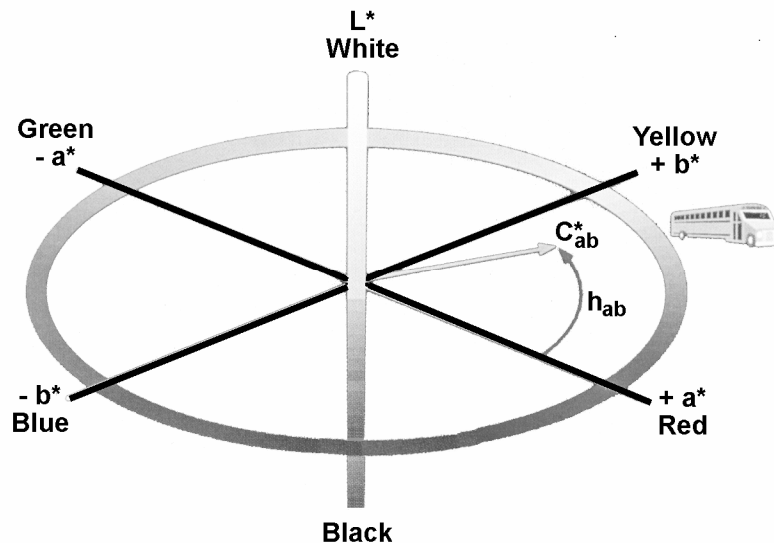




CIE L*C*h Color Scale

Background

The CIE L*C*h or CIELCh color scale is an approximately uniform scale with a polar color space. The CIELCh scale values are calculated from the CIELAB scale values. They are described in Section 4.2 of CIE Publication 15.2 (1986). The L*, lightness, value is the same in each scale. The C* value, chroma, and the h value, hue angle, are calculated from the a* and b* of the CIELAB scale. The CIELCh color space is diagrammed below.



The basic delta values for this scale are ΔL^* , ΔC^* , and ΔH^* . They are the differences between the sample and standard in L*, C*, and h*. The total color difference, ΔE^* is the same as the ΔE^* in the CIELAB scale.

Another total color difference value often used with this color scale is ΔE_{cmc} . ΔE_{cmc} and associated values will be discussed in a separate Applications Note. Please refer to it for further information.

Conditions for Measurement

Instrumental: Any HunterLab color measurement instrument

Illuminant: Any

Standard Observer Function: 2 or 10 degree

Transmission and/or Reflectance: Either.

Formulas

If X/X_n , Y/Y_n , and Z/Z_n are all greater than 0.008856, then use the following equation for L^* :

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

If any of X/X_n , Y/Y_n , or Z/Z_n is equal to or less than 0.008856, then use this equation for L^* :

$$L^* = 903.3 \left(\frac{Y}{Y_n} \right)$$

where

X , Y , and Z are the CIE Tristimulus Values.

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

Y_n is 100.00.

X_n and Z_n are listed in the tables below.

CIE 2 Degree Standard Observer

Illuminant	X_n	Z_n
A	109.83	35.55
C	98.04	118.11
D ₆₅	95.02	108.82
F2	98.09	67.53
TL 4	101.40	65.90
UL 3000	107.99	33.91
D ₅₀	96.38	82.45
D ₆₀	95.23	100.86
D ₇₅	94.96	122.53

CIE 10 Degree Standard Observer

Illuminant	X_n	Z_n
A	111.16	35.19
C	97.30	116.14
D ₆₅	94.83	107.38
F2	102.13	69.37
TL 4	103.82	66.90
UL 3000	111.12	35.21
D ₅₀	96.72	81.45
D ₆₀	95.21	99.60
D ₇₅	94.45	120.70

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

$$h = \arctan \frac{b^*}{a^*}$$

where

If X/X_n , Y/Y_n , and Z/Z_n are all greater than 0.008856, then use:

$$a^* = 500 \left(\sqrt[3]{\frac{X}{X_n}} - \sqrt[3]{\frac{Y}{Y_n}} \right)$$

$$b^* = 200 \left(\sqrt[3]{\frac{Y}{Y_n}} - \sqrt[3]{\frac{Z}{Z_n}} \right)$$

If any of X/X_n , Y/Y_n , or Z/Z_n is equal to or less than 0.008856, then use:

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

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

where

$$f\left(\frac{X}{X_n}\right) = \sqrt[3]{\frac{X}{X_n}} \quad \text{when } X/X_n > 0.008856$$

$$f\left(\frac{X}{X_n}\right) = 7.87 \left(\frac{X}{X_n}\right) + \frac{16}{116} \quad \text{when } X/X_n < 0.008856$$

$$f\left(\frac{Y}{Y_n}\right) = \sqrt[3]{\frac{Y}{Y_n}} \quad \text{when } Y/Y_n > 0.008856$$

$$f\left(\frac{Y}{Y_n}\right) = 7.87 \left(\frac{Y}{Y_n}\right) + \frac{16}{116} \quad \text{when } Y/Y_n < 0.008856$$

$$f\left(\frac{Z}{Z_n}\right) = \sqrt[3]{\frac{Z}{Z_n}} \quad \text{when } Z/Z_n > 0.008856$$

$$f\left(\frac{Z}{Z_n}\right) = 7.87 \left(\frac{Z}{Z_n}\right) + \frac{16}{116} \quad \text{when } Z/Z_n < 0.008856$$

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

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

$$\Delta H^* = \sqrt{\Delta E^{*2} - \Delta L^{*2} - \Delta C^{*2}} \quad \text{if } h^{\circ}_{\text{SMP}} > h^{\circ}_{\text{STD}}, \text{ then } \Delta H^* \text{ is regarded as positive.}$$

if $h^{\circ}_{\text{SMP}} < h^{\circ}_{\text{STD}}$, then ΔH^* is regarded as negative.

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$

Typical Applications

This color scale may be used for measurement of the color of any object whose color can be measured.

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