

Daylighting Fact Sheet

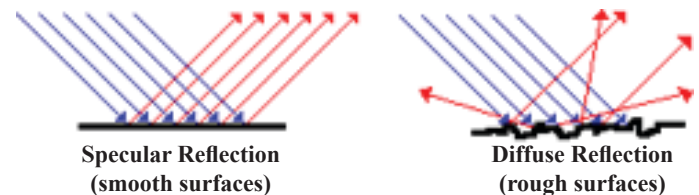
Performance characteristics of Tubular Daylighting Devices (TDDs) can vary greatly, depending on the materials used and the sophistication (or lack thereof in the case of some manufacturers) in the engineering of how the various product components work cooperatively together. Understanding the key performance indicators—such as surface spectral and Specular Reflectance, light collection selectivity and throughput / output, solar heat gain and ultraviolet (UV) blocking—and their relevance to the system's overall performance will help you select the best daylighting solution for your building project.

The most crucial aspect to understand is the difference between Total Reflectance and Specular Reflectance. These two terms are often confused because they are both measures of light reflection, but they are certainly not interchangeable.

Total Reflectance vs. Specular Reflectance

The reflection of light is extremely predictable. When light strikes a surface, it is either absorbed or reflected. Total Reflectance indicates the percentage of light that is reflected, regardless of the direction it travels after leaving the surface.

A surface's Total Reflectance can consist of both specular and diffuse components. To illustrate this, imagine a ray of light as a tight bundle of smaller, individual rays, all traveling parallel to each other. In accordance with the Law of Reflection, rays that strike a smooth surface will reflect and remain in a concentrated bundle. This is called Specular Reflection and represents a “mirror-like” reflection of light. On the other hand, rays that strike a rough, or diffuse, surface will reflect and scatter in many directions through Diffuse Reflection.



While a diffuse surface can have a high Total Reflectance, the reflected light is scattered, which prevents it from being transmitted in a consistent and tightly-controlled fashion. For TDDs, a high Specular Reflectance is imperative so that light can be efficiently transferred through the system. A Diffuse Reflectance should be avoided since that would result in light being scattered and lost back out through the top of the system.

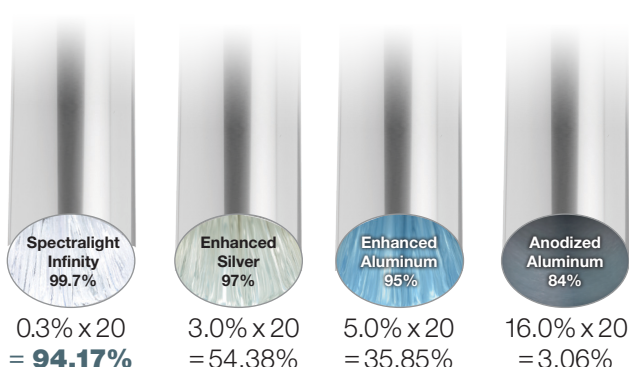
Although a product may appear to have a high Specular Reflectance, in reality a significant portion of the light may be absorbed by the reflecting surface, as would be the case with a tinted glass mirror or a polished piece of aluminum. In this instance, while the surface functions as a mirror, in actuality 20% or more of the light may be lost by absorption with each reflection. With this example, only five specular reflections may consume all of the available light.

The Spectralight® Infinity Tubing used in Solatube® Daylighting Systems is made of the world's most reflective material, allowing it to achieve a Specular Reflectance of over 99% for visible wavelengths of light (the light we use to see). As such, very little light is lost as it travels through the system, resulting in a highly efficient light transmission rate.

This is critical since even small differences in reflectance values can significantly impact light output. That's because every time a ray of light is reflected, a small amount of that light is lost. The difference of just a few percentage points in Specular Reflectivity makes a huge difference in overall performance. As a result, Solatube International's Spectralight Infinity Tubing is designed to:

- Deliver up to 99.7% specular reflectivity of visible light for maximum daylight transfer
- Allow for long tube runs, which can include 90° bends, to deliver consistent daylight to lower floors
- Provide the purest, most consistent spectral reflectance for visible wavelengths of light possible so colors are truer, brighter.

Percentage of light delivered after 20 bounces



Contrary to Total Reflectance, Specular Reflectance is a key factor in determining an optical tube's efficiency in transferring light, and manufacturers should provide Specular Reflectance data to demonstrate the true efficiency of their TDD systems.

To translate light output into practical applications, Solatube International uses a Design Calculator to evaluate a space by factoring geographic location, time of day and time of year daylight measurements based on the room characteristics, occupancy, and specific Solatube Daylighting System product configuration, including tube length and significant angles. This will develop a custom light study designed to meet specific lighting criteria.

Light Collection Selectivity and Throughput / Output

Along with Light Transfer Efficiency, the tubing in a TDD system plays an important role in the quality of light output as it relates to color. Color Temperature Maintenance (CTM) is a measure of how well a system can deliver reflected light without a color shift.

Solatube International's Spectralight Infinity Tubing is "spectrally-neutral," meaning that its Spectral Reflectance is consistently high for all wavelengths of visible light. In other words, the tubing reflects all the visible wavelengths of light equally well and does not change the color of the light it reflects. This allows it to deliver the brightest, purest daylight without major color shifts over the course of the day or changes in season.

Other tubing materials, such as silver-coated anodized aluminum, enhanced aluminum, and corrugated / flexible materials, are not only less efficient at reflecting light in a specular fashion, but are also not "spectrally-neutral." Therefore, the color of the reflected light can shift and appear more green / blue or more yellow, depending on the tubing material used.

Light Output of Various Tubing Materials

Tubing Material	Specular Reflectivity	Light Efficiency for 10' Tube Length	Light Efficiency for 20' Tube Length	Light Efficiency for 30' Tube Length	Light Efficiency for 40' Tube Length
Spectralight® Infinity	99.7%	97%	94%	92%	89%
Enhanced Silver	97%	74%	54%	41%	31%
Enhanced Aluminum	95%	60%	36%	23%	14%
Corrugated/ Flexible	84%	18%	3%	1%	0.1%
Approx. Number of Bounces based on Tube Length		10	20	29	38

Tubing materials have different performance characteristics, and some transport light more efficiently than others. Spectralight Infinity Tubing, found in Solatube Daylighting Systems, is made of the most reflective material in the world, and ranks at the top for delivering the maximum amount of light over the longest distances.

One of the best ways to ensure the tubing used in a TDD system will effectively minimize the color shift of the reflected light is to reference the L*a*b color model. This is a system for reporting and comparing the color consistency resulting from a reflective material, and serves as an excellent way to evaluate CTM consistency. A high CTM indicates that a product produces minimal color / spectral shift of the light, which makes it a highly desirable light source for interior illumination.

As standard procedure, manufacturers should publish their tubing's L*a*b color indices as part of the product's performance specification to demonstrate an accurate measure of color consistency.

When comparing TDD systems, also ask for a light study from manufacturers to ensure all your light output needs are being met. Solatube International can provide this quickly and easily using its Design Calculator. This tool can estimate the optimal daylight design for your building based on geographic location, time of day and time of year light output levels while factoring in room characteristics, occupancy, and specific Solatube Daylighting System product configurations.

The highly-engineered materials and product design allows the Solatube International daylighting products to perform with a level of consistency and predictability not possible with other traditional daylighting fenestration and TDDs.

Solar Heat Gain

Another key performance indicator is the Solar Heat Gain Coefficient (SGHC), which measures how well a product blocks heat from the sun. For the majority of the year, especially in warm summer months, solar energy that is allowed to enter a commercial building unchecked can lead to a rise in the thermal load. This may require an increase in air conditioning usage and/or the addition of supplemental equipment to manage the added heat.

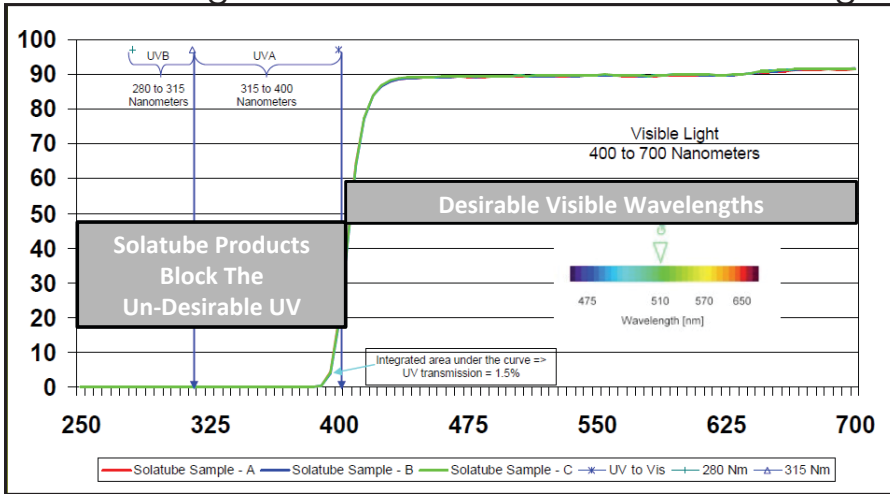
The SGHC is represented as a number between 1 and 0, where 1 is the highest amount and 0 is the lowest amount of solar heat that can enter through a fenestration product. For example, an SGHC of 0.30 means that 30% of the heat available from the sun is transmitted through the fenestration system. Thus, a system with a rating closer to 0 is more effective at blocking the solar heat. The National Fenestration Rating Council (NFRC) establishes uniform product ratings and testing protocols for defining and reporting a product's SGHC performance value under specific reference test conditions. Reputable products will have NFRC-certified SHGC ratings that are posted on the NFRC Certified Product Directory.

Independent building studies indicate that the most effective way to manage solar heat gain is to prevent solar heat from entering a building in the first place. Solatube International's Spectralight Infinity Tubing transmits the visible spectrum of light (400 to 760 nanometers), but provides significant blockage of Infrared (IR) wavelengths greater than 900 nm, which is the main culprit in solar heat gain. As a result, the SHGC of Solatube International products is greatly reduced which, in turn, will lessen the air conditioning load requirement for the space being lit by daylight. These technologies allow Solatube Daylighting Systems to provide the highest light output performance with minimal thermal impact.

UV Blocking

Along with blocking a significant amount of IR wavelengths, Solatube Daylighting Systems also prevent virtually all UV wavelengths from entering the TDD system. This is important because UV light can have a negative impact on building materials it contacts—like carpet, clothing, and furniture. Without the right UV inhibitors at the dome level, the truth is that any material exposed directly to UV will deteriorate. As a result, Solatube International's Spectralight Infinity Tubing is protected from UV light through uniquely engineered materials in the optical domes.

Visible Light Transmittance with UV Blocking



Independent test results have shown that Solatube Daylighting Systems allow in the full spectrum of visible wavelengths of light that provide clear vision, but block virtually all of the ultraviolet wavelengths that can degrade building interiors.

Degradation of the tubing is virtually impossible because the specially-formulated, protective acrylic outer dome that captures the sun's rays also has special UV inhibitors designed to block 100% of UVB (280 to 315 nm), 100% of UVC (100 to 280 nm), and 98.5% of UVA (315 to 400 nm) rays. In addition, Solatube International's tubing is specially engineered to be optically transparent to UV, preventing UV wavelengths from being reflected and/or transferred into the building's interior.

Third party testing of Solatube International's Spectralight Infinity Tubing material through 3M's advanced optical test laboratory proved the validity and reliability of its superior reflectance characteristics for both initial and sustained performance. When used in Solatube International's uniquely engineered daylighting system, the material provides consistent and sustained Specular Reflectance for over 20 years in the field.

This means building interiors will be protected from fading and other degenerating effects because the UV will not be able to penetrate through the system.

Conclusion

These are the key elements to consider when evaluating a TDD. While some manufacturers may compare components of a system separately, an accurate evaluation of its total performance is possible only when considering the system as a whole.

Energy Performance of Natural Light Products

Fenestration product	Visible Transmission (Vt)	Solar Heat Gain (SHGC)	Daylighting Energy Performance Ratio (Vt/SHGC)
Triple Glazed Low-e Window Clear glass, suspended low-e Heat mirror film	22%	0.16	1.38
Triple Glazed Window Clear glass, suspended low-e Heat mirror film, clear glass	63%	0.36	1.75
Double glazed Window Clear glass, low-e glass	71%	0.49	1.45
Double Glazed Prismatic Skylight Clear outside, prism inside	71%	0.51	1.39
Solatube® 750 DS Daylighting System	60%†	0.20†	3.00

Source: NFRC Spectral Weighting Function Research Project, Draft 2.0, March 2007

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▪ Solatube Daylighting systems offer energy performance ratio over **double** most fenestration products.

Solatube Daylighting Systems offer energy performance that is more than double that of other natural lighting products. Our daylighting solution creates the ideal balance between visible transmission and solar heat gain to deliver pure, bright daylight without the added solar energy that can cause heat buildup and force air conditioning systems to work harder.