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Technical Notes

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# Light Emitting Diode (LED) *Lighting Basics*

**This Technical Note reviews important photometric terms and concepts. It addresses common misconceptions in lighting and is intended to give *retailers*, *distributors*, and *consumers* a basic understanding of information included with an LED lighting product.**

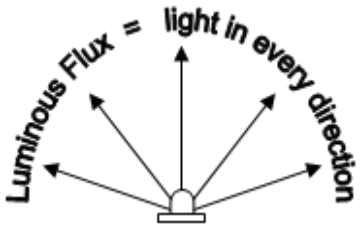
*The Information contained in this article builds on previous Technical Notes. See also: http://www.lightinaafrica.ora/resources/briefina-notes.html*

## Brightness and Luminous Intensity

Intensity is often equated with how 'bright' a light appears, and was originally described using light from a burning candle. Such 'standard candles' were used to define the candela, the basic unit of luminous intensity. A small spot of light like a candle (or an LED) may appear bright, but not produce enough overall light to cover a larger surface or illuminate a room very well.

## Luminous Flux and Illuminance

Luminous flux, measured in lumens (lm), is typically used to describe the total amount of light that a light source produces in all directions. A lumen represents a specific perceived amount of light, and takes into account the sensitivity of the human eye (the eye is more sensitive to green light and less sensitive to deep red and deep blue/purple).




**Lumen output examples**

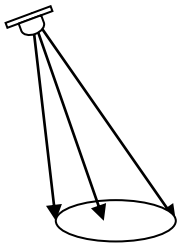
| | |
|---|---|
| Standard candle | = 12 lumens |
| Kerosene wick lantern | = 8 - 40 lumens |
| Pressurized kerosene lamp | = 330 – 1000 lumens |
| 60 watt GLS incandescent | = 900 lumens |
| 23 watt compact fluorescent | = 1000 lumens |

**Basic Photometric Units**

| Photometric Term | SI unit | Basic Units |
|---|---|---|
| Luminous Flux | Lumen | lm = cd • sr* |
| Illuminance | Lux | lx = lm/m$^2$ |
| Luminous Intensity | Candela | Cd = lm/sr |

*sr = steradian = solid angle. A solid angle is a two dimensional angular span in three-dimensional space, like a cone intersecting a sphere.

Illuminance is the amount of light incident on a surface, measured in lumens per meter$^2$ (lm/m$^2$). The unit of illuminance is lux; 1 lux = 1 lm/m$^2$. A typical handheld illuminance meter measures lux (or foot-candles in English units).



**Illuminance = Lux = Light incident on a surface. This is what you measure with an illuminance meter; this is NOT luminous flux!**

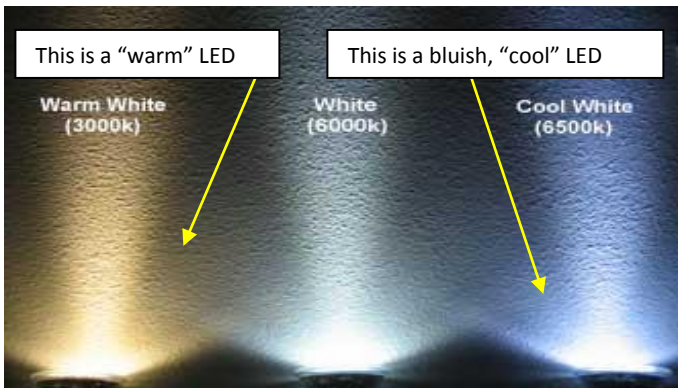
## Flux vs. Illuminance

The difference between lumens and lux is important. A focused LED can concentrate light onto a small area, and the illuminance at this point can be very high. But the total lumen output (luminous flux) for the device can still be very low because the light is only emitted in a narrow angle.

## Color (Chromaticity)

The human eye sees wavelengths between about 400 nm (deep purple) to 700 nm (deep red) - this is the visible spectrum (nm = nanometer). To make a white LED, a blue LED chip is covered with a phosphor that converts some of the blue light into other wavelengths. The resulting mixture is perceived as white light. The chemical composition of the phosphor determines the specific mixture, and white light of many different 'shades', or color temperatures, can be produced.

The color temperature of a white light source is defined by the different colors of light given off by a heated 'black body' emitter (think of a heated filament in a light bulb). At lower temperatures, the filament will glow red, then orange, yellow, and white. Heat the filament further, and the white glow will start to take on a bright bluish color. These different 'colors' of white light are referred to as correlated color temperature (CCT), expressed in degrees Kelvin (K)




White LED light with a strong blue component will appear cool or bluish in color. This is said to have a high color. If the phosphor has more red component added, the LED can appear much warmer and is said to have a low color temperature.

The first white LEDs were high color temperature (bluish). Recent advances have produced LEDs with lower color temperatures because some people prefer the warmer feel of the light. Very warm LEDs, similar to incandescent lights, have CCTs in the 2700K range, while cooler LEDs have CCTs of 5000K, 6000K, or higher.

## Efficacy

Efficacy is a term used to describe the lighting efficiency of an individual LED or an LED system. Efficacy is measured in lumens (total luminous flux) per watt, lm/w.

An LED manufacturer makes efficacy measurements of individual LEDs off of the assembly line, and lists the results when they sell the LEDs to a manufacturer. The tests are quick and do not allow the LEDs time to warm up. If the lamp manufacturer lists these results on their packaging, the efficacy will be exaggerated and will not include losses that occur in a real world LED system.

To get a true picture of the efficacy of an LED system, the entire system must be tested after the LEDs have had time to warm up. The power measurement should be the input power, and all lenses/diffusers should be in place.

Efficacy values are sometimes included on the datasheet for an LED product. This will often be the efficacy value for the bare LED, taken from the LED manufacturer's datasheet, and will not include many of the losses that are part of the completed product.

Efficacy Examples

| | |
|---|---|
| Incandescent GLS (bare) | = 15 lumens/watt |
| Compact Fluorescent (bare) | = 40 - 60 lm/w |
| LED (bare) | = 20 - 100 + lm/w |
| LED Light (complete system) | = 10 - 80 + lm/w |