Article Summary: In this article we will review:

Key Light Considerations – Not just color and contrast (lightness/darkness) but also the type of light reflection (specular or diffuse).

Light Reflectance Value (LRV) – The measurement of the total reflection of visible light, used to assess how light or dark a color will appear relative to black or white extremes.

Gloss and Sheen – The assessment of the concentrated reflection of visible light (seen as shine) from a specific viewing angle, influenced by surface texture, chemistry, and other factors.

Solar Reflectance/Reflectivity Value – Measures the reflection of visible and non-visible light (total solar spectrum) and used to determine how much heat will be reflected from a surface (which contributes to structure cooling costs).

Improving Metals Integration – New technology including textured and disruptive paints can be used to achieve a variety of light and dark colors while offering significantly lower visible shine.

Metal is a durable roof solution which affords unmatched design flexibility. However, traditional metal finishes may not be suitable for all applications. Homeowners associations, planning ordinances, and other building provisions may seek to restrict the selection of metal finishes due to their traditional interaction with light.

No-one wants a building that does not suit its environment or a surface that may create an unwanted distraction for others. To avoid this issue, many designers, homeowner's associations, and review bodies comparatively evaluate colors and end-products to facilitate the selection of an appropriate exterior material.

As explored in this article, this evaluation must include more than one single metric. Often planning bodies rely exclusively on the term Light Reflectance Value or LRV to determine the suitability of colors and products for an environment. In this document we outline the concept of LRV in building design, in addition to other key metrics to consider including gloss and sheen.

In this article we also review the importance of understanding the efficiency of a finish at reflecting heat, often a biproduct of color selection. Using the combination of these metrics and being aware of the finish enhancement options available will help ensure that designers and building owners select the right color and finish for their next project.

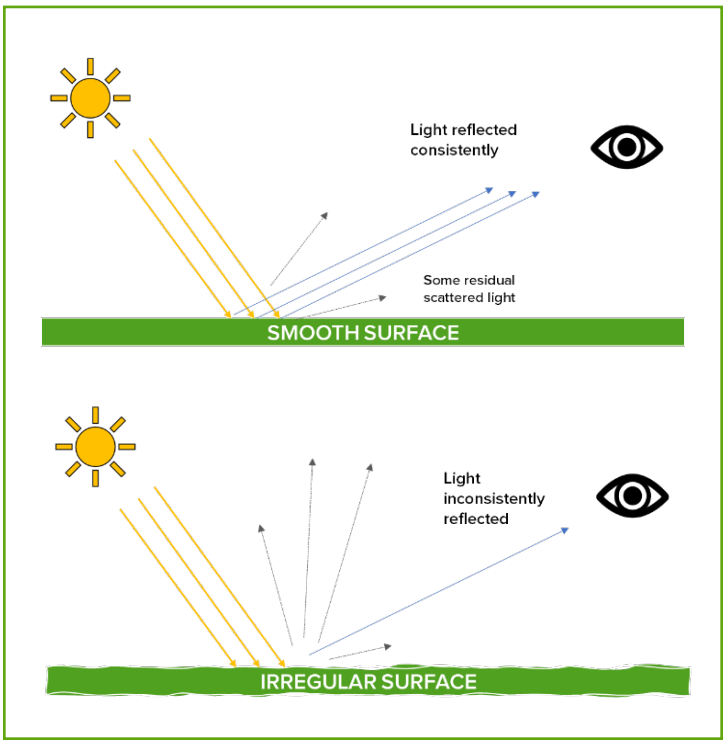
More than Just Color

The way light interacts with a surface is beyond just the color. Several attributes impact light reflection including chemical composition, translucency, cleanliness, and most importantly surface texture.

Why?

Surfaces can provide two distinct types of reflection, specular reflection (mirror like reflection) or diffuse reflection (the scattered reflection of light). Smooth surfaces reflect light in a consistent direction, intensifying the reflection and subsequent light observed. Irregular and varied surface textures do not reflect light in a consistent direction, creating the diffuse light reaction.

For specular reflective surfaces this concentrated reflection means that reflectivity will be nearly zero at all angles except at the appropriate reflected angle. By comparison for diffuse surfaces reflectivity will be uniform at all angles.



This underpins why some materials, irrespective of color, and when viewed from certain angles, will noticeably reflect light, such as metal, polished glass, or polished wood, creating a shine. By comparison, other materials, irrespective of color, such as shingles, clay, or aged wood, will offer a similar appearance at all lighting angles.

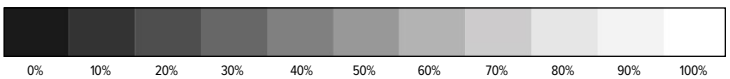
> ***Example of Concentrated v Diffuse Light:*** *A rich standard painted black metal color will appear black and full of color when viewed from 90 degrees, however in direct sunlight and when viewed from a side angle may appear lighter and provide a noticeable shine or reflection of light. This is because it is a specular reflective surface. By comparison a light gray asphalt shingle will generally appear the same irrespective of the lighting angle, this is because it is a diffuse reflective surface.*

So, what are some of the common metrics used to assess light reflection for building products and how will it impact my project?

Light Reflectance Value – Light v Dark

Light Reflectance Value, or LRV, measures the amount of visible or usable light that reflects from a surface. Of note, this measures the total amount of light reflected from the surface rather than the reflection of concentrated light at a specific viewing angle. LRV is expressed as a percentage from 0 to 100. Zero represents an absolute, all-absorbing black and 100% refers to a pure reflective white. This rating is best used to estimate how light or dark a color will appear. This value is often used to help designers and homeowners select hues within a color range and can be used for grouping and comparing colors, such as when creating complementary color palettes. LRV is typically calculated using a specially calibrated spectrophotometer.

For exterior applications, such as roof and siding surfaces, this alone may not be an accurate gauge of perceived light reflection. Specifically, sunlight falls at varied angles throughout the day, and may create a noticeable shine during certain hours. This is a combination of the specular reflection of light, the angle of the sun, the angle of the exterior building surface, and where the surface is being viewed from. LRV alone will not provide an accurate measure to assess the intensity of this concentrated reflected light.

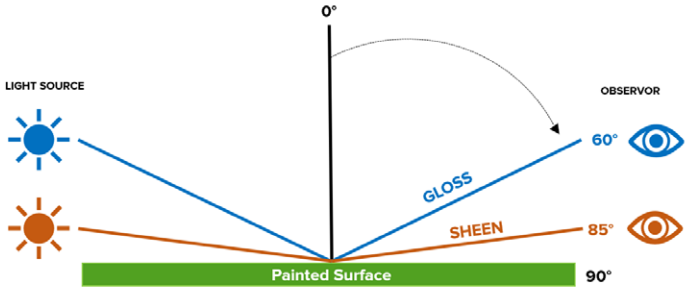


LRV is best used to assess how light or dark a color will appear.

Gloss and Sheen – Concentrated Light

Gloss and sheen both relate to the reflection of light but refer to the concentration of reflected light with the light source and measurement taken at a specific viewing angle. This measurement is used to assess the observable shine on certain surfaces.

Both gloss and sheen are measured based on striking a surface with a known quantity of light and observing the amount of light reflected at a specific viewing angle. Gloss is measured based on the reflection of the light source when observed at a 60-degree angle from the surface whereas sheen is observed at an 85-degree angle. The 85-degree angle is observed more in-line with the painted surface and can be a more accurate measurement for low gloss surfaces.



While correlated to color, other elements such as surface texture, surface chemistry, and cleanliness play a greater role in the impact of gloss and sheen. For example, a light covering of dust on the surface of your car will not drastically shift the color, however it will impact the intensity of light reflected.

Both gloss and sheen can be recorded using a consistent, scientific scale. Gloss Units (GUs) record the reflected light based on a 0-100 scale. The lower end (0 GUs) indicates a perfectly matte surface. The higher end (100 GUs) is based on a standard of polished black glass. It is possible for highly reflective surfaces such as a mirror to exceed 100 GUs. To perform this assessment accurately, gloss units can be recorded with a gloss meter with the testing process conducted in accordance with ASTM standard D523.

While this measure may not be as useful for grouping colors into a palette, this can be used to evaluate the intensity of reflected light from common viewing angles – often the concern with metal such as the way a roof plane may look to neighbors or pedestrians.

Solar Reflectance Value (SRV) - Efficiency not Vibrancy

Solar radiation reaches the earth's surface in three distinct wavelengths: ultraviolet, infrared, and visible light. Near infrared (NIR) radiation is responsible for heat build-up within a structure. Most dark pigments readily absorb IR radiation and trap heat compared

to lighter pigments. Solar Reflectance Value, or SRV, measures the amount of total solar radiation, visible and non-visible (infrared and ultraviolet) light that is reflected from a surface (sometimes called Total Solar Reflectance). SRV is expressed as a percentage from 1 to 100; the higher the number the more solar radiation that is reflected.

As with LRV, light colored objects often have a high SRV while dark colors are low. However, modern pigment technology has advanced and now includes the widespread use of 'cool' pigments. Cool pigment technology or 'Cool Colors' use infrared (IR) reflective pigments that have been altered chemically and physically to reflect IR wavelengths whilst still absorbing the same visible light. This means that traditional dark colors can offer solar reflectance values similar to lighter colors.

So while SRV is correlated to color, it should not be used to assess the visual impact of a color, particular when many modern exterior paints use highly reflective cool pigment technology.

Solar Reflectance Index (SRI) – Assessing Efficiency of Your Roof

The Solar Reflectance Index is a metric that incorporates Solar Reflectance Value and Thermal Emissivity to assess the impact of solar radiation on a surface and the transfer of heat to the structure.

SRI includes both Solar Reflectance, the amount of solar radiation reflected off a surface, and Emissivity, the amount of heat a surface can dissipate away from itself. The Solar Reflectance Index (SRI) is the consolidated value calculated from solar reflectance and emissivity with factors such as air flow considered. All three of these elements relate to non-visible light.

SRI is a scale from 0 to 100. Materials that absorb and retain solar radiation have a lower number, whilst highly reflective materials have a higher number. Absorbed radiation results in heat trapped within a structure, increasing the energy required to cool the structure for occupants, reducing the overall energy efficiency of structure. This underpins why many modern building codes and green building programs mandate that roof surfaces have SRI values above certain minimum thresholds.

Some colors may denote the initial and aged Solar Reflectance Values. This is because some surfaces quickly lose their reflective properties due to UV degradation or the accumulation of grime. A key advantage of metal is that its aged solar reflectance remains comparable to its initial solar reflectance for many years. Additionally, metal is specifically engineered to ensure LRV, gloss, sheen and SRI values are controlled and highly consistent. Several quality tests are performed on each production batch of painted metal to guarantee this consistency.

Reviewing the Data - Sample Metal Colors

Color Name	Parchment	Forest Green	Dark Bronze	Black
LRV	40	9	8	5
Gloss	11	10	11	21
Sheen	12	13	13	25
SRV	51	30	32	30
SRI	58	29	32	29

LRV: Notice how the LRV value is directly related to the contrast of the color relative to black or white, but offers little to differentiate the inherent surface shine in metal.

Gloss and sheen: Note how gloss and sheen are independent of the LRV, with three of the colors presenting very similar readings. Of note, the black has a low LRV but the highest gloss and sheen.

Solar Reflectance: As these are cool colors, note how the Solar Reflectance of Forest Green, Dark Bronze and Black are almost the same. However even with the use of cool pigments, very light colors such as Parchment, will always offer superior solar reflectivity and this is apparent in the significantly higher SRV and SRI values for this color.

This makes sense – But I want full color, metal, and limited visible light reflection.

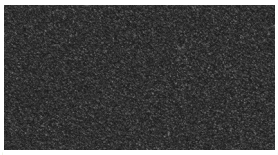
Modern paint technology has advanced to offer low reflective finish options to building designers and users. These include adding flatteners to the paint, textured paint systems, and micro-wrinkle paints (microscopic texturing) to produce diffuse light interactions.

Flatteners can be added to common paint systems (a custom paint specification) to reduce gloss and sheen and are the most traditional method to reduce the visually reflective properties of painted metal. Flattener particles impart roughness/texture that scatters light. These particles come in different particle size and shapes to achieve certain light and texture characteristics. However, this process can usually only reduce the gloss and sheen so far before negatively affecting viscosity, the stability of the solution or 'washing out' the perceived depth of the color.

Textured paint achieved through chemical reaction, such as Steelscape's Rawhide, offers a similar visual effect but utilizes a different approach. This is achieved through the paint's chemistry which causes the paint to crease during the curing process (heat controlled drying process), creating a texture like stucco or sandpaper. As this is done in a controlled environment on large-scale metal paint lines, this can be done consistently while still ensuring the product offers the same durability as traditional standard paints. The texture created by this process helps create a more diffuse light interaction with the surface.

A step further is advanced technology termed micro-wrinkle or disruptive paints (such as Steelscape's NEW Natural Matte®). These paints are chemically developed to create texture at a microscopic level, similar to natural elements such as wood or stone. Even though the texture variance is microscopic, it offers greater surface variance overall, creating a more diffuse light interaction. The result is a richly colored painted metal with industry leading light diffusing properties.

Natural Matte Comparison




Color Name	Natural Matte Carbon	Standard Black
LRV	5	5
Gloss	0.9	21
Sheen	3.8	25
SRV	26	30
SRI	25	29

These two colors are similar yet their interaction with light is completely different, and this is captured in the data. See how the LRV of these colors is identical, yet the gloss and sheen is completely different due to the paint technology. Despite its advanced texture, Natural Matte uses the same paint backbone as standard paints, including the use of cool pigments. This enables the Natural Matte product to offer SRV and SRI values similar to the standard black.