

Choosing the Right Spectrophotometer for Color Quality on any Surface



Color can be difficult to control in industrial applications, especially on surfaces with metallic reflection, texture, and special effects. To select the most appropriate color measurement device, it is important to understand each of the available measurement geometries. This whitepaper explains the characteristics and use cases of sphere (diffuse:8° or d:8°), 45:0 (or 0:45), and multi-angle (MA) spectrophotometers to help those involved in an industrial supply chain choose the right device for accurate, consistent color quality on any surface.

Color and appearance directly impact product sales and brand success. Color must reflect branding guidelines and conform to specifications, and all parts must match at assembly to ensure maximum consumer attraction. To maintain consistency throughout the manufacturing supply chain can present significant challenges, particularly in a global and distributed environment where components are manufactured in different locations and come together as an integral whole at assembly. Meeting these market requirements on specialized surfaces requires specific color measurement tools and techniques.

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The Difference between Sphere, 45:0, and Multi-Angle Spectrophotometers

There are three primary types of spectrophotometers used for industrial applications today: the traditional 45:0, the sphere, and the multi-angle.

Nomenclature

First, let's look at what the names mean. In the case of the 45:0 spectrophotometer, the first number refers to the angle of illumination and the second number refers to the detection angle. With a 45:0 spectrophotometer, the light source shines at 45° from the perpendicular of the sample, and the detector receives reflected light at a 0° angle, or perpendicular to the surface of the object. Figure 1 shows the geometry associated with 45:0 spectrophotometers.

With a sphere spectrophotometer (d:8), the object to be measured is illuminated diffusely, or from all directions, and the detector receives the reflected light at an 8° angle from the surface of the measured object. This is known as "sphere geometry" because this instrument contains a sphere that provides diffuse illumination.

In a sphere spectrophotometer such as the X-Rite Ci60 Series, the inside of the sphere is lined with a highly reflective, low gloss, matte white substance used to project and diffuse the light, making it a near perfect white reflector. As the light beam strikes a point on the surface of the sphere, more than 99% of the light is reflected. At the same time, the matte finish of the sphere causes the light to be scattered randomly in all

directions. This happens at every point on the surface and effectively causes light inside the sphere to seem to come from every direction at once, making the inside of the sphere the light source. Figure 2 is a depiction of how a sphere spectrophotometer operates.

A multi-angle spectrophotometer is best suited for measurement of industrial production applications involving special effect surfaces, such as automotive coatings, metallic or pearlescent coatings, and cosmetics. These are typically used in the lab, on the production line, in QC operations and in the shipping area. A multi-angle is quite complex and requires users to verify five or more sets of L*a*b* values or Delta E* values. They typically have an aperture size of 12mm, which is too large for measuring fine detail that occurs in many small-scale industrial applications. While primary illumination is usually provided at a 45° angle, some models have secondary illumination at a 15° angle. The latest generation of multi-angle spectrophotometers features up to 12 angles of measurement to fully characterize and measure effect finishes across a variety of applications, including automotive paint, plastics, and metals. Figure 3 is a depiction of how a multi-angle operates.

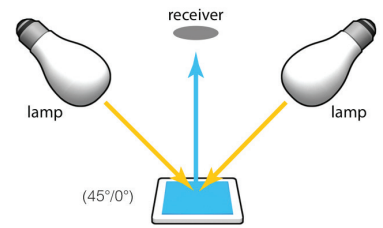


Figure 1: 45:0 Spectrophotometer Geometry

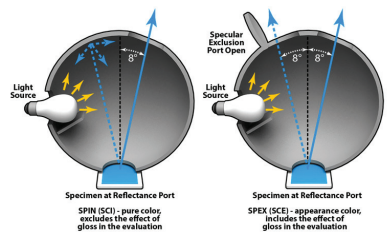


Figure 2: Diffuse Geometry for Sphere (Diffuse/8°) Spectrophotometers

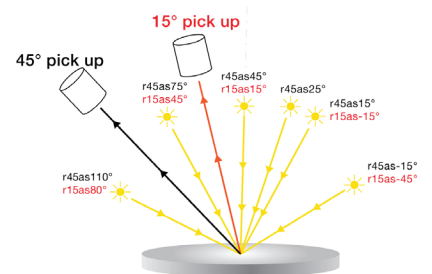


Figure 3: Multi-Angle Spectrophotometer

Use Cases for 45:0, Sphere, and Multi-Angle Spectrophotometers

45:0

When measuring color, a 45:0 spectrophotometer considers color as well as gloss and texture to deliver measurements as close to visual perception as possible. As in common observation conditions, light comes from one direction, not in a diffuse fashion like the sphere. A 45:0 instrument is generally preferred for applications such as measuring color on scattering surfaces like paper or on solid objects that do not have any angular effects. They are not necessarily the best choice for measuring color on highly reflective surfaces such as metalized foil or effect-pigmented colors like paint containing metallic flakes or sparkles.



MetaVue VS3200

The MetaVue VS3200 non-contact imaging spectrophotometer is the latest generation of 45:0 spectrophotometers from X-Rite for industrial applications. It is unique in the market and ideal for measuring samples such as small and non-planar items as well as liquids, pastes, powders and gels without contaminating the instrument or damaging the sample. It includes an on-board color camera to enable precise digital targeting as well as the ability to store image samples as part of a measurement audit trail with easy retrieval for future use.

Sphere

A sphere spectrophotometer offers the choice to include or exclude the gloss component of the measurement surface. In technical terms, this is called “specular included” (SPIN) or “specular excluded” (SPEX). This capability adds a level of flexibility to these devices not present in other types of spectrophotometers.

When measuring any glossy surface, a 45:0 instrument will essentially lose some of the reflected light which is diverted to the -45° angle, as shown in Figure 4. This causes colored samples with glossy surfaces to look darker and more saturated than the same color sample with a matte finish.

A 45:0 spectrophotometer is only capable of taking specular excluded measurements, which means the measurement includes surface and gloss variations. In practice, sphere instruments are more versatile since they allow for the measurement of a color with or without the impact of its substrate’s associated surface effects.

The primary reason to use a sphere instrument is for flexibility to measure a sample dependent or independent of surface gloss and texture. To recreate the sample, the object should be measured in SPIN mode so as not to consider the final object’s surface and gloss level. To match the visual perception, the object should be measured in SPEX mode in order to see the impact of gloss and surface reflected in the measurement results.

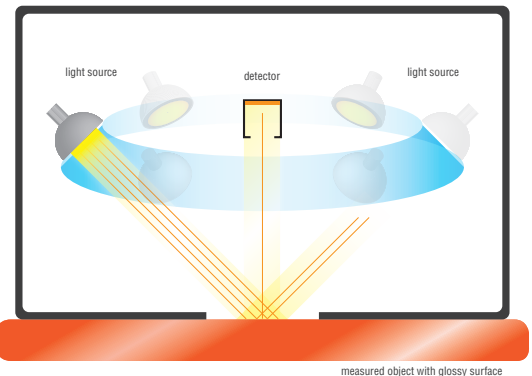


Figure 4: Effects of Glossy Surfaces on 45:0 Spectrophotometer Results - Object Looks Darker

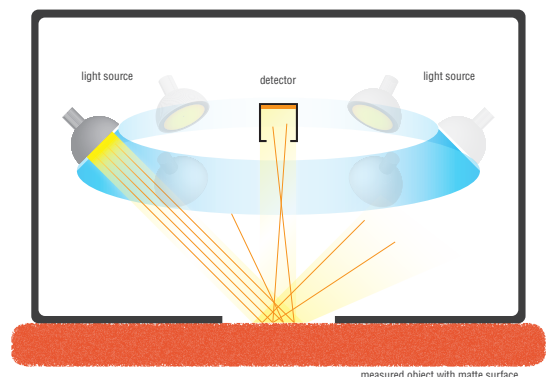


Figure 5: Effects of Matte Surfaces on 45:0 Spectrophotometer Results - Object Looks Lighter



Multi-Angle

More than 20 years ago, X-Rite launched the first MA68 five-angle spectrophotometer for use in the automotive industry. Over the years, this type of multi-angle spectrophotometer has become increasingly popular in other industries because it accurately captures the object's appearance, including surface and texture. With a multi-angle instrument, light is projected at a 45° angle from the perpendicular onto a sample's surface. The device measures up to 6 specular angles in one plane on top of the sample. Adding 15° illumination can measure 6 more angles for a total of 12. Figure 6 depicts this process.

The X-Rite MA-T6 and the MA-T12 multi-angle devices feature 6 and 12 measurement angles respectively and 1-2 illumination sources to capture all color relevant reflections around the entire surface of a sample. In addition, they include an on-board RGB camera, modern touch screen navigation and live camera measurement previews. These instruments can fully characterize and measure effect finishes across a wide variety of applications, from automotive paint to plastics and metals. See Figure 6 for a depiction of the 12 viewing angles of the MA-T12.

MA-5 QC, the newest multi-angle device from X-Rite, offers five standard measurement angles to accurately evaluate and control metallic colors and special effect finishes. Featuring strategically placed optics at the tip, it is lightweight and compact, allowing operators to easily position the MA-5 QC for fast measurements on production lines and loading docks, as well as other quality control environments.

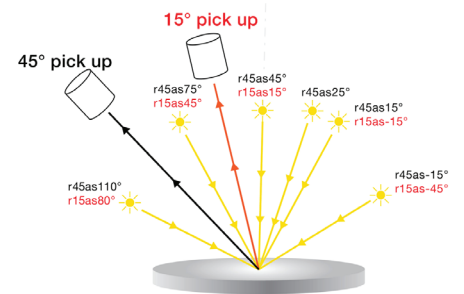


Figure 6: Viewing Angles of the MA-T12 Multi-Angle Spectrophotometer



MA-T6 & MA-T12



MA-5 QC

Choosing the Right Instrument

There is a spectrophotometer available to ensure color measurement accuracy for every type of surface.



Sphere: A sphere device like the Ci60 Series is ideal for measuring brand and custom colors with special visual effects and metalized or evenly reflecting substrates, because of the ability to provide specular-included readings.



45:0: It may be feasible to measure specialized surfaces like prints on scattering substrates or paints and coatings with a consistent level of gloss and no effect pigments with a 45:0 device like the MetaVue VS3200. However, it is important to understand the technology limitations that may indicate a sample is darker and more saturated than it really is.



Multi-Angle: For complex effect coatings, a multi-angle spectrophotometer such as the MA-T12 is the ideal choice because it enables measurement of both color and appearance, including coarseness and sparkle.

To determine the best device for a specific application, it is important to analyze both product mix and customer requirements to determine if essential and critical measurements can be made with one type of device, or whether it makes more sense to have multiple types available.