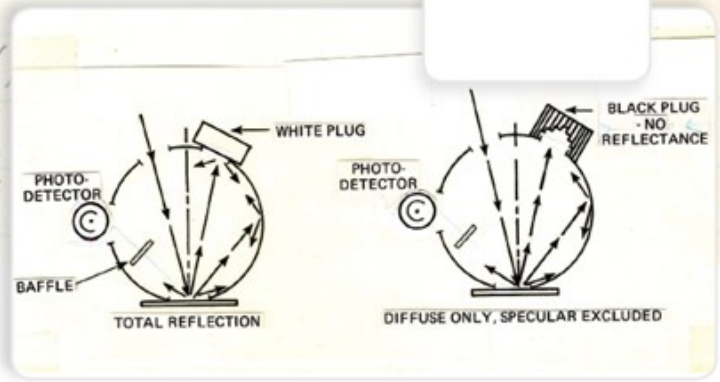
Applications Note

AN 1112




# CIE L*C*h* Color Scale

***In this color space, L* indicates lightness, C* represents chroma, and h is the hue angle. Chroma and hue are calculated from the a* and b* coordinates in L*a*b*.***


**Abstract**

The CIE L*C*h or CIELCh color scale is an approximately uniform scale with a polar color space. The CIE LCh 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.



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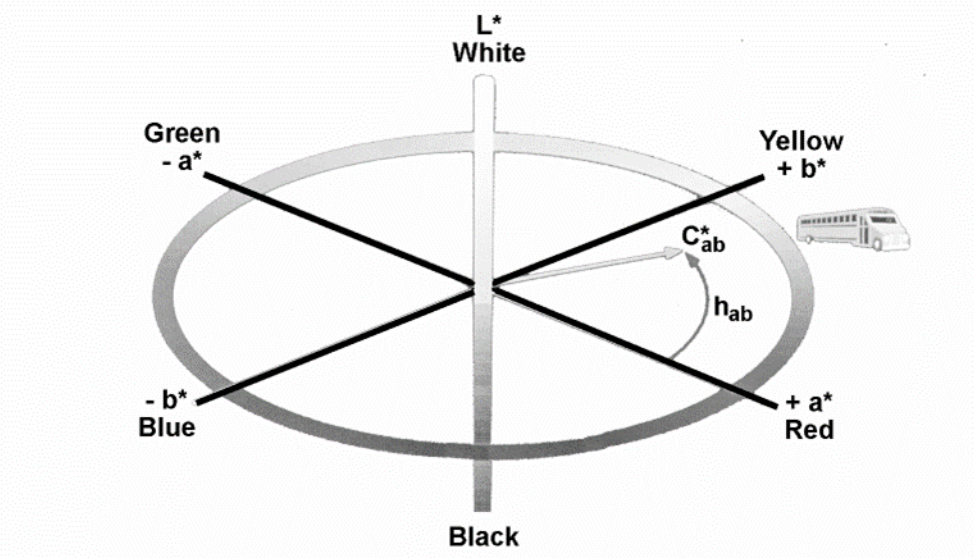
The CIE LCh color space is diagrammed below.




The basic delta values for this scale are DL*, DC*, and DH*. They are the differences between the sample and standard in L*, C*, and h*. The total color difference, DE* is the same as the DE* in the CIELAB scale.

Another total color difference value often used with this color scale is $DE_{cmc}$. $DE_{cmc}$ 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 |
| D65 | 95.02 | 108.82 |
| F2 | 98.09 | 67.53 |
| TL 4 | 101.40 | 65.90 |
| UL 3000 | 107.99 | 33.91 |
| D50 | 96.38 | 82.45 |
| D60 | 95.23 | 100.86 |
| D75 | 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 $\Delta H^*$ is regarded as positive.

if $h°_{SMP} < h°_{STD}$, then $\Delta H^*$ 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.

## About HunterLab

HunterLab is the technology leader in color measurement solutions, providing instruments, software, knowledge and service to a wide variety of industries.
With over 5 decades of experience in more than 65 countries, HunterLab applies our leading edge technology to your products helping you measure and communicate color simply and effectively.

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