CAL-OPTICS
LIGHT MEASUREMENT MADE EASY

Reflectance Coating and Stability

The primary purpose of an integrating sphere is to evenly distribute the radiometric energy emitted by a light source. A detector placed on the wall of the integrating sphere, properly shielded from direct exposure to the source, measures the radiometric energy.

An ideal integrating sphere would be perfectly spherical with no anomalies from ports, baffles, or other structures. It would reflect 100% of incident radiometric energy off the inner walls of the sphere. Finally, that energy would be diffusely reflected – meaning that the angle of reflection would have no correlation to the angle of incidence.

In practical application there are no perfect integrating spheres. Spheres must have ports, baffles, and other anomalies. There are no diffuse reflecting materials that reflect 100% of incident energy.

The goal is to approximate the ideal integrating sphere in a practical approach to ensure accurate, repeatable, results.

Like any measurement system an integrating sphere based system should be stable and repeatable. The method of calibrating this type of system is through the use of a known standard of radiometric energy. Once calibrated the integrating sphere system can measure other similar devices accurately.

One of the critical elements of integrating sphere theory is sphere throughput – or the amount of radiometric energy incident on the sphere wall or the integrated signal when compared to the energy that would be incident directly on a detector.

The objective of an integrating sphere is to evenly disperse radiometric energy across the inside surface area of the sphere. To do this energy is diffusely reflected many times to evenly "mix" the radiometric energy. As a result the energy incident on any area of the sphere wall should be the same. That energy will be much lower than what would be measured with a detector directly "viewing" the source. This difference can be measured and expressed in terms of sphere throughput.

Coatings used to diffusely reflect light can reflect up to 95% of the incident energy. The reflected energy is again reflected several times over. A sphere with a 95% coating will have a reflection loss of 5% on each reflection.

Cal-Optics offers integrating spheres with 95% and 80% coatings. The standard we use is 80%. The reason for standardizing on 80% coating is based on the stability of the coating and the repeatability of sphere system measurements. In practical application 95% sphere coatings will deteriorate faster than 80% coatings. Furthermore, the same level of deterioration experienced by a 95% coated sphere and an 80% coated sphere will be much more evident in the 95% coating.

To explain it is easiest to use an example.

The equation to calculate sphere throughput is:

$$E_{\mathrm{d}} = \frac{\rho_{\mathrm{e}}}{1 - \rho_{\mathrm{e}}} \cdot \Phi \, / \, A$$

E_{d} represents throughput. ρ_{e} is sphere wall reflectance, Φ is total luminous flux, and A is the area of the sphere wall.

Let's use an example of an integrating sphere light measurement system that includes a 300mm sphere and a 2,600 lumen source.

A 2% reduction in the reflectance of sphere coating over a relatively short period of time due to environmental factors, use, and normal conditions is not abnormal.

The reduction in throughput between a 95% and 80% coated integrating sphere system is significant.

Using the formula above for the system described, the throughput reduction in a system whose coating degrades from 95% to 93% is about 30%. Specifically the detector in such a system would see a 30% reduction in signal.

The same system with a coating that degrades from 80% to 78% would see a reduction in throughput of 11%. Under practical use the same environmental and usage factors would have a lower gross impact in the 80% system.

The more stable system is always preferred to ensure repeatability of measurements.

For this reason Cal-Optics standardizes on 80% coatings. All of our sphere based systems may also be ordered with 95% coatings.