Expectation of metal roofing reflected in LEED version 2.2

By Kevin Corcoran and Gene Johnson

The architectural community has embraced the concept of sustainability using the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) program as an economic and environmental standard for measuring construction products and systems conducive to green building. And while other ad hoc organizations and standards are pushing their way into the marketplace with variations of standards, more than 20,000 building and design professionals have already earned LEED certification.

Used as a guide toward environmental design, LEED standards were the brainchild of the Green Building Council ,whose members are government officials, architects, interior designers, builders, manufacturers, and representatives of several branches of the military. That group conceived, tested, and voted on the rating criteria.

The Englert standing seam roof installed on the South River Primary school in South River, N.J., is painted in the school's colors — Colonial Red and Slate Gray. The Ultra-Cool colors meet LEED requirements. ENGLERT PHOTO

Role of metal roofing

The USGBC unveiled changes to the LEED program at its Greenbuild Conference & Expo in Atlanta in November. Among the many changes affecting scores of LEED categories were new requirements that affect metal roofs.

The LEED program uses a credit or point system to establish an overall building performance. Points are earned for various sustainable features in five categories: building site, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. Ratings — categorized as platinum, gold, silver, or certified — are based on the number of points earned. A building rated platinum needs at least 52 points out of a total of 57 to qualify, while a gold rating would mean it has scored 39 to 51 points. Scoring in the 33 to 38 range is needed to achieve the silver level and a certified rating requires a score of 26 to 32 points. According to the Green Building Council, a platinum-rated building would be able to effectively reduce its environmental impact by more than 70 percent, and a gold-rated building by approximately 50 percent.

Like other green organizations seeking to establish standards for environmentally sound construction, the USGBC is seeking to generate consumer awareness of green building benefits through the LEED program that hopefully will engender design and construction that will be the norm for building in the future.

The new LEED Version 2.2 requirement retains its original intent of reducing heat islands to minimize impact on the environment but changes the requirements necessary to qualify for the Heat Island credit. Now roofing materials used on low-slope roofs with a slope of less than 2:12 must meet a solar reflectance index, or SRI, of 78 while steep-sloped roofs with a slope of more than 2:12 must have an SRI of 29.

An SRI is defined as "a measure of the constructed surface's ability to reflect solar heat as shown by a small temperature rise. It is defined so that a standard black with reflectance of 0.05 and emittance of 0.90 is zero, while
the SRI for a standard white with

reflectance 0.80 and emittance 0.90 is 100."

Calculating SRI

To calculate the SRI for a given material, it is necessary to obtain its reflectance and emittance values. SRI is calculated according to ASTM E 1980, a standard practice for calculating the solar reflectance index of horizontal and low-sloped opaque surfaces with emissivity greater than 0.1. Reflectance is calculated according to any one of three ASTM standards—ASTM E 903, ASTM E 1918, or ASTM C 1549.

ASTM E 903 covers the measurement of spectral absorptance, reflectance, and transmittance of materials using spectrophotometers equipped with integrating spheres.

ASTM discontinued this test method in August 2005 in accordance with section 10.5.3.1 of the Regulations Governing ASTM Technical Committees, which requires that standards shall be updated by the end of the eighth year since the last approval date.

ASTM E 1918-97 is a Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field and covers the measurement of solar reflectance of various horizontal and low-sloped surfaces and materials in the field, using a pyranometer. The test method is intended for use when the sun angle to a surface is less than 45 degrees.

ASTM C 1549 is a standard test method for determining solar reflectance of flat opaque materials in a laboratory or in the field using a portable, commercial solar reflectometer. It does not replace and is supported by comparison of measurements gained from E 903.

Emittance is calculated according to ASTM E 408 or ASTM C 1371. ASTM E 408 is a standard test method for total normal emittance of surfaces using portable inspection-meter techniques. ASTM C 1371 is a standard test measure for determining emittance of materials near room temperature using a portable, differential thermopile emissometer to evaluate temperatures, heat flows, and the thermal resistances of materials.

Cool roofs lead to LEED points

Regardless of their material, "cool" roof materials have two important surface properties: a high solar reflectance and a high thermal emittance. Solar reflectance is a measure of the ability of a surface material to reflect sunlight — including the visible, infrared, and ultraviolet wavelengths — on a scale of 0 to 1. Essentially, it is the percentage of solar energy reflected by a surface. Solar reflectance is also called "albedo."

Thermal emittance is defined as the percentage of energy a material can radiate away after it is absorbed. Solar emittance of a material refers to its ability to release absorbed heat. Scientists use a number between 0 and 1, or 0 and 100 percent, to express emittance. With the exception of metals, most construction materials have emittances above 0.85 (85 percent).

With respect to roofing products, LEED previously used the Energy Star program as the qualification for a solar reflectivity environment credit. Both the Energy Star program and LEED program had specifically spelled out that the minimum solar reflectance of a low-sloped roof must be 65 percent initially and 50 percent after three years of in-field aging, and 25 percent initially and 15 percent after three years for steep-sloped roofs.

LEED had differed from Energy Star in that it also had required data concerning the thermal emittance of the roofing product. The LEED program had required that in order to achieve a credit, the product must have a minimum emissivity of 0.9 for 75 percent of the roof surface and made it clear it was not acceptable to round up the emissivity value in order to achieve this credit under LEED standards.

The solar reflectance of cool roofs tends to decrease over time. This is because surface particles like dew, dust, and air pollutants accumulate. Another factor that affects long-term solar reflectance is slope — the greater the angle of roof slope, the more dirt and particles dislodge and fall off the roof surface. Studies done at the Florida State Energy Center show that during the first two years of a cool roof's life span, solar reflectance can deteriorate up to 11 percent for a membrane roof if regular maintenance is not provided. However, studies by various Kynar paint manufacturers show that the solar reflectance of metal roofing material remains almost constant.

Cool roofs reflect heat well across the entire solar spectrum, especially in the infrared and visible wavelengths. The less solar radiation materials absorb, the cooler they are. In addition to absorbing less heat, the coolest roofing materials radiate away any absorbed heat.

Solar reflectance and thermal emittance have noticeable effects on temperature. Conventional roof surfaces have low reflectance from 0.05 to 0.25 and high thermal emittance typically over 80 percent. These surfaces can heat up to 150 to 190 degrees Fahrenheit at midday during the summer. Bare metal or metallic surfaced roofs have a solar reflectance of 0.5 or higher and may have low thermal emittance, anywhere between 20 to 60 percent, depending on their surface treatment. These surfaces warm to 140 to 170 degrees Fahrenheit. Cool roofs with both high reflectance and high emittance properties warm to only 100 to 120 degrees Fahrenheit in the summer sun.

Department of Energy research shows that one additional percent of reflectivity in a coating on average will reduce the roof temperature by one degree. The ultimate result is heat is reflected away from buildings, energy costs are lowered, smog is reduced, and the life expectancy of the roof will be increased due to less expansion and contraction.

Emissivity leeway

However, utilizing the weighted average calculation as defined by LEED in one of its recent Credit Interpretation Rulings (CIR), only 75 percent of the roof surface must have 0.90 emissivity. Any level of emissivity is allowed for the remaining 25 percent. There are many LEED Credit Interpretations Rulings that have allowed a lower emissivity or solar reflectance — but not both — where 100 percent of the roof surface is covered by one material, including a painted metal. The following calculation results when using the thermal emittance requirement of .9 on 75 percent of the roof surface requirement:

[(75 percent minimum coverage X .90 Emissivity) + (25 percent X .10) (the emissivity of bare Galvalume)] = .70 over all emissivity for 100 percent of a roof surface excluding parapets, skylights, and equipment

This means any pre-painted metal covering 100 percent of the roof, meeting the Energy Star Solar Reflectance specification, and having a thermal emittance of .70 or greater, meets or exceeds the LEED 7.2 credit criteria. The most widely known credit for roofing is LEED Credit 7.2, for roofs reducing the heat islands effect, worth one LEED point. The intent, according to LEED, is to "reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat."

Urban areas produce what is called the urban heat island effect with dark, heat-absorbing roofs ranked among the chief culprits. The temperatures in the air above heat islands and their heat-absorbing roofs can be as much as 12 degrees Fahrenheit hotter than the surrounding suburbs, leading to higher air conditioning costs, greater use of electricity, and discernable, unhealthy levels of smog and ozone.

These Credit Interpretation Rulings can be critical when planning a LEED-compliant building and are available from the Green Building Council in a catalog of questions formally asked of the U.S. Green Building Council by registered LEED projects, along with the USGBC's official answers to those questions. CIR rulings, once published, apply to all subsequent projects, and provide important guidance not found in the LEED reference manual.

Most industry experts agree that reflectivity has a greater impact than emissivity on the energy performance of the roof during hot weather. If a majority of the initial solar radiation is reflected, then a smaller portion is left for infrared emittance. Many cool roofs have reflectivities of 75 to 80 percent, or 0.75 to 0.80, which means that only 20 to 25 percent of the sun's energy is absorbed into the roof.

According to the Lawrence Berkeley National Laboratory, at an ambient temperature of 98 degrees, a change in a roof's emissivity from 0.75 to 0.90 while keeping reflectivity constant results in a surface temperature reduction of two degrees. Conversely, raising a roof's reflectivity from 0.25 to 0.40 while keeping emissivity constant, results in a surface temperature reduction of 13 degrees, a substantial difference.

Still, the combination of high reflectivity, usually a result of light-colored or white surfaces, and high emissivity during hot summer months results in a surface temperature sometimes as much as 60 to 70 degrees cooler than a non-reflective roof. The reduction in heat energy means less need for air conditioning and lower energy costs.

RESOURCES

U.S. Green Building Council
www.usgbc.org

Leadership in Energy and Environmental Design
www.usgbc.org/LEED

Cool Roof Rating Council
www.coolroofs.org

Sustainable Project Rating Tool
www.cecer.army.mil/SustDesign/SPiRiT.cfm

Englert
www.englertinc.com

Cool palette keeps growing

Tests have shown that on a 90-degree day, a white roof will only have a temperature of 110 degrees at its surface while a black roof will have a reading of 190 degrees. However, it would be a very dull country if architects and builders could not enhance the appearance of their products and were restricted to white, despite the energy savings. Consequently, roof coatings manufacturers have been developing cool roof coatings that increase heat reflectivity and reduce emissivity.

New infrared-reflective pigments incorporated into paints used on architectural metal roofing products allow them to achieve higher reflectivity values, even in darker colors such as black and brown. This improved reflectivity — black changes from 0.07 with normal pigments to 0.32 with infrared-reflective pigments, for example — can mean a much cooler surface temperature and thus greater energy savings for the building below. This allows facility executives to select a sustainable roof without having to sacrifice color choices and aesthetics.

Much has been discussed about the ability of existing cool roof products to meet Energy Star and LEED requirements for reflectivity and emissivity.

Most of the cool roof coatings and colors available today have little or no trouble meeting the reflectivity standards. Some, however, would fall short in meeting emissivity requirements if the entire roof surface required it.

Other cool factors

While the reflective and emissive properties of a roof are important concerns, they are not the be all and the end all. Other factors such as insulation, roof orientation, and roof slope are equally essential to a building's overall energy efficiency. Cool roofs save more energy when installed on buildings with low roof insulation. Attic radiant barrier can be used to reduce the energy saving potential of cool roofs. Buildings with low attic ventilation see a greater benefit from a reflective roof. Climate plays a huge role, particularly in areas with long, sunny, hot summers where cooling energy savings are typically greatest.

In addition, building owners should never agree to a roof based solely on its color. The long-term performance characteristics of metal roofing should be strongly considered, particularly its low maintenance costs and durability.

The question remains however, if a cool roof will be a thermal detriment in traditionally cooler climates characterized by cool summer evenings and cold winters.

A roof designed with specific reflective and emissive properties can't change its properties with the technology currently available in the marketplace. Perhaps a decade from now we will see acrylic-wax coatings that can repulse heat in summer and absorb it in winter (see sidebar, page 30). But for now, the effectiveness of a cool roof must be gauged by energy saved during the hot summer months versus energy consumed during the cold season. Some critics of the LEED prescription for cool roofs contend that geographics are missing from the standard and must be included to accommodate environmental considerations unique to cold climates where the cost of energy required to compensate for heat loss would make a cool roof counterproductive.

Some experts contend the summer cooling savings even in cold climates are able to counteract the winter heating losses. They argue that days during the winter months are shorter and the solar angle is lower so less total energy is hitting the roof to be absorbed or reflected over the same period of time as during the summer. They also contend that white snow piled up on the roof during the winter reflects the sun's energy and that resources like natural gas and oil have been traditionally cheaper than electricity to heat buildings in the winter.

Arguments like these have been a key reason why some critics of the LEED standard are arguing for revisions or looking to other organizations to emerge with their own criteria for judging what is green.

Achieving compliance

LEED stipulates that products and their manufacturers meet standards before they can be designated Energy Star or LEED compliant products. In the case of Energy Star and LEED, any qualified laboratory can determine the solar reflectance required by the program. The laboratory does not need to be independent of the material manufacturer; therefore both third party and manufacturer laboratories can be used to provide data to the Environmental Protection Agency.

However, the Cool Roof Rating Council, an independent non-profit industry association, requires that the laboratory conducting the measurement be accredited. Either the lab must be listed as an Accredited Independent Testing Laboratory (AITL) by the CRRC or it must be an Accredited Manufacturers Testing Laboratory (AMTL) to perform the determine reflectivity and emissivity. Both the AITL and the AMTL must meet the requirements of the CRRC, which includes ISO certification of the lab, as well as additional required CRRC training. (For more information, visit www.coolroofs.org.)

There are no fees for having products listed as being Energy Star compliant. Therefore, there is no fee for the LEED compliant evaluation of roofing products. However, associated fees may be required for obtaining recognition of the complete facility construction through the LEED program.

The non-profit CRRC does have a fee structure, which is based upon the volume of all roofing products manufactured or applied by the licensee. The association also charges a label fee for each product type. That label fee is broken down into two categories; one that relates to frequently produced products and one that relates to custom colors, applicable to metal roofing applications.

Government awareness

The cost efficiencies of green building have been widely questioned and debated, but for those interested in building environmentally sound structures, the LEED program can result in economic and social incentives. Installing metal roofing is a path to earning those incentives.

Following President Bush's signing of H.R. 6, the Energy Policy Act of 2005, cool metal roofing can now receive preferential tax treatment.

Eighteen states have or are considering tax rebate and incentive programs tied to LEED certification. Dozens of major cities and counties throughout the United States require LEED certification for government structures or offer incentives for LEED-compliant construction.

The Air Force encourages the use of LEED for new or major renovations for military contract (MILCON) projects, has developed a LEED Application Guide for Lodging projects, and has conducted LEED training seminars for its design and construction personnel. It also has created an online design guide for sustainable development structured after LEED and is developing an online Sustainable Training course. The Army has adopted LEED into its Sustainable Project Rating Tool (SPiRiT) and all of the EPA's significant new facility construction and new building acquisition projects must meet the LEED silver standard. The federal General Services Administration requires all new GSA building projects meet criteria for basic LEED certification. The U.S. Navy stresses that submission to the USGBC for LEED certification is not a requirement, but is recommended for high visibility and showcase projects. The State Department has committed to using LEED on the construction of new embassies (180) worldwide during the next 10 years.

Whatever the standard for heat island effect in environmental building one thing is clear: A metal roof is a natural choice. And architects and builders already working with metal have a clear opportunity to add yet another reason for choosing it over other surface materials. ■

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New cool roofing technology may be on the way

Another technology may be emerging that will further enhance the effectiveness of new cool roof coatings. While its presence in metal roof coatings is still down the road, a new micro encapsulation technology that reduces energy costs and increases room comfort in wall materials may also provide an answer to roof heating and cooling problems.

BASF's Micronal phase-change microcapsules (PCM) apply an established technique used in space exploration technology for interior temperature management in buildings. The technique is simple: plastic capsules are filled with a wax that absorbs and releases energy by melting and solidifying. The technology holds microscopic wax droplets inside hard acrylic polymer shells. The small, 2- to 20-micrometer-sized microcapsules are impervious, making them safe to process, and far too small to be damaged by sanding, drilling, or cutting of the construction material.

Just as ice melts to form water when warmed and freezes again when the temperature drops below 32 degrees Fahrenheit, the wax microcapsules work in the same way, except the melting and freezing occurs at 78.5 degrees Fahrenheit. The key with the Micronal capsules is that a lot of heat energy is needed to fully melt the wax. For example, the energy required to melt 1 pound of ice at 32 degrees Fahrenheit to form water at 32 degrees Fahrenheit is actually equivalent to the amount of energy needed to heat the same pound of water from 32 degrees Fahrenheit to about 175 degrees Fahrenheit. The wax used in Micronal also absorbs a large amount of heat energy during its melting. When used in a building material, room heat is readily absorbed when interior temperature starts to climb just above the wax's melting point. While the wax is absorbing the room's heat to melt, the room temperature stays constant, thus modulating temperature swings in the room. This system works in daily cycles so that at night, when the room temperature drops below 78.5 degrees Fahrenheit, heat energy stored in the microcapsules' liquid wax is released as the wax freezes. Consequently, Micronal provides a dampening effect on the room's temperature during the day and night because it reversibly absorbs energy (e.g., from the air and sunlight), stores it, and later releases it as the ambient air temperature drops.

"Manufacturers of interior building materials can utilize BASF's Micronal phase-change microcapsules to create new product categories that can give them a competitive advantage," said Michael Guibault, a marketing manager for BASF's construction polymers business in North America. That will include exterior metal roof coatings as well, according to Tom McKay, product manager at BASF.

Guibault said that for architects, these tiny capsules add a new and innovative tool to address the growing green building trend. While phase-change microcapsules are not a replacement for insulation, Micronal enhanced coatings could enable a reduction in air conditioning needs and allow the equipment to be run at a more constant level. It can also slightly reduce the need for heating at night. ■