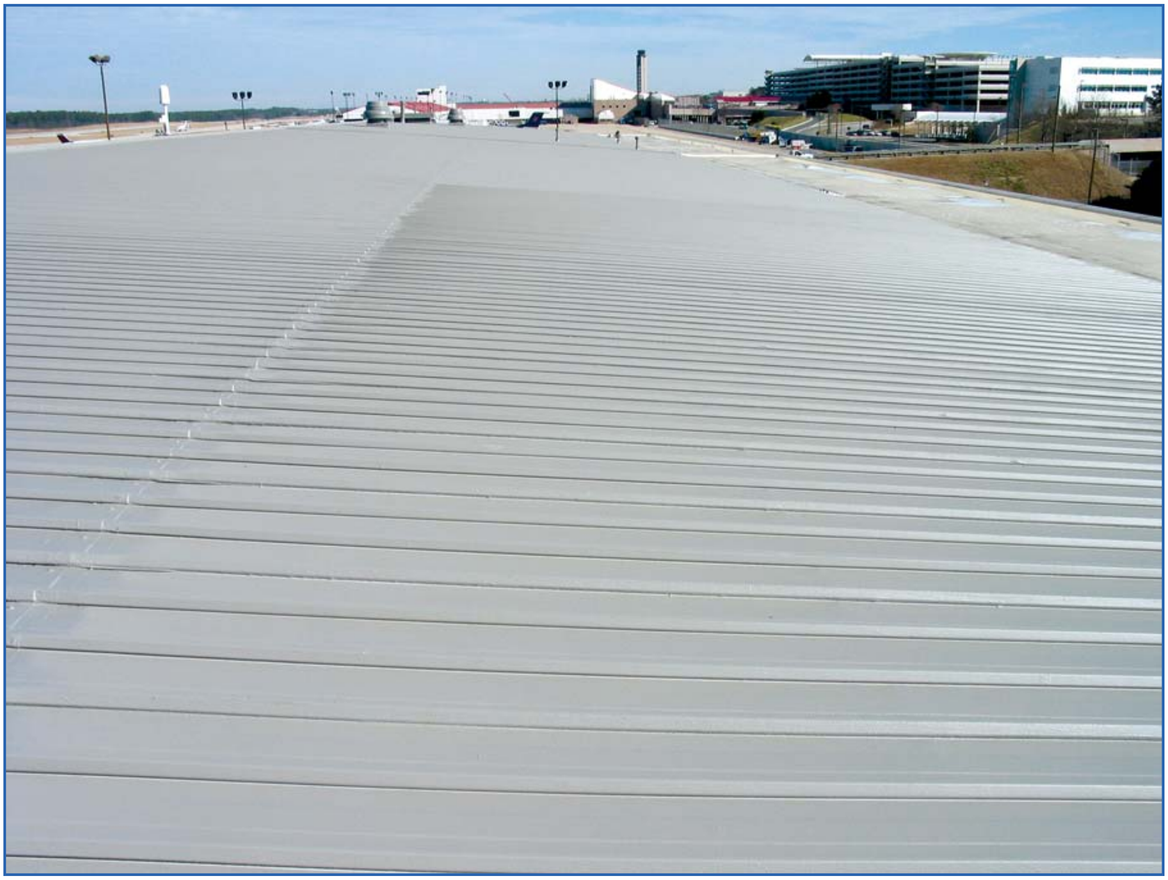
Abstract

Acrylic roof coatings have proven themselves as useful tools in maintaining and prolonging the life of a roof. This paper is unique in its perspective since it describes the fundamental and theoretical aspects and requirements of coatings to facilitate informed coating selection. The paper addresses the key issues of: Why coat a roof? Is the roof sustainable with coating? What are the functional demands placed on the acrylic coating with respect to different types of roofing systems? What will the acrylic coating provide that the original roof system has failed to do? What other demands are placed on the coating? Does the coating alter the way the roof performs from a watertightness standpoint? Are all roofs sustainable with coatings?"

Introduction

"Sustainability" and "sustainable architecture" are increasingly used terms in the construction industry as architects, specifiers, and commercial building owners wrestle with the economics of keeping buildings functioning in spite of ever decreasing maintenance dollars. While certain components of the building envelope such as walls, windows, floors, and electrical systems last reasonably long, or indefinitely, the roof seems to require replacement or substantial maintenance at much shorter intervals. Any technique to prolong the roof life, i.e., make it more sustainable, is welcomed by those responsible for the financial aspects of the building.



Roof coating being applied.

The recent emergence of the concepts of "cool roofing," EnergyStar™ roofs, California Title 24, and U.S. Green Building Council's (USGBC) LEED points for reflective roofs have also focused attention on the use of white, reflective coatings to achieve these energy and environmentally important goals. Acrylic coatings used to maintain and increase solar reflectance of a roof are the single best tools for those charged with this responsibility. Coatings have been shown to extend the life of the roof and reduce the air conditioning costs associated with the building.[1,2] LEED points are awarded for increasing the solar reflectance and emittance of the building's roof.

Why Coat?

Roofs are usually replaced for one of two reasons: either they wear out or they fail catastrophically. (Catastrophic failure usually involves some serious error on the part of the materials manufacturer, designer, or installer and is not the subject of this discussion.) Roofs wear out as a result of physical and chemical effects on the membrane, causing it to require such extensive repair that it exceeds the building owner's tolerance and patience. It is at this point that the building owner concedes defeat and succumbs to the realization that the roof must be replaced or recovered. But what actually happened to the roof? Why did it "wear out?"

Physical damage may have been the result of excessive foot traffic, hail, or tree limb impact or abrasion, scouring of ballast, airborne dirt, and thermal cycling, causing the membrane to fatigue and crack. The thermal effects may be seasonal (summer to winter) or diurnal (day to night). Freeze/thaw cycling also causes physical damage. Physical damage encompasses membrane stress resulting from excessive dead and live loads. The record snowfalls of the winters of 1996 and 2005-06 are examples of this scenario. Other forms of physical damage are related to wind uplift, causing stress on the membrane and fasteners used to affix the insulation board and membrane to the structural deck.

Recent years have also seen a notable trend toward light-gauge roof deck construction using bar joists and light-gauge fluted metal decks. This increases the deflection that can occur either from live or dead loads. Increased deflection will also increase the size of long-term standing water or "ponded" areas on the roof. These factors have increased the physical stresses placed on the roofing system and particularly on the waterproofing membrane.

The term "chemical effects" used here refers not merely to the effects of atmospheric pollutants, but embodies the chemical changes the roof membrane undergoes as a result of weathering. These include loss of light fractions in asphalt and coal tar and loss of plasticizer in thermoplastic and vulcanized single-plies.[1,3,4,5]

Sunlight – more specifically the UV component of the sun – can initiate chemical reactions that are observed as membrane embrittlement.[1,2] Oxygen from the air can react with asphalt, just as the commercial process of "blowing" used to manufacture harder or higher "pen" types of asphalt. The sun also provides heat necessary for accelerating the rate of these chemical degradation effects. Classic chemistry textbooks clearly document this causal relationship.[6]

From a roofing standpoint, the hotter the roof gets, the faster it will wear out. With greater emphasis on increased building insulation, the solar heat cannot dissipate through the deck and into the building, but rather builds up within the membrane and accelerates the degradation process. This heat also accelerates the loss of plasticizers and "light fractions" from single-plies and asphaltic membranes. Again, classic chemistry has shown the diffusion mechanism to be thermally accelerated.[7] The hotter the environment, the faster the reaction.

Water acts to extract chemical components and participates in the galvanic electrochemical reaction observed as metal roof rusting.

Chemical pollutants are another factor in roof degradation. These include acid rain and microclimate pollutants such as effluent and exhaust stack gases from nearby manufacturing equipment.

All of these factors, individually and in concert, cause the membrane to deteriorate. Theoretically, a maintenance coating can act as the first layer of protection on the membrane. The "ideal" coating would block UV solar attack and keep the roof cool. It would also prevent further egress of light fractions of asphalt from BUR and modified bitumen, and plasticizers from single-ply materials. It would provide some measure of water resistance to prevent its contact with the underlying roof. This would reduce leaching out of light asphalt fractions from BUR or modified bitumen and eliminate the physical damage caused by freeze/thaw cycling.

When to Maintain

The use of coatings is sometimes considered during the design phase of a roofing project, but all too often, is dismissed as not necessary to achieve the building owner's immediate need for a watertight building. This decision is easily cost-driven when the building owner sees the proposal for the new roof.

If the coating is to be applied during the service life, the question is, "When is the appropriate time to coat the roof?" The obvious answer is, "While it is still possible for the coating to be effective." If the roof has significant water entrapped below the membrane, the prudent decision would be to tear off that section and replace it with new membrane. However, if the mechanical and structural integrity of the membrane is viable, then it would be a suitable candidate for coating. The mechanical and structural integrity of the membrane refers to the membrane's ability to tolerate the mechanical stresses associated with that specific roof under those specific design and environmental factors. If the reinforcing mat or scrim in a single-ply has deteriorated substantially due to excessive weathering, an unreinforced coating cannot be expected to have the tensile strength required to maintain the membrane. Similarly, if the glass or polyester mat of a conventional built-up or modified bitumen roof has significantly deteriorated, the surface may not be suitable for coating. Today's coatings, without scrim reinforcement, are not capable of providing the tensile strength normally provided by glass and polyester mats.

Functional Demands

Roofing membranes move. Thermal effects caused by diurnal and seasonal temperature changes cause loose-laid, mechanically fastened, and fully adhered membranes to move. Obviously, the amount of movement is a result of the coefficient of expansion of the membrane material and the temperature extremes the membrane experiences. If one considers the adhered coating as an integral part of the membrane, the coating must also tolerate the movement dynamics associated with the exposure. Thus, the proper coating selection must tolerate these demands.

Adhesion

By definition, the coating is a "fully adhered, single-ply membrane formed *in situ* on the existing roof." For the coating to function properly, it must remain adhered. Many chemical and interface science principles are involved in the study of adhesion and are beyond the intent of this paper. But simply stated, adhesion is an interfacial property, i.e., the quality of adhesion is dependent on the composition of each of the materials being joined. Applying an epoxy adhesive to a silicone release paper will not provide a satisfactory bond. However, the glue is not deficient. Thus, the quality of adhesion of a roof coating is a function of the coating and the membrane, the coating substrate.

As a membrane surface ages, several things happen. Release agents, talc, sand, mica, and other parting agents erode away. If cleaned, this will improve the quality of the adhesive bond between the coating and the membrane. In addition, the surface begins to wear or scuff as it is impinged by wind-blown dirt and debris. This wearing away is particularly helpful in improving adhesion, just as a house painter might lightly sand an already painted surface before repainting. However, as the membrane ages, environmental fallout begins to collect on the surface, interfering with adhesion. Also, as the membrane weathers, it may "chalk" or generate a powdered surface, which will act as a release agent and compromise the adhesion quality. Proper surface cleaning prior to coating application can dramatically reduce or eliminate these problems.

Water Resistance

While adhesion and tolerance for dynamic movement are critical for a successful roof coating, the need for water resistance may or may not be a critical requisite. If the maintenance coating expectations include stopping leaks that have developed during the weathering period, the coating must have sufficiently low permeance to act as a waterproofing membrane in the same fashion as the existing roof. If the coating requirements are to protect the existing roof membrane, then low permeance is not a performance requirement.

However, whether or not the coating provides actual water resistance, it is also important for it to exhibit low swelling characteristics. Swelling is defined as the percent weight or volume gain after immersion into a solvent (water). If the coating exhibits high swelling values, the volume increase will produce unwanted stress on the coating-to-substrate interface. This can result in coating delamination.

While the above paragraphs may have created some confusion regarding how to identify a "quality coating," this can be greatly simplified by employing ASTM D-6083, "Standard Specification for Liquid-Applied Acrylic Coating Used in Roofing." This specification, first introduced in 1997 and reapproved in 2005, outlines specific tests and minimum values for mechanical properties (tensile strength and elongation), adhesion, permeance, water swelling, mildew resistance, and in-can physical properties.

Buildings with roof coatings installed.

What the Coating Does that the Original Roof Covering Didn't Do

Does the coating replenish or rejuvenate the roof? For many years, asphalt re-saturants had been touted as replenishing the light fractions of asphalt into the bituminous membrane. The light fractions in the original roof dissipate during natural weathering and cause the membrane to become brittle and less tolerant of the movement dynamics associated with the roof. This concept can be considered as the "sacrificial anode" of roof membrane restoration. This analogy is derived from the use of zinc plates attached to ships subject to galvanic corrosion in salt water. The anode preferentially corrodes and dissolves rather than the necessary ferrous components. The zinc is periodically replaced as a maintenance activity. Theoretically, plasticizers and oils used to enhance the flexibility of some single-ply membranes could be applied to the weathered membrane to prolong its life.

From a practical perspective, chemical components that leach out during weathering and can be readily re-infused into the membrane via a maintenance coating will probably migrate out in a similar but shorter timeframe. The ideal coating, from a practical standpoint, would at least prevent further loss of plasticizers and other key components from the membrane. However, if the coating could block UV, reduce water contact with the membrane, and keep the membrane cooler, the roof would indeed last longer.[1]

Are All Roofs Maintainable with Coatings?

This question can be answered with the statement, "Yes, if the coating provides some performance property inherent in the roofing membrane that has deteriorated as a course of normal weathering." For example, the coating on a metal roof may erode during weathering and can be recoated using the appropriate maintenance coating. Even uncoated metal subject to galvanic corrosion can be coated with a corrosion-inhibiting coating to prolong the roof life. Built-up and modified bitumen roofs subject to surface degradation can be coated with products that can provide additional protection in the form of high film thickness over the weathered and worn areas. If the coating has additional reflective properties, in the case of white coatings, the roof membrane temperature can be reduced and the life extended.

As single-ply roofs weather, causing chalking, crazing, and checking, they too can be maintained. This type product would be specifically formulated to adhere to the membrane, tolerate the dynamics associated with the installation method (i.e., fully adhered or mechanically attached), and have excellent weathering characteristics equal or superior to the membrane chemistry. The coating must have the functional properties necessary to be compatible with the existing roofing assembly and membrane.

A white or light-colored, reflective coating applied to a black, single-ply membrane will reduce the membrane temperature and thus reduce the thermally induced elongation and contraction of the membrane. This will reduce the stresses imposed on the mechanical attachments of the membrane.

> Improved understanding of the roof's physical and dynamic requirements will ensure a successful coating selection and installation.

Life Cycle Cost Effects (LCC)

Life cycle costing is an excellent system for demonstrating that low first cost (i.e., a cheap roof) may actually be more expensive than a premium system when studied over the life of the roof. A simple analogy exists with an automobile requiring routine maintenance. The premium automobile will ideally require fewer repairs during its service life than a cheaper model.

The use of coatings has been studied and shown to reduce the life-cycle costs for the roof.[8] Obviously, the longer a roof can remain in place without costly tear off, disposal, and disruption to the occupants during re-roofing, the lower the long-term cost. Coating and subsequent recoating offer several additional benefits from a LCC standpoint. Periodic maintenance and recoating provide the roofing professional with an opportunity to inspect and survey the condition of the roof. He can then effect the necessary repairs while the problems are still relatively minor. Also, unlike reroofing, coating and recoating add relatively little dead load to the structural demands of the roof. The typical elastomeric coating applied at three gallons per square adds merely 24 pounds per square when dry. Thus, many recoats can be applied without concern for structural load issues.

"Cool Roofing," Solar Reflectance, EnergyStar, California Title 24, and LEED

The concept of "cool roofing" has gained tremendous support through such governmental initiatives as the Environmental Protection Agency's EnergyStar program, California Title 24, and private efforts through USGBC's LEED program. Each of these requires the roof to have a high solar reflectance and thermal emittance, with the obvious value of reduced air conditioning costs and reduced ambient air temperature. While the benefits of this technology are intuitively obvious, ironically, data reported by the National Roofing Contractors Association (NRCA) have shown that approximately 80% of installed roofs do not qualify for EnergyStar or these other mandates.

White acrylic roof coatings have proven fully satisfactory in complying with these requirements over all types of low-slope roofing substrates. There are numerous calculators available to estimate the air conditioning energy savings afforded by coating a dark-colored roof with a white, acrylic roof coating. Both Oak Ridge National Laboratory and Lawrence Berkeley Laboratory have calculators on their Web sites. Moreover, there are several proprietary mathematical models that are even more sophisticated than the ORNL and LBL models that can generate more accurate estimates of energy cost savings.

The Cool Roof Rating Council (CRRC) was formed to provide a fair and accurate measure of radiative properties of roofing materials. Values for radiative properties have been measured independently by the CRRC, with some products having over 90% solar reflectance. Specific product listings are provided on the CRRC Web site, **www.coolroofs.org**. Currently, only initial reflectances are listed. Three-year exposure data are being generated. The aged reflectance will be lower as a result of dirt pickup associated with natural weathering.

USGBC's LEED program also allows for points to be awarded for roofing material with high solar reflectance and thermal emittance properties. While not all roofing materials meet these requirements, simply applying a white acrylic coating to the roof substrate will result in LEED points being awarded.

Summary

Acrylic coatings have proven to be a useful and complimentary tool in maintaining and sustaining roofs. Today's high-performance, acrylic, elastomeric coatings not only protect the underlying roofing membrane, but also provide air conditioning energy savings through solar reflectivity. These coatings have demonstrated significant "value-add" to the building in actual life-cycle cost studies. Moreover, these coatings are actually more weather-resistant than some membranes they protect. Ideally, in the future, only the original roof will be required, which can be easily coated periodically, just as floors or walls are painted and repainted. "Sustainable roofing" exists today through the use of acrylic coatings.

The roofing professional and the building owner can incorporate the criteria described in this paper to make a prudent and cost-effective acrylic coating selection. Improved understanding of the roof's physical and dynamic requirements will ensure a successful coating selection and installation.

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