Cool Metal Roofing

A Hot Topic with Cool Solutions

By Chris Manning

High-performance metal roof coatings are available in a variety of color options that still minimize solar-induced heating. Photo courtesy of Shepherd Color.

Hot Stuff

Imagine getting in to your automobile in summer... the seats are hot and you know that to hold the steering wheel it's going to be even hotter. No choice, you get in, grumble how hot it is, start the engine and run the air-conditioning at maximum to cool the interior down. Does this sound familiar?

This analogy brings a simple everyday issue into perspective when we talk about cool roofs, cool colors and their relationship with the building and construction industries. The color of an object can have a significant effect on the temperature it will reach after being exposed to sunlight. Another analogy that illustrates this point is the wearing of a white shirt vs. a black shirt in summer. Black objects will absorb more heat and become hotter than white ones.

In nature and by personal choice, white is not the most popular color, nor an ideal design strategy. Architects, designers and consumers look to color to help develop presence, character, accent, contrast and individuality. Therefore, The Shepherd Color Co. (Cincinnati) for example, has developed a range of Arctic pigments that assist in meeting the very high performance requirements in metal roofing products and still minimize solar-induced heating.

Cool metal roofing products have been developed and designed with these color choices in mind and still meet the Environmental Protection Agency's (EPA) building code requirements.

Urban Heat Islands

In the design of the building, the roof has a major influence on the heat absorption of sunlight. The hot building radiates heat and warms the air and the surroundings. Put this building alongside several hundred more in a city and you get to a phenomenon known as the "urban heat island effect." From Atlanta to Chicago and Los Angeles, to as far away as Tokyo in Japan, the effect is real and measurable.

In its Heat Island Reduction Initiative, the EPA reports:

- 50 percent of the population live in urban areas;
- 70 percent of the solar energy is absorbed by dark-colored pavements and roofs; and
- Urban areas are 12 degrees Fahrenheit warmer than the suburbs.

Depending on the roof construction, type, elevation, and especially color, the amount of heat radiated into the atmosphere will vary enormously. The amount of heat will also be absorbed through conduction into the building. With all this heat energy

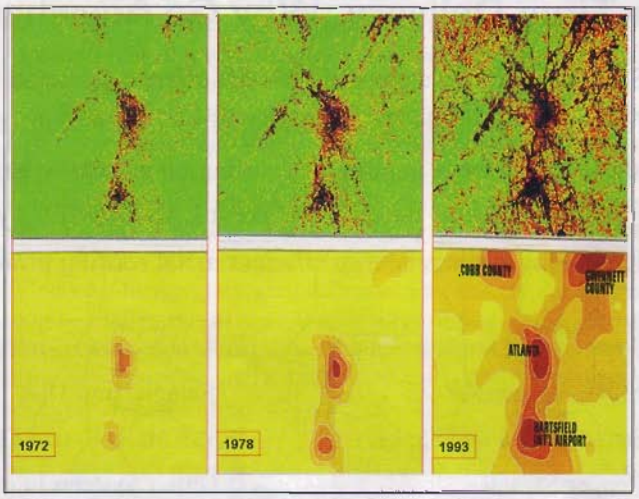


Figure 1: Atlanta when viewed from a thermal imaging satellite. The darker areas are hotter and show not only the increase in temperature, but also the growth of urban areas.

going into a building, there is a similar variable energy demand necessary in the form of air-conditioning to keep the interior of a building envelope cool and tolerable to live or work in.

Consequently, the need for a cooler roof is very desirable. Achieving a cooler roof requires an understanding of reflectivity and emissivity. Reflecting most of the sun's energy minimizes the amount of energy absorbed by the building.

Sun, Heat, Reflectivity and Emissivity

Around 42 percent of the sun's energy occurs in the visible region (400 to 700 nm) of the electromagnetic spectrum. Pigments used in coatings selectively absorb this visible light and reflect the rest of the light. For example, a blue pigment will absorb all wavelengths except those relating to blue (400 to 500nm), which it reflects. A blue roof therefore looks blue because it reflects only the blue portion. A black roof looks black because nothing is reflected and everything is absorbed. The more energy is absorbed, the more it needs alternative means to dissipate this heat.

More than 50 percent of the sun's energy is in the non-visible infrared region. Therefore, it is this region, in particular the near infrared (NIR), that is largely responsible for solar-induced heat build-up.

Emissivity is the ability of a roof to transfer the absorbed heat by emitting it in the far-infrared region. The higher a roof's emissivity, the more likely the heat absorbed by the roof will be radiated away from the building and city and less likely the heat will be transferred to the air around the building by convection. Bare metals have low emissivity and coated metals have high emissivity.

Based upon these principles, coated metal building products can respond to energy conservation requirements.

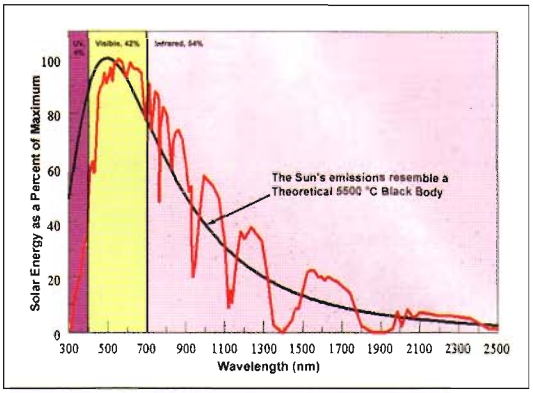


Figure 2: The intensity of solar energy at the Earth's surface. Although a significant proportion of the total solar energy is visible to the human eye, the majority is invisible and in the infrared region.

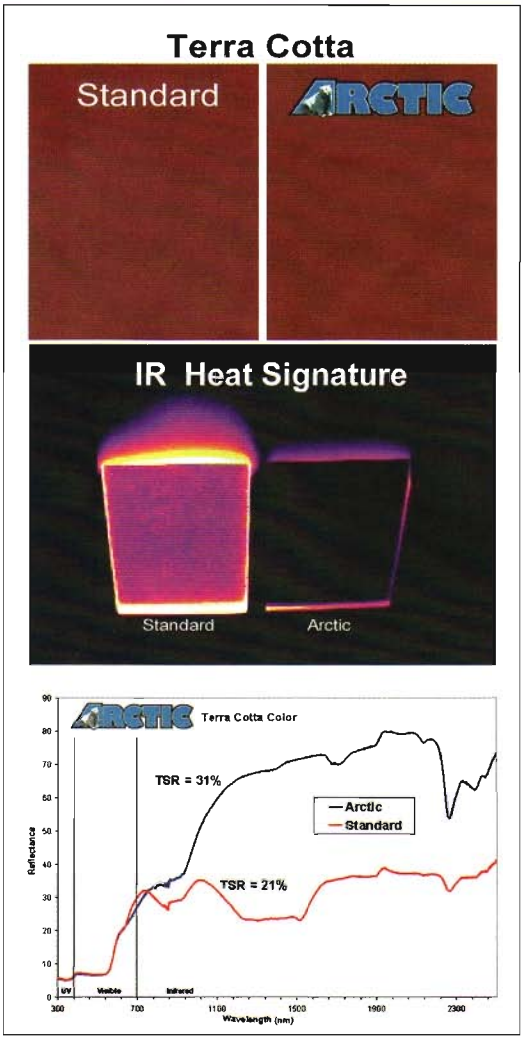


Figure 3: (left) Actual photo of two identical terra-cotta metal building colors and a corresponding thermal image. The Arctic panel (black) is 25 degrees Fahrenheit lower than the regular panel (pink). The IR reflectivity curves show a significant measured difference between the two panels.

Pigments are Cool

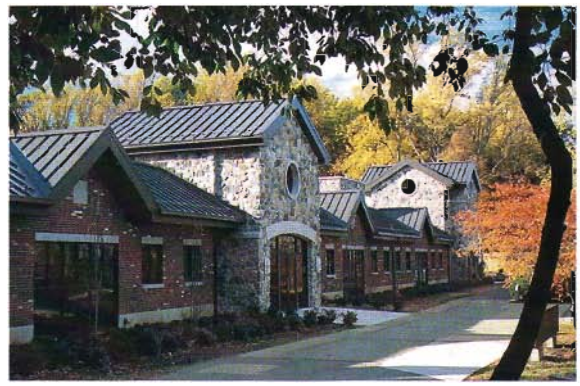
Cool metal roofs employ infrared reflecting pigment technology in the coatings used. Pigments, such as the Arctic pigments manufactured by The Shepherd Color Co. enable coatings to maximize reflectivity in the infrared and minimize the heat build up from the sun's radiation. These pigments are specially designed and developed to impart color to coatings, have outstanding durability (enabling 20-year color fade warranties to be given on certain metal roof products) and yet still deliver a greater than normal amount of infrared reflectivity.

As can be seen from the figures (figure 3), simply re-matching the same visible color with Arctic pigments enables the same color to stay 25 degrees Fahrenheit lower in temperature.

Different pigments have different and unique infrared reflecting characteristics. Using specially developed and selected yellow, blue, green, red, black and brown pigments means that a complete palette of colors can be produced; enough to satisfy most architects and designers and yet still be energy-efficient as far as the different agency and code bodies are concerned.

More recently, a new generation of Arctic black pigments has been launched by Shepherd. This new black pigment enables darker, more traditional colors to be matched, such as Slate Blue and Dark Grey and still meet the EPA's ENERGY STAR reflectivity requirements.

However, simply mixing two pigments to get the desired visible color does not guarantee that the reflectivity of the final color will be acceptable. It takes experience and skill to pick the pigment combinations that will maximize the reflectivity. Shepherd Color has built up a significant database and experience to help formulate many different colors. Use of some traditional pigments — such as carbon black or black iron oxide in concentrations as low as 5 percent — can destroy infrared reflectivity and make the end product unable to meet the different building agency and code requirements.



This student center utilizes Shepherd pigments in its roof coating.

New Requirements

Meeting the EPA's ENERGY STAR requirements means achieving a Total Solar Reflection (TSR) of 25 percent for a steep-slope roof. Moreover, the roof must maintain a minimum of 15 percent reflectivity after three years. Painted metal roof products easily meet this requirement and are likely to provide reflectivity above this minimum level for a number of years thereafter.

The Solar Reflective Index (SRI) is a new rating that has been developed to describe the influence of the roof to the building and the environment around it. Using a combination of reflectivity (as used in the ENERGY STAR program) and emissivity, the index seeks to take both variables into account.

The U.S. Green Building Council was formed to address the current and future needs for better building codes and created the Leadership in Energy and Environmental Design rating system (LEED) as a voluntary rating standard for environmentally friendly and sustainable buildings. Credits are earned for various elements of the total building. Metal roof products help meet some of the credits due to the recycled metal content of the substrate, the recyclability of the roof if the building needs to be demolished and as a contributor to energy savings due to less heat absorbed by the roof. Recent proposed changes to the standard use SRI as the measure. Minimum values are given for low-slope and steep-slope roof products. Some of the proposals imply that the excellent development work with

darker colors meeting ENERGY STAR requirements may not meet the LEED requirements.

The California Energy Commission (CEC) Title 24 requirements for roofing come into effect later this year. Roofing products will be required to be certified by the Cool Roof Rating Council (CRRC). Activities have already begun on an updated version. As a response to the new updated requirements, the Cool Metal Roofing Coalition (CMRC) has been working to define a series of color families that will have minimum TSR and emissivity measurements.

See the article on page S6 for more information.

Chris Manning is the marketing manager for Shepherd Color. Shepherd Color has been an active member of the Cool Metal Roofing Coalition, a contributor to work being carried out at Oak Ridge National Laboratory and works closely with many coatings manufacturers to provide the widest possible variety of colors meeting architects' and designers' desires and still meeting the current and future building code requirements. Arctic pigments can be used in other building products, such as single-ply, ceramic or concrete tile, shingles and others.