

Technical Technical Note



Identification of Measurement Parameters for Effective Color Communication

In a physical measurement of weight or volume, there is only 1 measurement parameter that can affect the measured values - the expression of units in American Standard or metric. In a psycho-physical measurement that quantifies human color perception, complete color quantification is always at least 3 numbers with 6 measurement parameters. Changing any of the parameters will affect the color values, so the first step is to clearly define those parameters.

Color Scale

Is it Hunter L,a,b or CIE L*,a*,b*? Both are L,a,b - type color scales but the values will be different depending on the scale used. Are these numbers expressed in absolute values, or differences as tolerances (ΔL^* , Δa^* , Δb^* , ΔE^*) relative to a product standard? Identify any special single metrics used for quantification of selected attributes of whiteness (WI), brightness (Y or Z%) or yellowness (YI). If you don't know which to use, choose CIE L*,a*,b*.

CIE Illuminant

There is a choice of several - A, C, D65 and F2 are the most common illuminants. Illuminant C (6770 degrees Kelvin) representing average daylight and Illuminant D65 (6500 degrees Kelvin) representing noon daylight are the most frequently used. If you don't know which to use, choose D65.

CIE Standard Observer

You have choices of the 1931 2 Degree or the 1964 10 Degree Standard Observer. Both are very similar but not the identical. If you don't know which to use, choose the 10 Degree Standard Observer.

Instrument Geometry

This parameter is fixed by the choice of instrument. There are two general categories of instrument geometries for color measurement - directional $45^\circ/0^\circ$ or $0^\circ/45^\circ$ instruments, and diffuse $8^\circ/d$ or $d/8^\circ$ sphere instruments. The appropriate instrument geometry is dependent on the type of sample - opaque non-metal, metal, translucent or transparent.

Sample Preparation

How is the sample prepared prior to measurement? It must be the same at all multiple locations to attain inter-instrument agreement.

Sample Presentation

What is the area of view of the measurement port, method of positioning the sample, number of readings averaged, measurement pattern, etc.? This must be the same to attain good inter-instrument agreement.

If you adequately identify your measurement methodology to include the above 6 parameters you will be able to communicate numerical color values effectively to another site so that they can replicate the values. Once everyone understands this concept of making the parameters the same for inter-instrument agreement and effective communication, it is possible to shorten the form to something that will fit in a few lines on a spec sheet, such as: CIE L*, a*, b* target and tolerances, D65°/10°, 45°/0° geometry, sample preparation, sample presentation including area of view and number of readings to average

The best inner instrument agreement in absolute color values will always be found using the same model of instrument with all of the six parameters matched at all sites.

If some of the parameters are not the same, this can be overcome by reading in a physical product standard on each instrument and setting the tolerance based on differences from that physical product standard. Instruments of the same geometry should agree on absolute differences from a physical standard, even if they don't agree exactly on absolute color values. If you still need to see agreement in absolute values, the hitching feature can be used as a last resort after aligning all of the 6 parameters as closely as possible.

We show these concepts in action on a variety of materials in the Solutions section of the HunterLab website at www.hunterlab.com.

Supporting Industrial Test Methods for Color Measurement

Color measurement is well documented in numerous industrial standards organizations - AATCC, CIE, CEN, DIN, ISO, BS, JIS, SAE, ASA, but the best collection of standard methods is found with ASTM. These ASTM standards tend to migrate to other standards organizations.

Here are a few that match the parameters of color measurement given above:

Color Measurement Metrics

- ASTM E308** **Practice for Computing the Color of Objects by Using the CIE System** provides a full description of calculation of CIE tristimulus color values X, Y, Z; CIE illuminants, CIE standard observers.
- ASTM D2244** **Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates** describes the calculation of rectangular, polar and elliptical color differences.
- ASTM E313** **Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates** defines the two most popular whiteness and yellowness metrics.

Instrument Geometries and Standards

- ASTM E1164** **Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation** covers sensor conformance issues including instrument geometry.
- ASTM E1331** **Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry** defines colorimetric measurement using a directional $d/0^\circ$ or $0/d^\circ$ geometry instrument.
- ASTM E1347** **Standard Test Method for Color and Color Difference Measurement Using Tristimulus (Filter) Colorimetry** defines tristimulus colorimeters versus spectrophotometers.
- ASTM E1349** **Standard Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry** defines colorimetric measurement using a directional $45^\circ/0^\circ$ or $0^\circ/45^\circ$ geometry instrument.
- ASTM E259** **Standard Practice for Preparation of Pressed Powder White Reflectance Factor Transfer Standards for Hemispherical and Bi-Directional Geometries** defines preparation of a transfer standard for both directional and sphere instruments.

Sample Preparation and Presentation

- ASTM E179** **Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission** for appropriate selection of instruments to match sample types.
- ASTM E1345** **Practice for Reducing the Effect of Variability of Color Measurement by Use of Multiple Measurements** describes averaging as a technique to minimize sample variation.
- ASTM E805** **Standard Practice for Identification of Instrumental Methods of Color or Color-Difference Measurement of Materials** describes identification of measurement methods for effective communication of color values.

Establishing Product Tolerances

- ASTM D3134** **Standard Practice for Establishing Color and Gloss Tolerances**