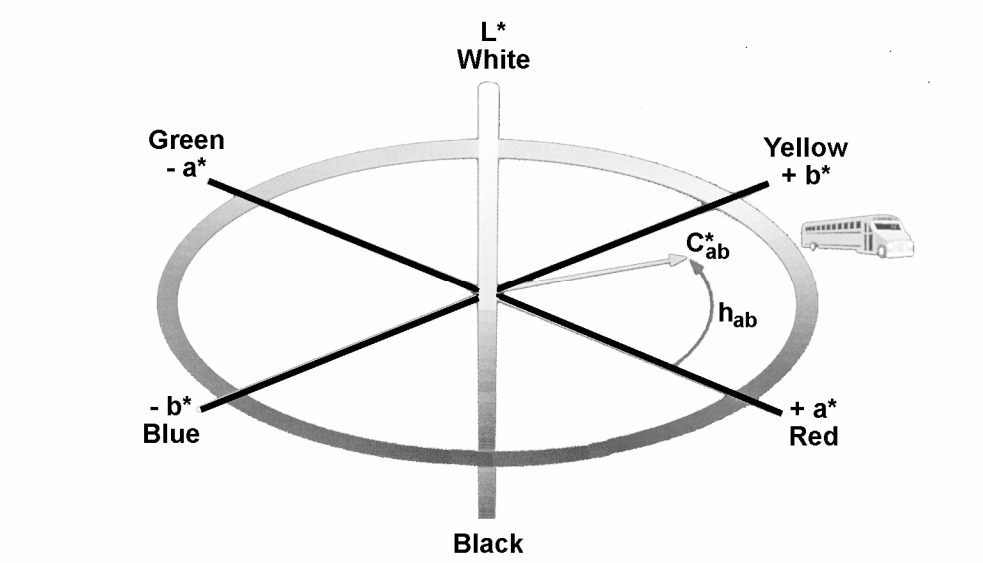
Applications Note

Insight on Color **Vol. 8, No. 11**

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

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

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

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

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

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

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

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

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

$$\Delta H^* = \sqrt{\Delta E^{*2} - \Delta L^{*2} - \Delta C^{*2}}$$

if $h°_{SMP} > h°_{STD}$, then ΔH^* is regarded as positive.

if $h°_{SMP} < h°_{STD}$, 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.

For Additional Information Contact:

Technical Services Department
Hunter Associates Laboratory, Inc.
11491 Sunset Hills Road
Reston, Virginia 20190
Telephone: 703-471-6870
FAX: 703-471-4237
www.hunterlab.com