

Colorimetric Reference Guide For MiniScan® EZ



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Caution: If the equipment is used in a manner not specified by the HunterLab, the overall safety may be impaired. - The instrument is for indoor use only and not suitable for a wet location.



Caution: There is a potential of a UV Light hazard in using this instrument. Please avoid looking directly at the light. The frequency of this flashing light is in the range of sensitivity for those prone to epileptic seizures.



Safety Notes

For your safety when using the Aeros, you should pay attention to the safety statements in this User's Manual.

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Measurement Values

Color values measured using the MiniScan EZ are relative to the absolute value of a perfect reflecting diffuser as measured under the same geometric conditions (see ASTM E308), according to the January 1, 1969 recommendation of the International Commission on Illumination, CIE. This manual explains the various color scales and indices available for display using the MiniScan EZ.

Absolute Color Scales

(available when Display Type is Absolute)

CIE Tristimulus Values XYZ

The MiniScan EZ performs integration of reflectance values over the visible spectrum to arrive at tristimulus X, Y, and Z values. These values simulate the color matching response functions of the human observer as defined by the 1931 2° Standard Observer or the 1964 CIE 10° Standard Observer. Tristimulus integrations based on any of the illuminants listed on the next page may be performed. For a complete description of how to calculate tristimulus values, refer to the publication CIE 15.2 and to ASTM E308.

CIE Chromaticity Coordinates Yxy

The relationship between CIE XYZ and the x, y, chromaticity coordinates is as follows: ,

Y = CIE Tristimulus Y

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

Opponent Color Scales Hunter L a b, CIE L*a*b*, and CIE L*C*h

The opponent-color scales yield measurements of color in units of approximate visual uniformity throughout color space :

In the **Hunter L, a, b** scale L measures lightness and varies from 100 for perfect white to zero for black, approximately as the eye would evaluate it. The chromaticity dimensions (a and b) yield understandable designations of color as follows:

- a describes redness when positive, gray when zero, and greenness when negative.
- b describes yellowness when positive, gray when zero, and blueness when negative.

The relationship between the Hunter L, a, b scale and the CIE XYZ scale for the CIE 1931 2° Standard Observer and the CIE 1964 10° Standard Observer is as follows:

$$L = 100 \sqrt{\frac{Y}{Y_n}}$$

$$a = K_a \frac{\frac{X}{X_n} - \frac{Y}{Y_n}}{\sqrt{\frac{Y}{Y_n}}}$$

$$b = K_b \frac{\frac{X}{X_n} - \frac{Z}{Z_n}}{\sqrt{\frac{Y}{Y_n}}}$$

where: X, Y, and Z are CIE tristimulus values

X_n , Y_n , and Z_n are tristimulus values of the standard illuminant as listed in ASTM E308 with Y_n always equal to 100.00 (normalized)

K_a and K_b are chromaticity coefficients for the illuminant used (see ASTM E308).

Illuminant A represents incandescent (tungsten) lamp light with an approximate color temperature of 2854K.

Illuminant C represents average, or north sky, daylight with a correlated color temperature of approximately 6770K.

Illuminant D50 represents daylight with a correlated color temperature of approximately 5000K.

Illuminant D55 represents daylight with a correlated color temperature of approximately 5500K.

Illuminant D65 represents daylight with a correlated color temperature of approximately 6500K.

D75 represents daylight with a correlated color temperature of approximately 7500K.

Illuminants F2, F7, and F11 represent light from a cool white fluorescent source.

The **CIE 1976 L*a*b*** scale is recommended by the Commission Internationale de l'Eclairage (CIE). It is a simplified cube root version of the Adams-Nickerson space produced by plotting the quantities of L*a*b* in rectangular coordinates.

The relationship between the CIE L*a*b* scale and the CIE XYZ scale for any illuminant referenced in ASTM E308 is as follows:

$$L^* = 116 f\left(\frac{Y}{Y_n}\right) - 16$$

$$a^* = 500 \left[f\left(\frac{X}{X_n}\right) - f\left(\frac{Y}{Y_n}\right) \right]$$

$$b^* = 200 \left[f\left(\frac{Y}{Y_n}\right) - f\left(\frac{Z}{Z_n}\right) \right]$$

where:

$$f\left(\frac{X}{X_n}\right) = \sqrt[3]{\frac{X}{X_n}} \quad \text{if } X/X_n > (24/116)^3$$

$$f\left(\frac{X}{X_n}\right) = \left(\frac{841}{108}\right)\left(\frac{X}{X_n}\right) + \frac{16}{116} \quad \text{if } X/X_n \leq (24/116)^3$$

$$f\left(\frac{Y}{Y_n}\right) = \sqrt[3]{\frac{Y}{Y_n}} \quad \text{if } Y/Y_n > (24/116)^3$$

$$f\left(\frac{Y}{Y_n}\right) = \left(\frac{841}{108}\right)\left(\frac{Y}{Y_n}\right) + \frac{16}{116} \quad \text{if } Y/Y_n \leq (24/116)^3$$

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$$f\left(\frac{Z}{Z_n}\right) = \sqrt[3]{\frac{Z}{Z_n}} \quad \text{if } Z/Z_n > (24/116)^3$$

$$f\left(\frac{Z}{Z_n}\right) = \left(\frac{841}{108}\right)\left(\frac{Z}{Z_n}\right) + \frac{16}{116} \quad \text{if } Z/Z_n \leq (24/116)^3$$

and X_n , Y_n , and Z_n are tristimulus values for any illuminant.

CIE L*C*h is a modification to the CIE L*a*b* scale, and plots in polar coordinates rather than rectangular ones.

$$L^* = 116 \sqrt[3]{\frac{Y}{Y_n}} - 16$$

$$C^*_{ab} = \sqrt{a^{*2} + b^{*2}}$$

$$h^\circ = \arctan(b^*/a^*)$$

Reference: Commission Internationale de l'Éclairage (CIE): "Recommendations on Uniform Color Spaces, Color Difference Equations, Psychometric Color Terms," Supplement no. 2 to CIE Publication No. 15, *Colorimetry*, Bureau Central de la CIE, Paris, 1978. For more information, see AATCC Test Method 173: *Calculation of Small Color Differences*.

Difference Color Scales

(available when Display Type is Difference; Reading of Both Standard and Sample Required) (

dXdYdZ

This scale yields the color difference between the sample and the standard via the CIE XYZ scale.

$$dX = X_{\text{sample}} - X_{\text{standard}}$$

$$dY = Y_{\text{sample}} - Y_{\text{standard}}$$

$$dZ = Z_{\text{sample}} - Z_{\text{standard}}$$

dYdxdy

This scale yields the color difference between the sample and the standard via the CIE Yxy scale.

$$dY = Y_{\text{sample}} - Y_{\text{standard}}$$

$$dx = X_{\text{sample}} - X_{\text{standard}}$$

$$dy = Y_{\text{sample}} - Y_{\text{standard}}$$

dLdadb

This scale yields the color difference between the sample and the standard via the Hunter L, a, b scale.

$$dL = L_{\text{sample}} - L_{\text{standard}} \quad (\text{If } dL \text{ is positive, the sample is lighter than the standard. If } dL \text{ is negative, the sample is darker than the standard.})$$

$$da = a_{\text{sample}} - a_{\text{standard}} \quad (\text{If } da \text{ is positive, the sample is redder than the standard. If } da \text{ is negative, the sample is greener than the standard.})$$

$$db = b_{\text{sample}} - b_{\text{standard}} \quad (\text{If } db \text{ is positive, the sample is yellower than the standard. If } db \text{ is negative, the sample is bluer than the standard.})$$

dL*da*db

This scale yields the color difference between the sample and the standard via the CIE L*a*b* scale.

$$dL^* = L^*_{\text{sample}} - L^*_{\text{standard}}$$

$$da^* = a^*_{\text{sample}} - a^*_{\text{standard}}$$

$$db^* = b^*_{\text{sample}} - b^*_{\text{standard}}$$

For more information, see AATCC Test Method 173: *Calculation of Small Color Differences*.

dL*dC*dH*

This scale yields the color difference between the sample and the standard via the CIE L*C*h scale.

$$dL^* = L^*_{\text{sample}} - L^*_{\text{standard}}$$

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$$dC^* = C^*_{\text{sample}} - C^*_{\text{standard}}$$

$$dH^* = h^{\circ}_{\text{sample}} - h^{\circ}_{\text{standard}}$$

where, if $h^{\circ}_{\text{sample}} > h^{\circ}_{\text{standard}}$, then dH^* is regarded as positive.

If $h^{\circ}_{\text{standard}} > h^{\circ}_{\text{sample}}$, then dH^* is regarded as negative.

Absolute Indices

(available when Display Type is Absolute)

457-nm Brightness

457-nm brightness (displayed as 457B) can be used to indicate the relative brightness of paper. 457-nm brightness is calculated over the range of 400 nm to 510 nm in accordance with TAPPI document T452.

Tint ASTM E313

ASTM E313 Tint (displayed as Tint) is calculated as follows:

$$\text{Tint E313} = 1000 (x_n - x) - 650 (y_n - y) \quad \text{when the } 2^\circ \text{ observer is in use, and}$$

$$\text{Tint E313} = 900 (x_n - x) - 650 (y_n - y) \quad \text{when the } 10^\circ \text{ observer is in use}$$

Where x_n and y_n are the chromaticity coordinates for the CIE illuminant and standard observer used. These values are provided in the table given in ASTM E313. This index is only displayed when the data view is configured for either the C or the D65 illuminant, as these are the only relevant illuminants.

A few caveats regarding measurement of tint:

- The application of this equation is restricted to samples that are called “white” commercially, that are similar in color and fluorescence, and that are measured on the same instrument at the same time. Under these conditions, their use should give relative, but not absolute, evaluations of tint that are adequate for commercial use.
- The more positive the value of tint, the greater is the indicated greenish tint of the sample. The more negative the value of tint, the greater is its reddish tint. Lines of equal tint are approximately parallel to the line of dominant wavelength 466 nm. For the perfect reflecting diffuser, tint = 0.
- Equal differences in tint do not always represent equal perceptual differences in tint.
- This equation should only be used for samples having tint values between -3 and +3.

Whiteness Index

Whiteness is associated with a region in color space in which objects are recognized as white. Degree of whiteness is measured by the degree of departure of the object from a *perfect* white.

Whiteness Index E313 (displayed as WIE is the whiteness index published in ASTM Method E313.)

$$WI_{CIE} = Y + 800 (x_n - x) + 1700 (y_n - y) = WI-E313$$

where Y, x, and y are the luminance factor and chromaticity coordinates of the specimen, and x_n and y_n are the chromaticity coordinates for the CIE illuminant and standard observer used. These values are provided in the table given in ASTM E313. This index is only displayed when the data view is configured for either the C or the D65 illuminant, as these are the only relevant illuminants.

Refer to ASTM Method E313, "Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates," for more information.

Y Brightness

Y Brightness (Y) is also known as luminosity or light intensity. This index is calculated in the same way as (and is equivalent to) the Y of the XYZ tristimulus scale.

Yellowness Indices

Visually, yellowness is associated with scorching, soiling, and general product degradation by light, chemical exposure, or processing. Yellowness indices are used chiefly to measure these types of degradation.

Yellowness Index per ASTM Method E313 (displayed as YIE is calculated as follows:)

$$YI_{E313-96} = \frac{100(C_x X - C_z Z)}{Y}$$

Where, X, Y, and Z are the CIE tristimulus values and the coefficients depend on the illuminant and observer as indicated in the table given in ASTM E313. This index is only displayed when the data view is configured for either the C or the D65 illuminant, as these are the only relevant illuminants.

Refer to ASTM Method E313, "Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates," for more information.

Yellowness Index per ASTM Method D1925 (displayed as YID) is defined in the MiniScan EZ as follows:

$$YI_{D1925} = \frac{100(1.274641506X - 1.057434092Z)}{Y} \quad \text{under } C/2^\circ \text{ conditions.}$$

The yellowness index formula is shown in ASTM D1925 as:

$$YI_{D1925} = \frac{100(1.28 X_{CIE} - 1.06 Z_{CIE})}{Y_{CIE}} \quad \text{under } C/2^\circ \text{ conditions.}$$

The tristimulus values of clear air (for CIE illuminant C and the 1931 CIE 2° standard observer) are X = 98.041, Y = 100.000, Z = 118.103. Using these values, the ASTM formula yields YI = 0.303 for clear air because the factors are truncated to three significant figures. In order to set the yellowness index for air equal to 0.0, the constant multipliers for X_{CIE} and Z_{CIE} have been expanded slightly in the MiniScan EZ.

The ASTM D1925 method was withdrawn in 1995, but this formula still provides useful information. This index is only displayed when the data view is configured for C/2°, as this is the only relevant illuminant/observer combination.

Paper Brightness

(Z%) Paper brightness, Z%, is used in the evaluation of the degradation of white materials. It can also be a measure of the effectiveness of bleaching.

$$Z\% = \frac{100Z_{\text{CIE}}}{Z_n} .$$

Difference Indices

(Available when Display Type is Difference; Reading of Both Standard and Sample Required)

D457B

This index yields the difference between the sample and the standard via the 457-nm Brightness index.

$$D457B = 457B_{\text{sample}} - 457B_{\text{standard}}$$

dTint

This index yields the difference between the sample and the standard via the Tint indices.

$$dTint = Tint_{\text{sample}} - Tint_{\text{standard}}$$

dWIE

This index yields the difference between the sample and the standard via the Whiteness Index.

$$dWIE = WIE_{\text{sample}} - WIE_{\text{standard}}$$

dY Brightness

This index yields the difference between the sample and the standard via the Y brightness index.

$$dY = Y_{\text{sample}} - Y_{\text{standard}}$$

dYIE and dYID

These indices yield the differences between the sample and the standard via the Yellowness Index E313 and Yellowness Index D1925.

$$dYIE = YIE_{\text{sample}} - YIE_{\text{standard}}$$

$$dYID = YID_{\text{sample}} - YID_{\text{standard}}$$

dZ%

This index yields the difference between the sample and the standard via the Z% index.

$$dZ\% = Z\%_{\text{sample}} - Z\%_{\text{standard}}$$

Other Indices

(Available with Absolute and Difference Display Types; Reading of Both Standard and Sample Required)

dE Total Color Difference

The Hunter L, a, b total color difference for any illuminant and observer is calculated as follows:

$$dE = \sqrt{dL^2 + da^2 + db^2}$$

dE approximates the NBS Unit of Color Difference (Judd-Hunter), which represents the average maximum difference acceptable in a series of dye house commercial matches in 1939.

dC Chromaticity Difference

The Hunter L, a, b chromaticity difference for any illuminant and observer is calculated as follows:

$$dC = \sqrt{da^2 + db^2} .$$

dE* Total Color Difference

CIE dE* total color difference is defined as follows:

$$dE^* = \sqrt{dL^{*2} + da^{*2} + db^{*2}} .$$

dC* Chroma Difference

CIE dC* chroma difference is defined as follows:

$$dC^* = C^*_{\text{sample}} - C^*_{\text{standard}} \text{ where } C^* = \sqrt{a^{*2} + b^{*2}} \text{ and is termed metric chroma.}$$

Colorant Strength

When SMA is selected as the index, color values are adjusted based on the wavelength of maximum absorbance (minimum reflectance) of the standard. The strength value is displayed as a percentage.

SMA = (K/S)_λ, where

$$(K/S)_{\lambda} = \frac{(1.0 - K_{\lambda})^2}{[2.0 * (1.0 - S_{\lambda}) * (K_{\lambda} - S_{\lambda})]}$$

K_{λ} = the absorption coefficient of the specimen (the %R value normally measured by a spectrophotometer and normalized to 1.0)

S_{λ} = the scattering coefficient of the specimen (assumed to be 0.0 for most applications).

SW is K/S weighted by the visual function (such as the XYZ observer functions and the D65 illuminant energy function) and summed over a wavelength interval within the visible spectrum.

$$SW = \sum_{\lambda} E_{\lambda} * (K/S)_{\lambda} * S_{\lambda} d\lambda, \text{ where}$$

λ = wavelength over the available range of the spectrophotometer

E = energy distribution of the illuminant being used

S = observer functions.

dEc and CMC Autotolerancing

The equation for dEc describes an ellipsoidal volume with axes in the direction of lightness, chroma, and hue centered about a standard. When the semi-axis lengths for the ΔEc formula equal the calculated ISL, cSc, and SH values for the standard, the resulting ellipsoid describes a 1.0 dEc unit volume/tolerance.

This volume and the size of its component parts become the basis for the establishment of an appropriately-sized volume of acceptability for a given commercial situation by the application of a commercial factor (cf). The cf equals the dEc tolerance.

When $l = 2.0$ and $c = 1.0$, the equation fixes the ratio of the three components (SL:SC:SH) to correlate with visible assessment of typical textile samples. Other values of l may be required in cases where the surface characteristics change dramatically. The value of c is always left at 1.0.

$$dEc = \sqrt{\left(\frac{dL^*}{ISL}\right)^2 + \left(\frac{dC^*}{cSC}\right)^2 + \left(\frac{dH^*}{SH}\right)^2} \quad \text{Absolute}$$

$$dL^* * c = \frac{dL^*}{ISL}$$

$$dC^* * c = \frac{dC^*}{cSC}$$

$$dH^* * c = \frac{dH^*}{SH}, \text{ where}$$

L^* , C^* , and H^* are those of the standard unless otherwise specified.

$$SL = \frac{0.040975L^*}{1 + 0.01765L^*} \quad \text{for } L^* > 16$$

$$SL = 0.511 \quad \text{for } L^* < 16$$

$$SC = \frac{0.0638C^*}{1 + 0.0131C^*} + 0.638$$

$$SH = (FT + 1 - F) SC$$

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

$$h^{\circ} = \arctan\left(\frac{b^*}{a^*}\right)$$

$$dL^* = L^*_{SMP} - L^*_{STD}$$

$$dC^* = C^*_{SMP} - C^*_{STD}$$

$$dH^* = \sqrt{dE^{*2} - dL^{*2} - dC^{*2}}$$

$$F = \sqrt{\frac{C^{*4}}{C^{*4} + 1900}}$$

$$T = 0.36 + |0.4 \cos(35 + h)| \quad \text{for } h < 164^{\circ} \text{ or } h > 345^{\circ}$$

$$T = 0.56 + |0.2 \cos(168 + h)| \quad \text{for } 164^{\circ} < h < 345^{\circ}$$

Tolerances are:

$$dL^* = (cf) / SL \quad dLc = cf$$

$$dC^* = (cf) cSC \quad dCc = cf$$

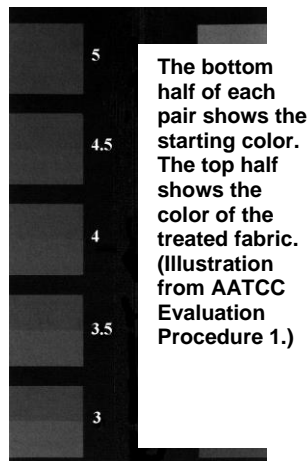
$$dH^* = (cf) SH \quad dHc = cf$$

$$dEc = cf$$

For a more detailed description of CMC, refer to "Calculation of Small Color Differences for Acceptability," AATCC Test Method 173-1992, published in the AATCC Technical Manual.

Gray Change

Gray Change indicates the amount of fading or color alteration that occurs with environmental exposure or washing of textiles. The loss of color using the Gray Change Scale is evaluated by comparison to five pairs of gray standards like those shown below. One half of each standard is always of identical chroma to the starting specimen. The second half ranges from the starting chroma (no loss of color) to white (loss of all color). The amount of contrast between the treated and untreated fabric is related to one of the standard pairs to yield the gray scale rating. On this scale, 5 indicates that next to no color was lost, and 1 indicates that most color was lost.



Gray Change, as implemented, is based on ISO 105-A05:1996, Textiles - Tests for Colour Fastness - Part A05: Instrumental Assessment of Change in Colour for Determination of Grey Scale Rating. This method is equivalent to AATCC Evaluation Procedure 7, "Instrumental Assessment of Change in Color of a Test Specimen." It is intended as an alternative to visual assessment as described in ISO 105-A02: 1993, Textiles - Tests for Colour Fastness - Part A02: Grey Scale for Assessing Change in Colour, or AATCC Evaluation Procedure 1, "Gray Scale for Color Change," and is generally used in color fastness testing. It may be used in assessing any samples except those which have been treated with fluorescent whitening agents (FWAs).

$$dE_F = \sqrt{dL^*{}^2 + dC_F^*{}^2 + dH_F^*{}^2}, \text{ where}$$

$$dH_F = \frac{dH_K}{1 + (10C_M/1000)^2}$$

$$\Delta C_F = \frac{\Delta C_K}{1 + (20C_M/1000)^2}$$

$$dH_K = dH^*_{ab} - D$$

$$dC_K = dC^*_{ab} - D$$

$$D = \frac{dC^*_{ab} C_M e^{-x}}{100}$$

$$x = \left[\frac{h_M - 280}{30} \right]^2 \quad \text{if } |h_M - 280| \leq 180$$

$$x = \left[\frac{360 - |h_M - 280|}{30} \right]^2 \quad \text{if } |h_M - 280| > 180$$

$$C_M = \frac{C_{abT} + C^*_{abO}}{2}$$

$$h_M = \frac{h_{abT} + h_{abO}}{2} \quad \text{if } |h_{abT} - h_{abO}| \leq 180$$

$$h_M = \frac{h_{abT} + h_{abO}}{2} + 180 \quad \text{if } |h_{abT} - h_{abO}| > 180 \text{ and } |h_{abT} + h_{abO}| < 360$$

$$h_M = \frac{h_{abT} + h_{abO}}{2} - 180 \quad \text{if } |h_{abT} - h_{abO}| > 180 \text{ and } |h_{abT} + h_{abO}| \geq 360$$

$L^*_T, C^*_{abT}, h_{abT}$ = lightness, chroma, and hue of Test specimen

$L^*_O, C^*_{abO}, h_{abO}$ = lightness, chroma, and hue of Original

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$$dL^* = L^*_T - L^*_O$$

$$dC^*_{ab} = C^*_{abT} - C^*_{abO}$$

$$\text{sign of } \Delta H^*_{ab} = \text{sign of } (h_{abT} - h_{abO})$$

$$dH^*_{ab} = \sqrt{dE^*_{ab}{}^2 - dL^*{}^2 - dC^*_{ab}{}^2}$$

$$dE^*_{ab} = \sqrt{dL^*{}^2 + da^*{}^2 + db^*{}^2}$$

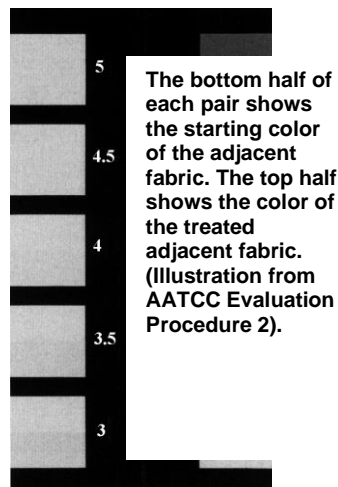
dE_F is used to calculate Gray Change using the equations below:

$$GSC = 5 - \frac{dE_F}{1.7} \quad \text{if } dE_F \leq 3.4$$

$$GSC = 5 - \frac{\log\left(\frac{dE_F}{0.85}\right)}{\log(2)} \quad \text{if } dE_F > 3.4.$$

Gray Stain

The transference of color from the test specimen to an adjacent specimen is evaluated in a manner very similar to that of Gray Change. Again, five standard pairs are used. One half of each standard is white, and the second half range ranges from white (no staining) to a gray with the chroma value of the test specimen (great deal of staining). A value of 5 corresponds to virtually no staining, whereas 1 indicates poor color fastness.



Gray Stain, as implemented, is based on ISO 105-A04:1989, Textiles- Tests for Colour Fastness - Part A04: Method for the Instrumental Assessment of the Degree of Staining of Adjacent Fabrics. It is intended as an alternative to visual assessment as described in ISO 105-A03: 1993, Textiles - Tests for Colour

Fastness - Part A03: Grey Scale for Assessing Staining, or AATCC Evaluation Procedure 2, "Gray Scale for Staining," and is used to assess the degree of staining of adjacent fabrics in a color fastness test.

$$dE_{GS} = dE^* - 0.4 \sqrt{dE^{*2} - dL^{*2}}$$

Use dE_{GS} to calculate the GSS as follows:

$$GSS = 6.1 - 1.45 \ln(dE_{GS}) \quad \text{for Ratings 1 to 4.}$$

If the GSS calculated by the above equation is greater than 4, recalculate using the following equation:

$$GSS = 5 - 0.23dE_{GS} \quad \text{for Ratings 4 to 5.}$$

Metamerism Index

In order to display metamerism index, two data views must be configured in your product setup that contain different illuminant/observer combinations.

The Metamerism Index is designed to indicate the degree to which two items which match under one illuminant no longer match under a second illuminant. The formula for deriving the index is:

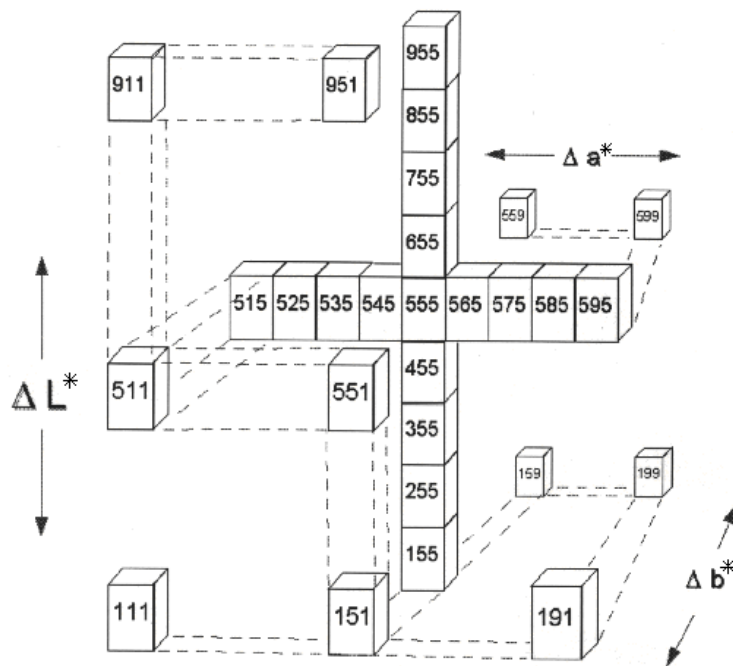
$$MI = \sqrt{(dL_{n1} - dL_{n2})^2 + (da_{n1} - da_{n2})^2 + (db_{n1} - db_{n2})^2}$$

Where, n1 is the original illuminant and n2 is the illuminant selected in the product setup using the Duplicate standard type.

Shade Number

The shade number, SSN, that can be obtained using your MiniScan EZ provides a convenient way of sorting samples into groups (or “blocks”) of similar color. This is helpful in situations where several separate pieces will be combined into a whole and the colors of the pieces must be closely matched.

In order to use shade sorting, you must first read an ideal product standard into your setup preferably as a PHYSICAL standard, and your first data view must be displaying the L*a*b*, L, a, b, or dLdCdH color scale. Then enter your desired tolerances into the setup as well. These tolerances will provide the borders on which your shade number blocks will be based. CMC autotolerancing may be used to calculate these tolerances if desired, but manually-entered rectangular tolerances work just as well. Then, on the CMC/Shade Sort screen, enter the number of shade blocks you wish to have fit inside your tolerance borders. Choices available are 1, 3, 5, 7, and 9. There are nine shade blocks within the acceptable limits (able to be displayed) for each dimension (L*a*b*), so there are 729 possible shade number assignments. Any sample that falls outside the displayable limits is indicated not with numbers, but with a + or -, depending on whether the actual shade number should be higher than 9 or lower than 1.



The illustration shown above uses the L*a*b* color scale. The middle shade block, 555, is where the standard is located. The first 5 denotes L*, the second 5 denotes a*, and the third 5 denotes b*. The tolerance values are indicated as ΔL^* , Δa^* , and Δb^* . There are five shade blocks on either side of the standard (including the standard's block) on the L* axis, five on either side of the standard on the a* axis, and five on either side of the standard in the b* direction. Suppose we wish to use five shade blocks. Not all of the shade blocks shown on the drawing (from 111 to 999) fall within the established tolerance. Five blocks for each parameter (L*, a*, and b*) do fall within the tolerance range. For the L* parameter, these will be blocks labeled 3-7 for the L* number. For the a* parameter, these will be blocks labeled 3-7 for the a* number. For the b* parameter, these will be blocks labeled 3-7 for the b* number. Thus, the 345 shade block would be within the tolerance range, but the 245 shade block would be too dark.

Continuing with our example given above, suppose the entered tolerance for each parameter is ± 1 unit. That is, $\Delta L^* = 1$, $\Delta a^* = 1$, and $\Delta b^* = 1$. Thus, with five shade blocks, the center (standard) block extends 0.2 units (1 unit divided by 5) in each direction. The size of this block (and, in fact, each block) is 0.4 units high, 0.4 units wide, and 0.4 units deep (± 0.2 units times 2 directions for each parameter).

Once the ΔL^* , Δa^* , Δb^* difference between the sample and the product standard has been established, a shade number can be assigned to the sample. A sample that is very close to the standard in a* and b*, but has values that put it one shade block away for L* would be assigned a shade number of 655 (if lighter than the standard) or 455 (if darker than the standard). Although this sample's color is slightly "off" from the standard, it will be a good match with any other samples in the same shade block and may still be used with these samples.

The number of shade blocks used can be varied using the MiniScan EZ. If fewer shade blocks are used with the same tolerance (e.g., 3 blocks rather than 5), fewer blocks will be required to fit into the tolerance and each block will be bigger. You may wish to lower the number of shade blocks if you find that your shade block tolerances are too tight. If more shade blocks are used with the same tolerance (e.g., 7 or 9 blocks rather than 5), more blocks will be required to fit into the tolerance and each block will be smaller. You may wish to increase the number of shade blocks if you find that your shade block tolerances are too loose.

Opacity

Opacity (OP) measurements determine opacity by a contrast ratio measurement. For opacity to be displayed the standard type needs to be set to WORKING. The Y value of the sample backed by black is divided by the Y value of the sample backed by white. The resulting fraction is Y%, or opacity, which is calculated as follows:

$$\text{Opacity (Y)} = \frac{Y_{\text{black backing}}}{Y_{\text{white backing}}} \times 100.$$

You will be prompted to make two separate readings before an opacity value is displayed.

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