

EC  SENSE<sup>®</sup>  
WORD BANK

## LIGHT MEASUREMENT UNITS

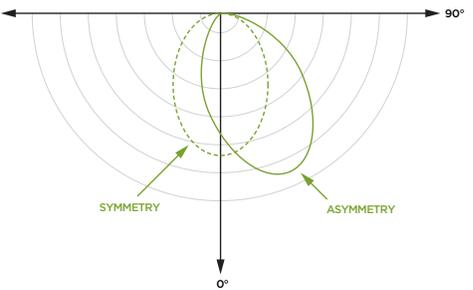
UNIT	ABBREVIATION	EQUATION	DEFINITION
<b>CANDELA</b>	cd	$1 \text{ cd} = 1(\text{lm}/\text{sr})$	The SI unit of luminous intensity. One candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency $540 \times 10^{12}$ Hz and has a radiant intensity in that direction of $1/683$ watt per steradian.
<b>FOOT CANDLES</b>	fc	$1 \text{ fc} = 1 \text{ lm}/1 \text{ ft}^2$	Non-SI unit of illuminance, measuring luminous flux per unit area
<b>KELVIN</b>	K		The kelvin is often used in the measure of the color temperature of light sources. Color temperature is based upon the principle that a black body radiator emits light whose color depends on the temperature of the radiator. Black bodies with temperatures below about 4000 K appear reddish whereas those above about 7500 K appear bluish. Color temperature is important in the fields of image projection and photography where a color temperature of approximately 5600 K is required to match "daylight" film emulsions.
<b>LUMEN</b>	lm	$1 \text{ lm} = 1 \text{ cd} \cdot 1 \text{ sr}$	The luminous flux emitted into unit solid angle (1 sr) by an isotropic point source having a luminous intensity of 1 candela
<b>LUX</b>	lx	$1 \text{ lx} = 1 \text{ lm}/1 \text{ m}^2$	SI unit of illuminance, measuring luminous flux per unit area
<b>STERADIANS</b>	sr		A unitless value that expresses solid angle. Is used in three-dimensional geometry, and is analogous to the radian which quantifies planar angles.

## LIGHT MEASUREMENT TERMS

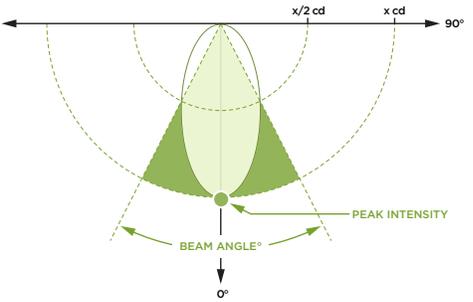
UNIT	ABBREVIATION	SYMBOL	DEFINITION
<b>ILLUMINANCE</b>	lx	E	Luminous power incident on a surface
<b>LUMINANCE</b>	cd/m <sup>2</sup>	L	Luminous power per unit solid angle per unit projected source area
<b>LUMINOUS EFFICACY</b>	lm/W	η	A ratio between the lumens generated and the power consumed
<b>LUMINOUS EFFICIENCY</b>	%	V	A measure expressed as a percentage that shows how the fixture's physical characteristics will affect how much light will leave the fixture. These include: fixture design, the reflectance of its materials, lamps/LEDs, optics, power supply and other material such as a lens or louver is used.
<b>LUMINOUS EMITTANCE</b>	lx	M	Luminous power emitted from a surface
<b>LUMINOUS ENERGY</b>	lm•s	Q	The perceived energy of light or the radiant energy factored by the sensitivity of the human eye
<b>LUMINOUS FLUX</b>	lm	Φ	The radiant power (is the total radiated power in watts, also called radiant flux) factored by the sensitivity of the human eye
<b>LUMINOUS INTENSITY</b>	cd	I	A measure of the wavelength-weighted power emitted by a light source in a particular direction per unit solid angle
<b>SOLID ANGLE</b>	sr	Ω	An object's solid angle in steradians is equal to the area of the segment of a unit sphere, centered at the angle's vertex, that the object covers

**LIGHT DISTRIBUTION TERMS**

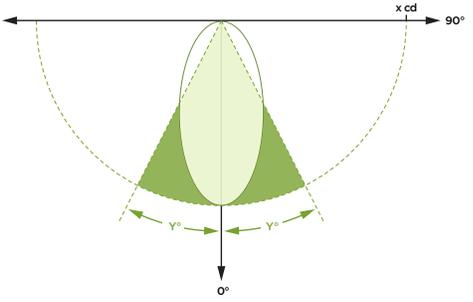
TERM	DEFINITION
<b>ASYMMETRY</b>	Denotes that 2 or more quadrants have differences in the candela distributions



<b>BEAM ANGLE</b>	The angle at which the candela intensity drops to 50% of the peak intensity
-------------------	---

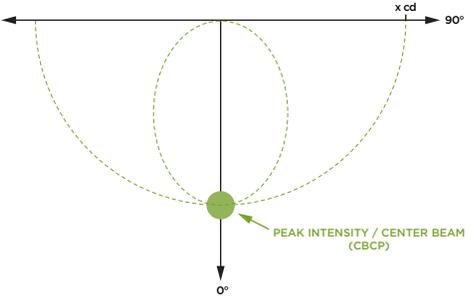


<b>BILATERAL SYMMETRY</b>	Denotes equal light intensity at adjacent quadrants (quadrants 1=2 & 3=4, or 2=3 & 4=1)
---------------------------	---

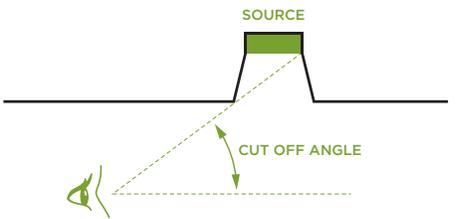


**CANDELA DISTRIBUTION** A curve (can be displayed or plotted in polar or cartieatian coordinates) showing the variation of luminous intensity of a source on a plane through the luminous center

<b>CBCP</b>	Center beam candle power- refers to the candela value at nadir (directly below the fixture)
-------------	---



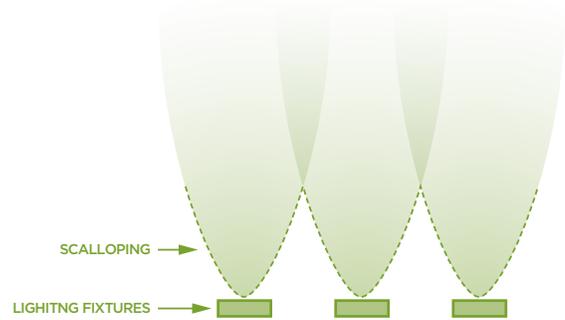
<b>CUT OFF ANGLE</b>	The angle measured off the horizontal at which the source is visible
----------------------	--





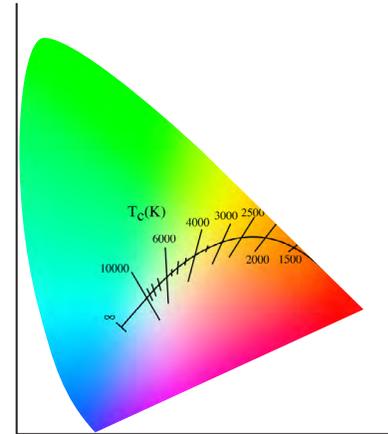
**LIGHT APPLICATION TERMS**

TERM	DEFINITION
<b>GLARE</b>	Powerful and uncomfortable concentration of light from a fixture that can leave the lasting impressions in vision
<b>SCALLOPING</b>	The pattern that is created when a cone of light intersects with a surface
<b>MULTIPLE SHADOWS IN THE BEAM</b>	When using multiple light sources, such as multiple LEDs in one fixture, multiple shadows can be cast from one object being illuminated
<b>SHADOW</b>	A shadow is a region where light from a light source is obstructed by an opaque object
<b>STRIATION</b>	A phenomenon which exaggerates the contrast between edges of the slightly differing shades of gray, as soon as they contact one another, by triggering edge-detection in the human visual system
<b>UNIFORMITY RATIO</b>	A ratio of the largest and smallest foot-candle value on a plane. Typically refers to luminance values on a surface.



TERM DEFINITION

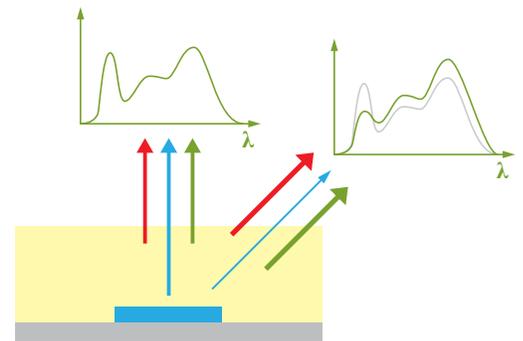
**CCT** Correlated Color Temperature - used to define the position on the Black Body Curve for White Light  
Unit of Measure: **Kelvin (K)**



**CCT SHIFT OVER POWER INPUT** As the input power for a fixture decreases, the CCT of the light source will become slightly warmer in color

**CCT SHIFT OVER TIME** Over time, the CCT of an LED may shift due to curling (shift to blue) or delaminating (shift to yellow)

**COLOR OVER ANGLE (COA)** Color varies as a result of the angle by which it exits the LED. At large angles the optical path of blue light is larger leading to more absorption and a spectrum with less blue light and more phosphor-converted (yellow) light. Mid power LEDs routinely have worse color over angle performance than high power LEDs, and different manufacturer's versions of high power LEDs have a wide variations in color over angle performance as well.



**COLOR VARIATION** DUV noticeable to the human eye. Generally considered to be anything greater than 0.004 DUV for any observer, or greater than .002 DUV for a trained observer.

**DUV** The most accurate metric to describe the color shift of a light source is  $Du'v'$ -that is, the change in  $u'v'$  coordinates on the International Commission on Illumination (CIE) 1976 ( $u'v'$ ) chromaticity diagram, which is the most visually uniform diagram of a light source's color. Color shift can be caused by physical changes to the LED package that reconfigure the ratio of blue pump to phosphor emission. Different LEDs can vary considerably in terms of their color stability, and some of the problems in this regard that were observed in earlier versions have been corrected in newer LED packages. One thing that's certain is that color shift is not an inevitable outcome for LED lighting products.

**LED COLOR CONSISTENCY** A measure of the color variation over angle. Also reference Color Over Angle (COA).

TERM	DEFINITION
------	------------

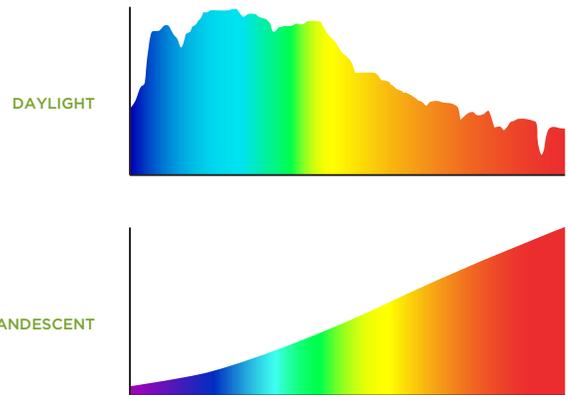
<b>LUMEN MAINTENANCE</b>	Lumen maintenance compares the amount of light produced from a light source or from a luminaire when it is brand new to the amount of light output at a specific time in the future. Useful lifetime estimates for LED lighting products are typically given in terms of the expected operating hours until light output has diminished to 70% of initial levels (denoted L70 life) for a given operating Temperature. <i>EX: 100,000hrs at L70 at 25C</i>
--------------------------	--

<b>MACADAM ELLIPSE</b>	In the study of color vision, a MacAdam ellipse is a region on a chromaticity diagram which contains all colors which are indistinguishable, to the average human eye, from the color at the center of the ellipse. ANSI recommends that lamp (light source) manufacturers stay within 4 MacAdam Ellipses. A 1-step MacAdam ellipse defines a zone in the CIE 1931 2 deg (xy) color space within which the human eye cannot discern color difference. Most LEDs are binned at the 4-7 step level, in other words, you certainly can see color differences in LEDs that are reportedly the same color.
------------------------	---

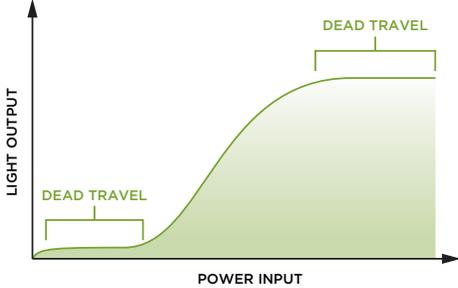
<b>PHOSPHOR COVERED BLUE LEDs</b>	The typical method for creating a white light emitting LED - to coat a blue LED chip with yellow phosphor. The blue + yellow spectra sum to white light output (cool white). Red phosphor is added to the yellow phosphor in order to create a warm white LED.
-----------------------------------	--

<b>SDCM (STANDARD DEVIATION OF COLOR MATCHING)</b>	SDCM has the same meaning as a “MacAdam Ellipse”
--	--

<b>SPECTRAL POWER DISTRIBUTION (SPD)</b>	A Spectral Power Distribution is a graph of the radiant power per unit area at each wavelength of a given source and provides a visual profile of the color characteristics of a light source
--	---



**DRIVER AND DIMMING PERFORMANCE TERMS**

TERM	DEFINITION
<b>DEAD TRAVEL</b>	<p>The point(s) at which the light level stays the same, as you reduce/increase the dimming level on a dimmer</p> 
<b>DROP OUT</b>	<p>Drop out occurs where the light turns off (or “drops out”) as you move decrease the dimming level, although you have not reached the bottom of the dimmer. This is common due to the fact that different dimmer models have different values for their lowest, low end voltage. A very common way to control Drop Out is to set the low end trim higher than the drop out point. Some dimmers lowest low end level might fall below the fixture support dimming range.</p>
<b>FLICKER</b>	<p>A flickering light source is one where its brightness level is unsteady or fluctuating and is noticeable by the human eye</p>
<b>POP-ON</b>	<p>The Pop-on effect results when the LED fixture does not turn on at its very lowest light level and the dimming level must be increased in order for the light to turn on. It is common practice in the industry to set the trim on the low levels of the dimmer in order to prevent instabilities. Low end trim could be set high enough to guarantee no pop-on behavior. Some dimmers can also be locked to turn on at a preset level. This is a level that could be set higher than the required pop-on threshold.</p>
<b>POPCORNING</b>	<p>Popcorning is a behavior experienced when turning on of a group of fixtures and individual fixture in that group turns on with noticeable delays</p>
<b>SHIMMER</b>	<p>A form of flicker that could be perceived as less annoying, or noticeable, but is still for unsteady or fluctuating light</p>
<b>SOFT OFF</b>	<p>The slow fade off of the light output when the fixture is turned off</p>
<b>SOFT ON</b>	<p>The slow fade on of the light output when the fixture is turned on</p>