Lighting - Terminology & Meanings

This glossary covers most of the advanced terminology used in the rating and selection of lighting products. Much of the terminology is based on IESNA (Illumination Engineering Society of North America) nomenclature and are the standards to which many lamp certification bodies and programs such as Energy Star, cULus, DLC and SaveOnEnergy adhere.

Some basic terms have been omitted due to space considerations and the presumed knowledge level of the reader. Also, some information and definitions do not apply directly to the CanAm Lighting product line, but have been included to clarify other concepts presented here.

If you have any questions related to CanAm Lighting specifications and applications, please contact us.

Beam Angle
Any directional lamp emits light energy in the shape of a cone. As you might expect, the Candlepower intensity is the greatest at the center of the cone and it diminishes the closer it gets to the edge of the cone; eventually, in theory, to zero. The usable portion of the cone is defined at the point where the Candlepower falls to 50% of the Candlepower at the center.
See: Spill Light

Beam Spread
Refers to the divergence angle of the light exiting the lamp. The smaller the number, the tighter and brighter the beam. A directional bulb or fixture emits a beam that forms a cone. The angle of that cone is the beam spread of that bulb.

Bulb
The bulb refers to the manufactured unit that produces light. The term lamp is often used in the lighting industry to refer to the whole unit, while the term bulb refers specifically to the portion that generates the actual light.

Candela
Candela is a measure of how much light is actually produced, as measured at the light source. The unit of measure used for LED intensity is the millicandela (mcd), 1000 millicandela equals 1 candela.

Most other light sources like the bulbs found in your home use the Lumen, as the unit of measure. Lumens measure how much light actually falls on a given surface.

So, how do you convert lumens to mcd? There is not an exact conversion since they are different types of measurements but here is a rough conversion: Divide the number of lumens by 12.57 and you will get the equivalent candelas, candelas times 1000 = mcd

Incandescent lamps used for interior lighting generally have an intensity ranging from a few cd to several hundred cd. The common 40-watt lamp has an intensity of about 35 cd; a 100-watt lamp gives about 130 cd. Note that a 40-watt fluorescent lamp has an intensity of about 200 cd. The intensity of any lamp depends on the direction from which it is measured; the average cd power in all directions in space (spherical candle power) is often given.

Candlepower
The unit for measuring the quantity or intensity of light energy emitted by a directional lamp.
Examples of directional lamps include the narrow spot, spot, flood, wide flood, etc. Candlepower is expressed in Candelas.

Confusion is caused for some when one manufacturer lists a lamp’s Candlepower as “Center-Beam Candlepower” while another notes it as “Mean Candlepower” while still another uses “Candela” as the heading for the same information in their Lamp Data Chart. Any of these listings refer to the lamp’s Candlepower and are considered to be the same. Candlepower is used in the Inverse Square Law calculation.

Some texts indicate that 1 candela = 12.57 lumens, however, do not try to convert lumens to candelas using this formula as the results will be inaccurate.

Candlepower is used by lighting designers to calculate the foot-candles illuminating a surface (C.P./distance in feet squared) or Lux illuminating a surface (C.P./distance in meters squared).

**Correlated Color Temperature (CCT)**
A measure of the apparent color of a light source. Different light sources described by color temperature as measured in degrees Kelvin. Lower color temperatures have “warmer” colors closer to red, and higher color temperatures have “cooler” colors with more blue.

Note: The color temperature of daylight can change throughout the day, so “Daylight” should not be used as any sort of standard. CCT measurements should not be confused with color rendering as they are not associated with each other.

**Color Temperature**
The color of the lamp itself as compared to the color of a black reference substance when heated to various temperatures Kelvin and the effect the lamp color has on the color of an objects being illuminated by it. Note: color temperature does NOT depend on the intensity of light, just the color of the light.

- Clear blue sky (without direct sun) 12,000K
- Overcast sky 6,500K to 8,000K
- Sunlight (middle of the day) 4,700K to 5,700K
- Cool lamps range from 3,600K to 6,500K
- "Pure" White is about 4,700K
- Metal Halide 4,500K
- Neutral lamps range from 3,000K to 3,600K
- Halogen 3,000K
- Warm lamps range from 2,700K to 3,000K
- House (incandescent) Lamp 2,500K
- Orange color averages 3,000K
- Candle Flame 1,500K

- Fluorescent lamps are available in Daylight (blue tint), Cool white and Warm white (sometimes called "Kitchen & Bath" lamps.
- Halogen lamps are considered Neutral.
- Incandescent lamps are considered Warm.
- LED lamps are made in the 2700K to 6000K range.
**Color Rendering Index (CRI)**
A measure of how well a light source renders color as compared to daylight. CRI can only be used to compare light sources with the same color temperatures. A CRI of 100 would indicate the light renders the same as daylight at the same color temperature. A CRI in the upper 90's is considered the best assurance that the light source will render all colors properly.

For interior design work, only lamps over 80 should be used.

- Fluorescent lamps are available in 50, 60, 70, 80, & 90 CRI.
- Incandescent and Incandescent Halogen lamps are 99 CRI.
- High quality LED lamps are 80 CRI and higher.

**Coefficient of Utilization (CU Table)**
The efficiency in which the luminaire (total light source) directs lumens to the Work Plane, expressed as a percentage. This CU percentage is listed in a table produced by the fixture manufacturer and is used in the Lumen Method to determine the number of fixtures required to achieve a given Foot Candle level in an area.

**Daylight**
A general term describing the combination of direct sunlight and skylight. Although considered by some as the best light for optimal color rendering, the actual color temperature of daylight will change throughout the day, so it should not be used as any sort of standard.

**Dielectric Coating**
Microscopic layers of material which alter the transmission and reflection of light through clear glass.

**Diffuser**
A translucent piece of glass or plastic sheet that shields the light source in a fixture. The light transmitted throughout the diffuser will be redirected and scattered.

**Efficacy**
The ratio of lumens produced by a lamp vs. the watts consumed, expressed as lumens per watt (LPW). The higher the lumens per watt, the more efficient the lamp. For example, if a 100-watt source produces 9000 lumens, then the efficacy is 90 lumens per watt.

**Electromagnetic Spectrum**
Refers to the orderly arrangement of radiant energy by wavelength or frequency. This spectrum of energy of electric and magnetic waves has an enormous range that includes cosmic rays, x-rays, illumination, radar, television and power transmission waves. In the visible light spectrum, the eye is sensitive to radiant energy between 380 nanometers (violet) and 780 nanometers (red).

**Electroluminescent**
A light source technology used in exit signs that provides uniform brightness, long lamp life (approximately eight years), while consuming very little energy (less than one watt per lamp).

**Electronic Ballast**
A ballast that uses semi-conductor components to increase the frequency of fluorescent lamp operation from 60 Hz to 20-40 kHz range. Smaller inductive components provide the lamp current control. Fluorescent system efficiency is increased due to high frequency lamp operation.

**Electromagnetic Interference (EMI)**
High frequency interference (electrical noise) caused by electronic components or fluorescent lamps that interferes with the operation of electrical equipment. EMI is measured in micro-volts, and can be
controlled by filters. Because EMI can interfere with communication devices, the Federal Communication Commission (FCC) has established limits for EMI.

**Fluorescent Phosphors**
The color of fluorescent lamps is created by mineral phosphors in powder form which coat the inside of the lamp tube. The chemical make-up of these phosphors determines the lamps CRI, its Color Temperature, and how much light the lamp produces. There are four types of phosphor coatings:

Traditional halo phosphors are inexpensive coatings which usually provide the entire spectrum of light. But, there is a trade-off between Color Rendering and Lumen output. Poor color rendering lamps such as "warm white" and "cool white" have high Lumen output. Good color rendering lamps such as "warm white deluxe" and "cool white deluxe" have low Lumen output.

Prime color or Tri-phosphors are very expensive coatings with good color rendering and high lumen output.

Double-coat lamps have a coat of halo-phosphor and a coat of tri-phosphor. Double-coat lamps which have a thick tri-phosphor coat are fairly expensive but have very good color rendering properties. Double-coat lamps with a thin tri-phosphor coat are much less expensive, but still have full light output and reasonably good color rendering.

Rare Earth Phosphors have a thin and thick coat of rare earth phosphors and are just becoming available. The CRI for these lamps will be 70, 80, and 90 and in a variety of Color Temperatures.

**Foot-candles** (Fc)
Measurement of light output in candela per square foot, or the unit of measurement indicating the light present on a surface or Work Plane. It derives from the early English unit of foot-candle defined as the illuminance on a surface placed one foot from the standard candle. 100 foot-candles is generally considered enough light to perform most tasks.

To convert Fc to Lux, use the formula:

\[ \text{Lux} = \text{Fc} \times 10.76 \]

To convert Lux to Fc, use the formula:

\[ \text{Fc} = \text{Lux} \times 0.0929 \]

**Foot Lambert**
The amount of light reflected off a surface. A smooth white surface reflects approximately 80% of the light while a black surface reflects only 4%.

**HID**
Abbreviation for high intensity discharge. Generic term describing mercury vapor, metal halide, high pressure sodium, and (informally) low pressure sodium light sources and luminaires.

**High Pressure Sodium Lamp**
A high intensity discharge (HID) lamp whose light is produced by radiation from sodium vapor and mercury.

**Illuminance**
The concentration of light falling on a surface. Defined as the luminous flux that is incident from all
directions onto a square meter or $E_v = \text{incident luminous flux/surface area receiving it}$. Illuminance is usually measured in Lux.

**Infrared Radiation (IR)**
"Infra" meaning frequencies below those of red light. Essentially, any radiant energy with longer wavelengths than the visible spectrum. The energy is sensed as heat.

**Inverse Square Law**
A formula used for directional lamps to determine the relationship between the Candlepower (Cp) of the lamp, the Distance (D) the lamp is from the surface to be illuminated, and the Foot Candle (Fc) level produced on that surface. If any two of the three elements are known, the third can be determined.

The formula for Inverse Square Law states that illuminance varies inversely with the square of the distance from a point light source. $E = \frac{1}{r^2}$ where $E$ is illuminance and $r$ is the distance. It means that when you double the distance from a point source of light (like our bulbs) the intensity falls off by a factor of four. If you triple the distance, the intensity falls by a factor of nine. You square the distance. This is helpful in understanding how much the intensity drops off as you mount a light source further away from the object you want to illuminate.

Example: an island counter top is 3' high in a kitchen with an 8’ ceiling height. Recessed cans (pot lights) are to be used with a lamp rated at 1150 Candlepower. The distance from the lamp to the counter surface is approximately 5’. By squaring the Distance (D2) between the counter and the lamp (5’ x 5’ = 25’), then dividing it into the lamps rated Candlepower (1150), the Foot Candle level at the counter surface is found to be 46.

**Lamp Current Crest Factor (LCCF)**
The peak lamp current divided by the RMS (average) lamp current. Lamp manufacturers require $<1.7$ for best lamp life. An LCCF of 1.414 is a perfect sine wave.

**Lamp Lumen Depreciation Factor (LLD)**
A factor that represents the reduction of lumen output over time. The factor is commonly used as a multiplier to the initial lumen rating in illuminance calculations, which compensates for the lumen depreciation. The LLD factor is a dimensionless value between 0 and 1.

**LED**
Light Emitting Diode is the light source component of an LED or SSL (Solid State Light) lamp. Voltage applied to the LED chip causes light energy, which can be given focus and direction the same as any incandescent, HID, halogen or fluorescent light. LED lamps are far more energy efficient than other forms of light sources and last substantially longer under the same use conditions and parameters.

**Light**
The visible portion of the electromagnetic spectrum extending from 380 nanometers (ultra-violet end) to 770 nanometers (infra-red end). White light is made up of all three primary colors. The three colors of light are red, blue, and green, and are also called Additive colors. The Subtractive colors are magenta, cyan and yellow.

**Light Loss Factor (LLF)**
Factors that allow for a lighting system’s operation at less than ideal conditions. These factors are used to calculate maintained light levels. LLFs are divided into two categories, recoverable and non-recoverable. Examples are lamp lumen depreciation and luminaire surface depreciation.
Light Output
Also thought of as intensity or brightness. This is measured in candelas also called candlepower units. Note: The farther away the light source is, the less intense the perceived light output, and this process is logarithmic. If you double the distance to the light source, you will receive only one fourth the radiation.

Light Output (Lumen)
The most common measure of light output (or luminous flux) is the lumen. Light sources are labeled with an output rating in lumens. For example, a T12 40-watt fluorescent lamp may have a rating of 3050 lumens. Similarly, a light fixture’s output can be expressed in lumens. As lamps and fixtures age and become dirty, their lumen output decreases (i.e. lumen depreciation occurs). Most lamp ratings are based on initial lumens (i.e. when the lamp is new).

Light Level
Light intensity measured on a plane at a specific location is called illuminance. Illuminance is measured in foot candles, which are work plane lumens per square foot. You can measure illuminance using a light meter located on the work surface where tasks are performed. Using simple arithmetic and manufacturers' photometric data, you can predict illuminance for a defined space. (Lux is the metric unit for illuminance, measured in lumens per square meter. To convert foot candles to Lux, multiply foot candles by 10.76.)

Low-Pressure Sodium (LPS)
A low-pressure discharge lamp in which light is produced by radiation from sodium vapor.

Lumen
The unit of measurement used to indicate the quantity or intensity of any lamp. Think of it in terms of the lamps raw power. Lumens are measured at the lamp. Note: As a light source’s color temperature increases, less light is required to achieve comparable brightness and visual acuity. The lumen is the international unit to describe the quantity of light (also called luminous flux). Lumens are used in the Lumen Method calculation to maintain a given Foot Candle level as required for the application. Some texts indicate that 1 candela = 12.57 lumens, but do not convert lumens to candelas using this formula as results will be inaccurate.

Lumen Maintenance
A comparison of the amount of light produced from a light source when it is brand new to the amount of light output at a specific time in the future. For instance, if a luminaire produced 1000 lumens of light when it was brand new and now produces 700 lumens of light after 30,000 hours, then it would have lumen maintenance of 70% at 30,000 hours. Sometimes this is stated as lumen depreciation, which in our example would be 30% lumen depreciation from the original light output. Lumen maintenance is often specified as LM50, LM70, LM80, or LM90. In each case, L stands for lumen maintenance and the number is the percentage of light output remaining.

The appropriate lumen maintenance target is usually based on the application and the requirements set forth by customers. Since the human eye generally cannot detect a change in light output until there has been 30% depreciation, LM70 is often established as the target for an application. Today’s technology provides LEDs which generally require tens of thousands of operating hours before the LED will lose 30% of its initial light output.

Technical advances in all areas have led to the industry’s longest lived, most reliable LEDs. LEDs meet the LM-80 test criteria developed by the Illumination Engineering Society and the Department of Energy Solid State Lighting Standards Development group by a wide margin. Luminaire and lamp manufacturers that use high quality LEDs can achieve Energy Star certification and ensure their products perform as promised.
**Luminance**
A photometric term that quantifies brightness of a light source or of an illuminated surface that reflects light. It is expressed as foot lamberts (English units) or candelas per square meter (Metric units).

**Luminaire**
A complete lighting unit; an assemblage made up of the fixture and any trim, lenses, reflectors, diffusers and the bulb itself.

**Luminaire Efficiency**
The ratio of total lumen output of a luminaire and the lumen output of the lamps, expressed as a percentage. For example, if two luminaires use the same lamps, more light will be emitted from the fixture with the higher efficiency.

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**Lux**
The metric unit of measurement indicating the amount of light present on one square meter of surface or Work Plane. Lux is the metric equivalent of the Foot Candle. It differs in that instead of using a sphere with a radius of one foot it uses one square meter. One Lux is equal to the amount of light provided by an ordinary wax candle on a spherical surface with an area equal to one square meter, positioned one meter away from the flame. For reference, 10 lux is generally considered enough light to perform most tasks.

To convert Lux to Fc, use the formula:
\[ \text{Fc} = \text{Lux} \times 0.0929 \]

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**Maintained Illuminance**
Refers to light levels of a space at other than initial or rated conditions. This term considers light loss factors such as lamp lumen depreciation, luminaire dirt depreciation, and room surface dirt depreciation.

**Mercury Vapor Lamp**
A type of high intensity discharge (HID) lamp in which most of the light is produced by radiation from mercury vapor. Emits a blue-green cast of light. Available in clear and phosphor-coated lamps.

**Metal Halide**
A type of high intensity discharge (HID) lamp in which most of the light is produced by radiation of metal halide and mercury vapors in the arc tube. Available in clear and phosphor-coated lamps.

**Metamerism**
An effect created when objects having different spectral distributions look alike under one light source but appear different when viewed with a dissimilar light source.

**Nadir**
Zero angle of light perpendicular to the lamp’s face and bisecting the beam angle. Nadir is a line perpendicular to the illuminated surface and the lamp face.

**PAR Lamp**
A Parabolic Aluminized Reflector lamp. An LED, incandescent, metal halide or compact fluorescent lamp used to redirect light from the source using a parabolic reflector. Lamps are available with flood or spot distributions.
PAR 30, 36 and 38
A PAR lamp that is 30, 36 or 38 one-eighths of an inch (3.75" or 4.5" or 4.75") in diameter with a parabolic shaped aluminized reflector and a lens to create various beam angle spreads from spot to flood light.

Parabolic Luminaire
A popular type of fluorescent fixture that has a louver composed of aluminum baffles curved in a parabolic shape. The resultant light distribution produced by this shape provides reduced glare, better light control, and is considered to have greater aesthetic appeal.

Paracube
A metallic coated plastic louver made up of small squares. Often used to replace the conventional flat lens in a fluorescent fixture to enhance its appearance. The Paracube is visually comfortable, but the luminaire efficiency is lowered. Also used in rooms with computer screens because of their glare-reducing qualities.

Reflectance
The ratio of light reflected from a surface to the light incident on the surface. Reflectance is often used for lighting calculations. The reflectance of a dark carpet is around 20%, and a clean white wall is roughly 50% to 60%.

Reflector
The part of a light fixture that shrouds the bulb and redirects some light emitted from the lamp.

Refractor
A device used to redirect the light output from a source, primarily by bending the waves of light.

Spectral Power Distribution (SPD)
The relative power emitted by a light source as a function of wavelength, usually shown in graphical format. SPD graphs provide an easy visual profile of the color characteristics of a light source. Lights that have relatively even representation across the color spectrum have the best color-rendering capabilities. Lights with marked unevenness and spikes will not provide good color rendering.

Spill Light
Outside the beam angle is an area of "spill" light. It extends from the edge of the Beam Angle out to a point in the lamp's cone of light where the Candlepower drops to 10% of the Candlepower at the center of the cone. See: Beam Angle

SSL (Solid State Light)
See: LED

Tungsten Halogen Lamp
A gas-filled tungsten filament incandescent lamp with a lamp envelope made of quartz to withstand the high temperature. This lamp contains some halogens (namely iodine, chlorine, bromine and fluorine), which slow the evaporation of the tungsten. The bulb uses an inert gas to recycle fragments of burnt off tungsten back to the filament. Also commonly called a quartz lamp and the term used to describe an incandescent lamp or bulb that offers a substantially increased life compared to a standard incandescent. Also described as quartz-tungsten-halogen.

Ultraviolet Radiation (U.V)
"Ultra" meaning frequencies above those of violet light. These rays are associated with suntans and fading of pigments and dyes and have a colour temperature of 3,500K to 4,100K.
Voltage
Electric potential expressed in volts or power/current. Most North American households have electric outlets that have a voltage of 110 to 120 volts.

Visual Comfort Probability (VCP)
A rating system for evaluating direct discomfort glare. This method is a subjective evaluation of visual comfort expressed as the percent of occupants of a space who will be bothered by direct glare. VCP allows for several factors: luminaire luminance at different angles of view, luminaire size, room size, luminaire mounting height, illuminance and room surface reflectivity. VCP tables are often provided as part of photometric reports.

Watt
The unit of power or how fast energy is expended over time or power. One watt is equal to one joule/second of time. A joule = 1 kilogram x meters\(^2\) / seconds\(^2\). In single phase circuits, it is related to volts and amps by the formula: Volts x Amps x PF = Watts. Note: For accurate energy calculations in AC circuits, the PF must be included. See Wattage Power Factor

Watts
A rating to measure the amount of energy consumed by a lamp.

CAUTION: Do not select a lamp based solely on wattage. This is a very common mistake as wattage has little to do with the amount of light produced by a lamp.

The fact that a bulb uses 100 watts of energy doesn't mean it gives 100 watts of light. Typically only 10% or less of the energy consumed by incandescent lamps is actually used to produce light. The rest ends up as heat.

In a 120 volt, 100 watt "standard" bulb with a rated light output of 1750 lumens, the efficiency is 17.5 lumens per watt. This compares poorly to an "ideal" of 242.5 lumens per watt for one idealized type of white light, or 681 lumens per watt ideally for the yellowish-green wavelength of light that the human eye is most sensitive to.

Most light bulbs average around 500 lumens per 60 Watts. Quality LED lamps have substantially higher lumens per watt outputs with many in the 90 to 100 lm/w range. A lumen is the unit of luminous flux equal to the light emitted in a unit solid angle by a uniform point source having an intensity of one candela. There is no direct correlation between lumens and watts because other variables may affect the relationship, such as lamp design life and fill pressure.

A lamp should be chosen based on its Candlepower or Lumen rating which indicates the light energy intensity of the lamp. Only then should wattage be considered to find the most economical lamp among those lamps powerful enough to provide the proper Foot Candle level on the Work Plane.

Wattage Power Factor
The ratio of AC volts x amps through a device to AC wattage of the device. A device such as a ballast that measures 120 volts, 1 amp and 60 watts has a power factor of 50% (volts x amps = 120 VA, therefore 60 watts/120 VA = 0.5). Some utilities charge customers for low power factor systems.

Quality LED lamps with their integral LED driver circuitry should have power factors exceeding .95.

Weibull Data for Lamp Life
Weibull distribution has become established as the standard method for analyzing the life of technical products. Endurance tests on products without technical faults produce failure curves which represent the proportion of products that fail in the course of use. Because of their special properties, these
curves can be normalized for the purposes of comparison. This involves approximating the distributions to a straight line. To show this, a special coordinate system is needed (named after Dr. E. H. Wallodi Weibull, 1887 to 1979). Service life distribution can now be accurately defined by specifying two points on the straight line without having to refer to a failure curve.

The following failure rates have been defined as standard failure rates. The B3 life value represents the premature failure rate of lamps. It means that 3% of all the tested lamps failed after this number of hours burned. The Tc life value represents the failure rate of 63.2% of the lamps. B3 and Tc are of particular interest in industry. Another important point is the B50 value. This indicates the average life of the lamps (50%).

To show this approximation to a straight line, a special graphic matrix is needed. The failure rates are indicated as a percentage plotted against the number of hours burned. The benefit here is that the distribution of the life of, say, a headlight lamp can be uniquely defined by specifying particular failure rates.

Point 1: The B3 life value means that 3% of the tested lamps failed after this number of hours burned.

Point 2: The B10 life value means that 10% of the tested lamps failed after this number of hours burned.

Point 3: The B50 life value indicates the average life of the lamps. The failure rate is 50%.

Point 4: The Tc life value represents the characteristic failure rate of 63.2% of the lamps.

Rule of thumb:

5% over voltage

- Half the life
- 15% higher luminous flux
- 8% higher power consumption
- 3% higher current

5% under voltage

- Twice the life
- 15% lower luminous flux
- 8% lower power consumption
- 3% lower current

**Work Plane**
In any space there is an actual or implied distance from the light source where the activity to be illuminated takes place, called the Work Plane. It is on this Work Plane that the Foot Candle measurement is taken.

**Zenith**
The direction directly behind the luminaire, at 180° angle to the main direction of light output.