ARMA WHITE PAPER: LOW-SLOPE COOL ROOFING

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A “cool roof” is defined as one that uses roofing products with high solar reflectance (the ability to reflect the visible and near-infrared wavelengths of the sun’s energy) and high thermal emittance (the ability to re-radiate absorbed energy). Although high reflectance/emittance products are an increasingly popular roof option, they are only one of many approaches to help building and home owners reduce building energy use and address contemporary environmental concerns.

LOW-SLOPE COOL ROOF OPTIONS

Cool roof options are available for virtually any roof and any building structure, and they can often be utilized in conjunction with other building envelope enhancements to accomplish design goals.

Asphalt roof systems used on low-slope roofs generally are constructed on site by assembling multiple layers of individual products to create a roof system with superior durability and waterproofing protection. These roofing systems generally fall into two categories – modified bitumen roofing (“MB”) and built-up roofing (“BUR”). MB and BUR roofing systems have been successfully utilized for well over 40 years and 100 years, respectively, and constitute over 40% of today’s North American low-slope roofing market.[1] Low-slope asphaltic roof membranes provide arguably the longest-lasting roof system available.[2] Because of their longevity, asphaltic roofing systems provide excellent value for building owners by delivering superior durability and sustainability at reasonable cost.

Asphaltic roof systems (except metal foils) typically have thermal emittance values greater than 0.80. However, solar reflectance of these systems varies significantly based on the surfacing used.

Granule-surfaced Cap Sheets
A cap sheet is the final layer installed during construction of many MB and BUR roof systems. Mineral granules are a surfacing material that has been used for many years, and use of either conventional white or reflective granules can generate cap sheets with solar reflectance values from less than 0.30 to greater than 0.80.

Reflective Cap Sheets
In recent years, manufacturers have begun offering reflective cap sheets that allow construction of highly reflective roof systems. Although a variety of technologies are used to create these materials, all share a common goal of providing cap sheets with solar reflectance values that range from 0.65 to 0.85.

[1] NRCA Market Survey, 2015-2016
[2] “Roofing Industry Durability and Cost Survey,” Carl Cash, RCI Proceedings, 2005

Metal-foil Surfaced Cap Sheets
These products are produced with a metal foil surfacing which can provide high reflectivity, but the foil surface typically results in thermal emittance values that are significantly lower than other asphalt roof surfacing options.

Field-applied Coatings
Roof membrane coatings have been used for decades as a surfacing option for low slope asphaltic membranes. These coatings are typically protective in purpose, providing the membrane a finished surfacing and protection from UV degradation. They are available in a variety of formulations, including bituminous emulsions, solvent-based bituminous coatings, silicones, and acrylic roof coatings. Depending on the formulation and color selected, solar reflectance values can range from less than 0.20 to greater than 0.80.

Gravel or Stone (aka Aggregate) Surfaced Systems
Use of gravel or stone as the surfacing for BUR systems is an established practice that has been employed for decades and is variously referred to as gravel, stone, aggregate, or ballast surfaced. Although these systems generally do not have high solar reflectance values, research has shown that "a ballasted system with a reflectance value of only 0.21 does perform at the same level of thermal performance" as products rated by Energy Star® for solar reflectance and thermal emittance.[3] Gravel-surfaced systems are expected to maintain their thermal performance throughout their service life even if their reflectivity changes. Recently, gravel products with high reflectivity properties have been introduced to the market, with some values approaching 0.70.

Various test methods are used to measure solar reflectance and thermal emittance of roofing materials. The ASTM standards listed below are employed to determine the associated properties. Values determined by the various methods are generally similar although not identical.

Reflectance	ASTM C1549, E903, or E1918
Emittance	ASTM E408 or C1371
Solar Reflectance Index	ASTM E1980

COOL ROOF LIMITATIONS

While cool roofs can offer a number of immediate and long-term savings in building energy costs, as well as environmental benefits, there are potential drawbacks to consider. Cool roofs may show dirt, algae and stains more than traditional low-slope asphalt roofing systems due to their typically lighter color and may require cleaning and maintenance to retain their high reflectivity. If not properly performed, cleaning can damage the roofing products.

Prior to installation of a cool roof, consider the potential effect on adjacent surfaces or buildings that will be exposed to concentrated reflected heat, which can damage surrounding building components, such as plastic, masonry and other rooftop equipment.[4]

Impact on occupants of surrounding buildings is another design consideration that should not be ignored. Light reflected into adjacent structures can be troublesome for building occupants during certain times of the day. This consequential effect needs to be taken into account before installing a highly reflective roof surface.

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[3] Desjarlais et al, "Evaluating the Energy Performance of Ballasted Roof Systems," Oak Ridge National Laboratory Report Number UF-04-396, September, 2007.
[4] "A Roofing Industry Professional Shares His Views About Current Issues Facing the Industry," *Professional Roofing*, October, 2008.

Another issue is the potential for moisture condensation within the roof assembly. The lower surface temperature of cool roofs reduces heat transmission into the building relative to traditional roofing materials. This leads to an increased risk of moisture accumulation, especially in cooler climates, because there is less heat available to dry out roof assembly materials.[5] "If a reflective cool roof is designed for a temperate or cold climate, its moisture behavior should be analyzed by hygrothermal simulations in order to avoid critical water content in the construction."[6]

Former U.S. Secretary of Energy Dr. Steven Chu has suggested "painting all roofs white" to help offset carbon dioxide.[7] Such a broad generalization can help make a point, but in many cases taking such an action is neither practical nor appropriate, and can lead to unintended consequences that can adversely affect the roofing system or other building components. For instance, typical exterior paint is not suitable for use as asphalt roofing system coating. Only products specifically designed for use as a roof coating and approved for use by both the roofing product manufacturer and coating manufacturer should be considered.

CONSIDER THE WHOLE BUILDING ENVELOPE

The roofing system is a vital component of a building's moisture and thermal barrier and deserves in-depth consideration when developing policy or incentive programs. However, it is only one component in the building envelope. ARMA asserts that the "whole building envelope" approach, which considers *all* elements of the building envelope, internal and external, is the appropriate method to comply with today's green building programs, energy codes, and standards. The selection of a low slope roof system should be based on performance requirements of the overall building, taking into account information pertaining to the roof's durability, environmental impact during its entire life-cycle, and its economic feasibility and cost effectiveness. Affordability and flexibility of choice are two additional requirements for any low slope roof system. Performance as a cool roof is only one of several factors to consider.

In addition to the cool roof options described previously, there are many areas of the whole building envelope that can be addressed to reduce energy use and accomplish environmental goals.

Insulation
Insulation can be used in lieu of, or in addition to, highly reflective surfaces. Insulation is often allowed as an alternative to cool roofing. A major advantage of insulation is that it does not require cleaning over its lifetime and works well in both cooling and heating climates, reducing energy usage throughout the year.

Glazing
Glazing elements have a significant impact on building energy efficiency, and proper selection is an important design consideration. Not only must the properties of the glazing elements be considered, but proper installation and integration with other building envelope elements is necessary to assure desired performance is achieved.

Vapor Retarders
The use and proper placement of vapor retarders where required can have a major effect on the energy efficiency of the roofing system and building envelope. It is important to understand proper vapor control principles and insure that a vapor retarder is utilized when required to mitigate water vapor damage to the roofing system.

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[5] Urban, Bryan and Kurt Roth, "Guidelines for Selecting Cool Roofs," U.S. Department of Energy: Building Technologies Program, July, 2010.
[6] "Condensation Problems in Cool Roofs", Bludau, Zirkelbach, Künzel, 2008
[7] Chu, Steven, "White Roofs to Fight Global Warming", *Wall Street Journal*, May 27, 2009

Air Barriers

Like vapor retarders, the proper placement and utilization of air barriers impacts the energy efficiency of the roofing assembly and building envelope assemblies. Air barrier materials control heat flow and air movement in the building enclosure. Proper material selection and placement within assemblies are necessary to reduce energy losses, primarily through the loss of conditioned air from within the building.

BENEFITS OF COOL ROOFS AND THE WHOLE BUILDING ENVELOPE APPROACH

When properly utilized in a building's overall design, both cool roofs and the other building envelope enhancements discussed previously can offer benefits for both the building owner and the environment.

Improve Energy Efficiency

A reduction in heat transfer into the conditioned space of a building improves energy efficiency in the cooling season, but may have the opposite effect for heating loads. Balancing these competing variables is a complex and critical design consideration that is specific to the building, its geographic location, and the relative cost to heat and cool the building. A combination of options may provide the best design solution. As an example, cool roofing is an excellent choice to reduce solar heat gain, but is an incomplete solution in climates where heating costs predominate. Combining reflective roofing with insulation is one approach that may be more appropriate.

Reduce Urban Heat Island Effect

A localized temperature increase in an area with a high concentration of surfaces that absorb and retain solar energy (e.g. roofs, streets, sidewalks) is referred to as the "urban heat island effect." Cool roofs are a viable option to help address this issue. By reflecting a portion of incoming solar energy, cool roofs reduce the heat gain of the roofing surface, resulting in less localized temperature increase. Other approaches to improve energy efficiency (e.g. insulation, improved envelope sealing) can help mitigate urban heat islands as well by reducing operating demands on HVAC equipment, which reduces the amount of elevated temperature exhaust released into the local environment.

Reduce Greenhouse Gas Generation

Any building envelope enhancement that reduces building energy use can contribute to a reduction in greenhouse gas generation. However, the magnitude of this benefit depends directly on the fuels used to cool and heat the building. In areas where utilities generate energy primarily from fossil fuels, energy efficiency improvements, including cool roofs, may help reduce greenhouse gas generation. This may not be the case if energy is generated using methods that do not produce greenhouse gases (e.g. wind, solar, hydroelectric).

Offset Carbon Dioxide

Cool roofs have been touted as one mechanism to offset carbon dioxide emissions and potentially delay climate change.[8] Increasing the reflectivity of the built environment is a form of geoengineering intended to reduce the average temperature of the planet, and cool roofs can play a part in this effort. However, application of this concept on a wide scale raises serious questions that are beyond the scope of this paper to address.

Improve Roof Durability

By design, cool roofs reflect solar energy away from the roof surface, leading to a reduction in the average surface temperature of the roofing system. Since heat is one factor that contributes

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[8] "Global Model Confirms: Cool Roofs Can Offset Carbon Dioxide Emissions and Mitigate Global Warming," Lawrence-Berkley National Laboratory News Release, July 19, 2010.

to roof aging, the reduction in surface temperature is expected to have a positive—although possibly not easily measurable—impact on roofing system durability.

RESPONSIBILITY AND CONSUMER CHOICE

Cool roofs may be required by code or regulation in some jurisdictions. In others, incentive programs are used to drive consumer choice. In many cases, third-party verification of product solar reflectance and thermal emittance is specifically required by these programs. Unfortunately, some jurisdictions (e.g. California) have limited the third party verification function to a single organization (i.e. Cool Roof Rating Council). Allowing competition in the third-party verification arena will positively affect cost of compliance. ARMA encourages and supports the availability of multiple verification agencies.

Importantly, ARMA believes that the cost of a cool roof must not outweigh its benefits over its lifetime. Building owners and consumers selecting cool roofing options must be confident in the economic value initially and over time.

In some cases, energy efficiency goals are not based on cost effectiveness, but are based on social goals such as reducing greenhouse gas emissions. Society has limited resources to address issues like reducing greenhouse gas emissions, and needs to achieve those goals in the most cost effective manner without further burdening the consumer.

CONCLUSION

While a roof's primary function is to keep water out of the building, today's environmentally-conscious agencies and consumers have made cool, an increasingly important consideration in the roof selection process. In a similar fashion, these groups are promoting cool roofs as the best solution to achieve energy efficiency and environmental goals for buildings. ARMA recommends weighing the potential benefits and limitations of all cool roof options when making roof selection decisions, and encourages designers to remember that a combination of strategies may provide the most suitable option. Finally, ARMA believes the best solution will be achieved when cool roofs are recognized as but one option within the "whole building envelope" that is available to accomplish energy efficiency and environmental goals.

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The Asphalt Roofing Manufacturers Association (ARMA) is the trade association representing North America's asphalt roofing manufacturing companies and their raw material suppliers. Committed to advances in asphalt roofing, ARMA produces white papers and technical bulletins to educate consumers and industry stakeholders about the benefits of asphalt as the roofing solution.