COOL ROOFING JARGON…

What it *Says*, What it *Means*, and What it *Implies*

By William A. Kirn, RRC

Introduction

First a quick, one-question, multiple choice quiz:

Albedo is defined as:

1. Something having to do with sexual drive.
2. Someone with the first name of "Al."
3. Raw pastry material used for baking albies.
4. A female species of deer.
5. A measure of solar reflectivity

If you answered number 5, you are correct and should find the rest of this paper a relatively easy read. If not, please read on more closely.

The recent emergence of EPA's EnergyStar® roofing products, the ongoing work of the Cool Roof Rating Council, "Cool Communities," and the "urban heat island" have provided the design and consulting community with another new set of terminology for describing roofing products.

Albedo

First, let's define albedo. It is merely an imposing word for solar reflectance. For example: A roofing product that has high solar reflectance when measured by any number of standard methods has high albedo.

Solar Reflectivity

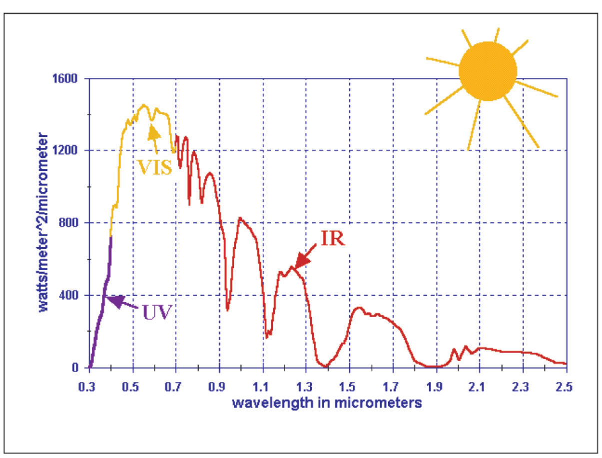
This is simply the percentage of sunlight that is reflected by a surface when it is "hit" by sunlight. A typical method, "Test Method for Measuring Solar Reflectance of Horizontal and Low Slope Surfaces in the Field," ASTM D-1918, involves using a pyronometer - a device for measuring solar radiation, aiming it at the sun, then rotating it 180 degrees and aiming it at the roof surface. The ratio of reflected radiation to incident or direct radiation is solar reflectance and is measured as a percentage. One slight complication: sunlight is composed of a wide spectrum of energy. Some of the energy is visible light. Shown in *Figure 1* is the solar spectrum.

This light can be broken into its components using a prism (remember the simple school science experiment) where sunlight is split into red, orange, yellow, green, blue, indigo, and violet. Sunlight also contains other components that are invisible. Right next to the visible portion of the red light is the infrared portion of sunlight. Simply put, it's the portion of sunlight that provides heat. This can be observed at a fast food restaurant, where the hamburgers and French fries are kept warm under a heat lamp. Notice that the lamp is always red. It has been designed to emit a large portion of light in the red and infrared (read: heat) portion of the spectrum.

One additional point: We often notice that dark-colored asphalt shingle roofs seem to deteriorate more quickly than light-colored

Radiative Properties of Roofing Materials

Energy from the Sun



- ***Ultraviolet (UV)***
  - *3% of total energy*
  - *responsible for sunburn*
- ***Visible (VIS)***
  - *40% of total energy visible light*
- ***Infrared (IR)***
  - *57% of total energy*
  - *felt as heat!*

Figure 1: The solar spectrum.

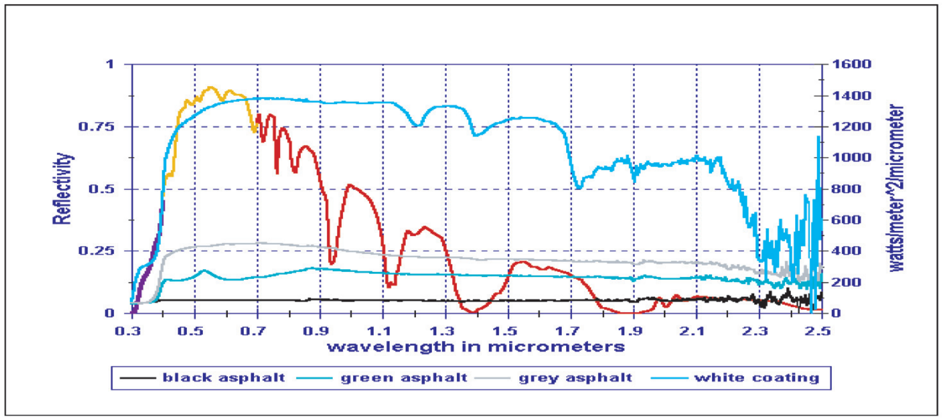
roofs having the same orientation and exposure. This is because the dark color absorbs more of the sunlight, and specifically, the infrared portion of the sunlight, causing the dark colored roofs to be hotter.

There are two other methods used for measuring solar reflectance. They are "Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres," ASTM E-903, and "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer," ASTM C-1549.

The E-903 method employs a very delicate spectrophotometer to measure the reflected light from the sample. While the sample size required is rather small, the equipment is not suitable for *in situ* (field) measurements. Thus, samples must be cut from the roof and sent to the testing laboratory. Another more recently developed method is ASTM C-1549 (previously known as the D&S method). This method uses a portable unit that contains a light source and photocell array to create and measure the reflected light from the roof sample. Because it is portable, lightweight, and self contained, it is widely used. Obviously, there is no need to cut samples from the roof, and the sample is about the size of a quarter.

Radiative Properties of Roofing Materials

Reflectivity and Albedo of Roofing Materials



Albedo (overall	**5%**	**15%**	**25%**	**75%**
solar reflectivity)	**black**	**green**	**gray**	**white**

Figure 2: Albedo or overall solar reflectivity.

Photo 1 depicts two of the pieces of equipment used to measure solar reflectance. The microphone stand attached by a wire to a small meter (off camera) is the ASTM E-1918 reflectance method. The other instrument with what appears to be a gallon paint can attached by a wire to a small suitcase is the ASTM C-1549 (D&S) method.

Photo 1: The microphone stand attached to a small meter (off camera) measures reflectance. The instrument which appears to be a gallon paint can attached by wire to a small suitcase is performing the D&S test.

Back to the Basics

On the other side of the spectrum lies the ultraviolet (UV) portion of sunlight. These are the notorious rays responsible for causing skin cancer through over exposure. Ultraviolet also factors heavily in the chemical degradation of roofing materials. (See Reading Sources at the end of this article for additional reading.)

From a material durability standpoint, reflecting both the infrared (heat) portion of sunlight and the ultraviolet portion is the key to achieving the most long-lasting roofing assembly.

One might easily assume that light-colored roofing materials reflect more sunlight and are therefore cooler than dark-colored materials. This is true to a point. Recent technical developments have brought pigments to the market that, while dark in color, have high reflectance in the infrared portion of sunlight. This means that a roofing material formulated with one of these pigments will have color (red, brown, black, gray), but will be cooler than the same colored materials formulated with traditional pigments. This technology has come from military applications and has been used in "stealth" materials where one wishes to reduce the "heat signature" of military equipment and personnel. These pigments can be easily formulated with existing coating technologies, and their long-term durability and color retention performance appear to be satisfactory. One note: While these materials have higher solar reflectance than their traditional counterparts, they remain much lower in reflectance than white materials.

Emittance

While reflectivity is a straightforward concept (light colors are better at reflecting light than dark colors), the concept of emittance is a bit more complicated and not as intuitive. Emittance is technically defined as "the ratio of an object's radiance to that emitted by a black body radiator at the same temperature and at the same wavelength." (And you thought the quiz was difficult!) Let's look at what this complicated term really implies. A simple analogy is the ability of a material to hold or release heat. This should not be confused with conductivity or the ability of heat to transfer through the material. In fact, metallic materials have very high heat conductivity, but when left uncoated, they have very low emissivity.

A simple experiment serves to demonstrate this property. Take two uncooked potatoes of equal weight and cook them in a microwave oven. Remove them and immediately wrap one in aluminum foil and the other in paper. After a few minutes notice that the one in aluminum foil remains hotter longer. This is because the aluminum foil has low emittance (~0.1) and "traps" the heat in, while the paper has high emittance (~0.9) and allows the heat to escape. Interestingly, if the aluminum foil is coated, it behaves like the paper and has high emittance. Thus, for a cool roof, the membrane surface should be either a non-metallic or coated metal material. Typical methods used for measuring emittance are "Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers," ASTM C-1471; or "Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques," ASTM D-408. The C-1471 is the most widely used, although both methods are cited in standards and specifications.

Photo 2 shows the apparatus that conforms to the ASTM C-1471 emittance test protocol.

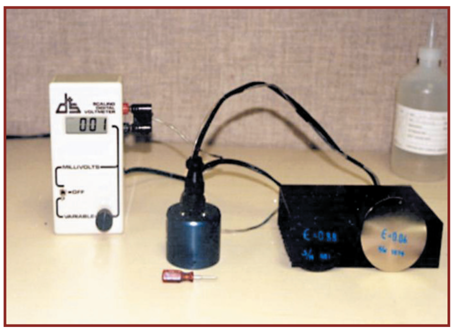


Photo 2: This apparatus is used with the ASTM C-1471 emittance test protocol.

Putting the Two Together

From the above, the value of the two numbers – solar reflectance and emittance – can be seen. However, for convenience, there is a way to "capture" both values as one singular coefficient. This can be found in an ASTM method, "Practice for Calculating Solar Reflectance Index of Horizontal and Low Slope Opaque Surfaces," E-1980. The method is simply a mathematical formula, using the two experimentally derived coefficients, solar reflectance and thermal emittance, to generate a single number. This is called the "Solar Reflectance Index." References to this number are also being seen in specifications and codes.

Impact of Solar Properties on Roof Life

While a basic understanding of these concepts and terms will assist in understanding "Cool Roofing," there is a greater value in recognizing how these properties can affect roof longevity and durability. Reflectance plays a critical role here: the better the roofing material reflects both the infrared (heat) and the ultraviolet (destructive) portion of sunlight, the longer the roof will perform satisfactorily.

First, consider the infrared. It is well understood that mechanical equipment has a longer service life if it is kept cool. This is why car engines have radiators and car transmissions have coolers. This is also why many other types of mechanical equipment (including the computer used to write this article) have fans. Simply stated: any piece of equipment will perform satisfactorily longer if it is kept cooler. (Think of a roof as a piece of mechanical equipment without any moving parts.) In truth, even fully adhered roofs do "move" as the roof moves due to thermal expansion and contraction of the deck. In its most severe form, consider a dark colored roof that experiences an afternoon thunderstorm. The roof surface temperature may drop by as much as 80° to 100°F in a brief period. This "thermal shock" will cause the roof membrane to contract rapidly and will accelerate the roof degradation process. Consider two asphalt-shingled houses in the same setting. The dark colored roof will show signs of weathering before the light colored roof, even though the exposure is the same.

If the roof surface or coating has high UV reflectance, this can also extend the service life. Remember, this invisible portion of sunlight is what causes skin cancer as well as deterioration of unprotected asphaltic roofing materials. If a dark colored roof is surfaced with a UV reflective material such as a white elastomeric acrylic roof coating that contains UV blocking pigments, the roof will last longer. Think of the coating or surfacing as a form of "sunscreen" designed to protect the membrane surface from the harmful effect of the UV portion of sunlight.

Summing (or Sunning?) It Up!

If the roof surface is light in color or has high solar reflectance, it will be cooler. This will also extend its service life. Thus together, the IR (heat) and UV (degradation) portions of sunlight are a primary cause of degradation. A roofing system that has high solar reflectance, high thermal emmittance, and excellent UV resistance will be preferred where longevity is desired. ■

Reading Sources

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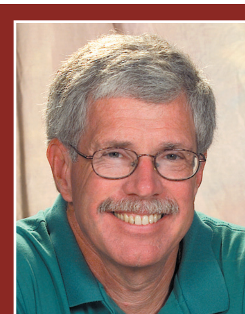
4. McElroy, William C., *Roof Builder's Handbook,* 1993, p. 238.
5. Griffin and Fricklas, *The Manual of Low Slope Roofing Systems,* 3rd Edition, pp. 32, 81, 200, 241, 399; 1996.

About the Author

Bill Kirn is key accounts manager and technical director of National Coatings Corporation. Prior to joining National Coatings, he worked for Rohm and Haas Company for 30 years, holding positions in research, technical service, and marketing for roof coatings and other construction chemicals. Bill is on the board of directors and is chairman of the technical committee of the Cool Roof Rating Council. He is a Registered Roof Consultant and active in CSI and ASTM.



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