Guide to Lighting Basics

1. Lighting Terminologies

Light is a form of electromagnetic radiation with a wavelength which can be detected by the human eye.

1.1. LED

Acronym for Light-Emitting Diode, a solid-state component that emits light when exposed to electric current. LED lighting represents the state-of-the-art in the industry, outclassing most other types of lighting in terms of energy efficiency, design flexibility and colors of light available.

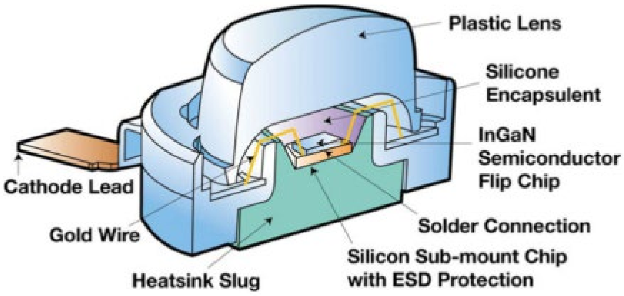


Image 1.1.1 - LED

1.2. Luminous Flux (lumen - Φ)

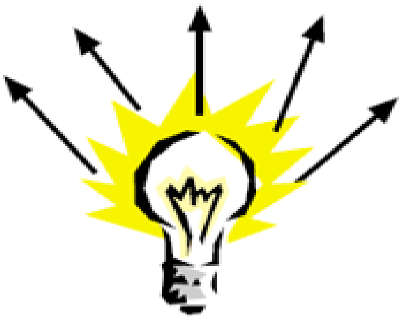
Total output emitted by a light source, measured in lumens (lm). The luminous flux describes the total lighting output of a lighting fixture without considering direction.

This radiation could basically be measured or expressed in watt. This does not, however, describe the optical effect of a light source adequately, since the varying spectral sensitivity of the eye is not taken into account.

To include the spectral sensitivity of the eye the luminous flux is measured in “lumen” and denoted by “lm”.

Photopic luminous efficacy of radiation has a maximum possible value of 683lm/W, for the case of monochromatic light at a wavelength of approximately 555nm (green).

for an example 1W of monochromatic light at 555nm will be equivalent to 683 lumens.



Luminous Flux
Total Power (lumen)
“Light Power”

Image 1.2.1 – Luminous Flux

1.3. Luminous Intensity (Candela – I)

Defined as luminous flux (lumens) emitted per unit solid angle in any given direction measured in "Candela" (cd). Luminous intensity changes depending on the viewing angle.

The luminous intensity of a lamp or luminaire is not equal in all directions. By plotting luminous intensity in the room (or in planes) around the lamp or luminaire, luminous intensity distribution can be defined. This offers a precise description of the photometric characteristics of the lamp or luminaire. Luminous intensity distribution is normally represented in the form of either a polar or linear diagram.

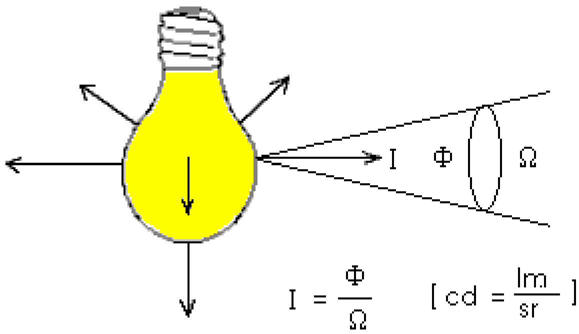


Image 1.3.1 – Luminous Intensity

1.4. Illuminance (E)

The luminous flux on a surface, per unit of area. The illuminance requirements of built environments are determined by their intended purpose, and there are two common units of measurement:

- Lux - Equivalent to one lumen per square meter.
- Foot-candle - Equivalent to one lumen per square foot.

Higher illuminance levels make surfaces appear brighter to the human eye and improve visibility.

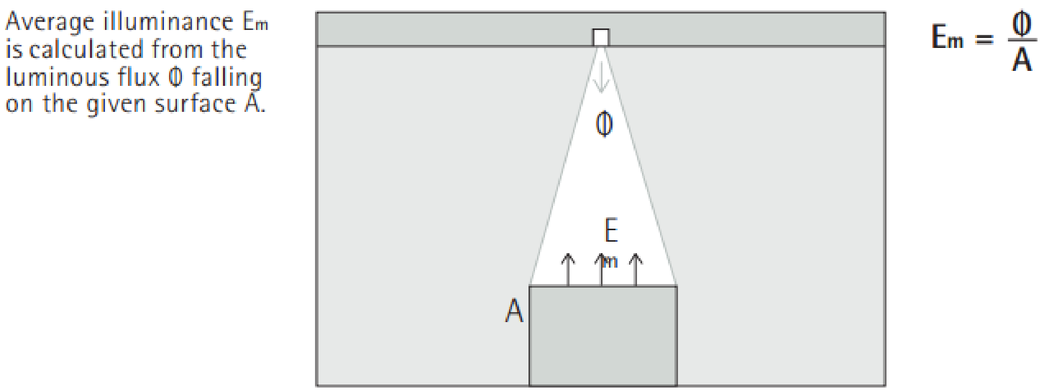


Image 1.4.1 – Illuminance

1.5. Luminance or Brightness (L - cd/m^2)

The brightness of an object or surface, as perceived by human eyesight from a specific direction. Luminance is measured in candelas per square meter (cd/m2). It is important to note that luminance changes depending on the viewing angle, and high luminance values are the direct cause of glare.

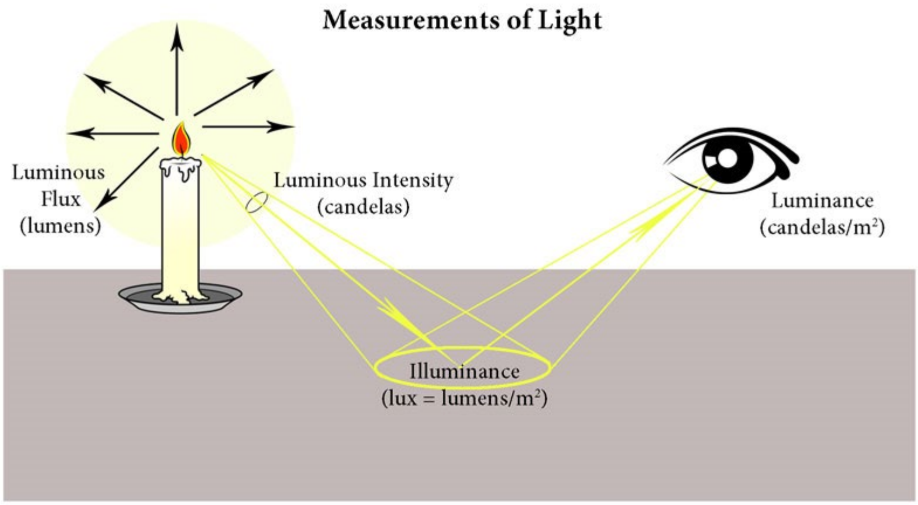
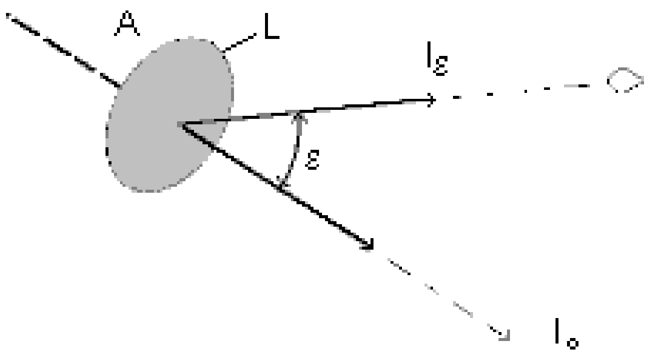


Image 1.5.1 – Luminance

Luminance “L” is also defined by the luminous intensity “Iε” of an area “A” in the direction “ε”.



$$L = \frac{I_\epsilon}{A * \cos\epsilon}$$

Image 1.5.2 – Luminance

1.6. Efficiency / Efficacy (η)

Conversion ratio between lighting power output and electric power input, measuring both quantities in watts. Not to be confused with efficacy, which describes the ratio between luminous flux (lumen output) and Watts consumed. Since lumens describe lighting output better than Watts, efficacy tends to be a much more useful concept in lighting design. Efficacy in calculated in lm/W.

$$\eta = \frac{\Phi}{P}$$

$$[\eta] = \frac{\mathrm{lm}}{\mathrm{W}}$$

Image 1.6.1 – Efficacy

1.7. Beam Angle

Also known as beam spread, the beam angle is a value that describes the downward light cone emitted by a lighting fixture with a reflector. The beam angle is measured between the downward direction, where the lamp provides maximum lighting intensity, and the direction in which intensity drops to 50%. In other words, a lamp with a large beam angle spread its lighting into a wider cone.

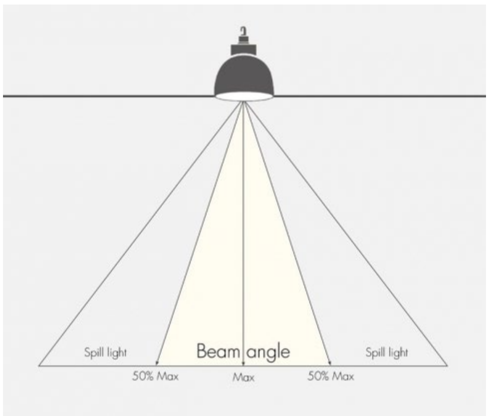


Image 1.7.1 – Beam Angle

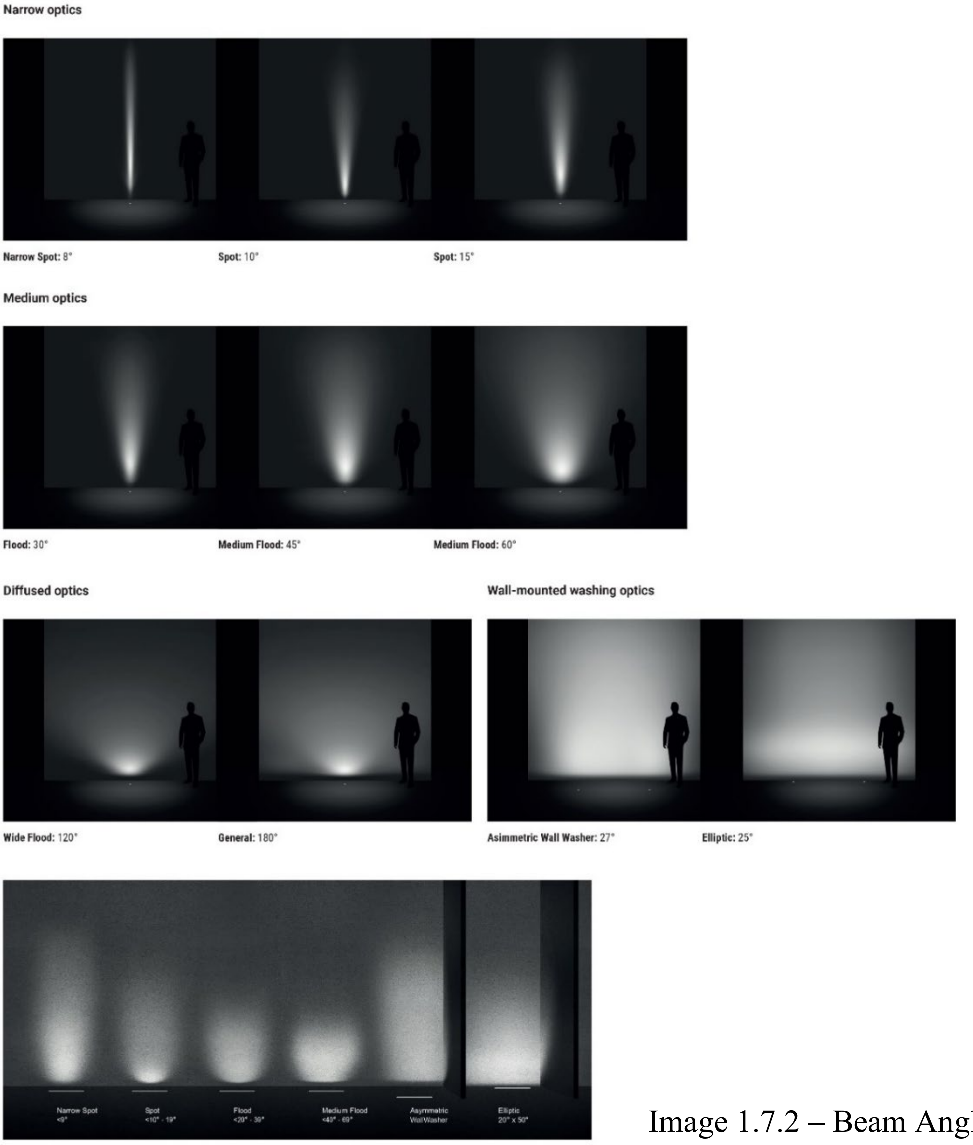


Image 1.7.2 – Beam Angle Examples

1.8. Cutoff Angle

The angle, measured up from nadir, the angle between the vertical axis and the first line of sight at which the bare light source is not visible. The cutoff angle of the below image is 50°.

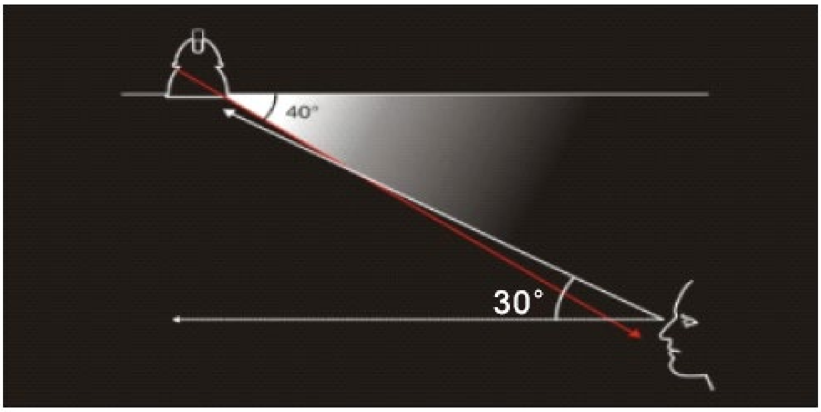


Image 1.8.1 – Cutoff Angle

1.9. Color Rendering Index (CRI)

A metric used to describe how faithfully a light source can render the true colors of objects and spaces, where natural light sources like the sun have a perfect index of 100.

Using lamps with a high CRI value is very important in high-end interior design of art galleries, clothing stores, museums etc., as they enhance the visibility of décor and fine details.

Image 1.9.1 – Differences of different CRI's

1.10. Correlated Color Temperature (CCT)

Color temperature of a light source is the temperature of an ideal black-body radiator (solid object with certain properties heated up to point of incandescence) that radiates light of comparable hue to that of the light source, and its temperature is expressed in Kelvins (K). As a black body gets hotter, wave length of light emits progress through a sequence of colors from red to blue Sequence of colors is described by curve (Planckian locus) within a CIE 1931 color space.

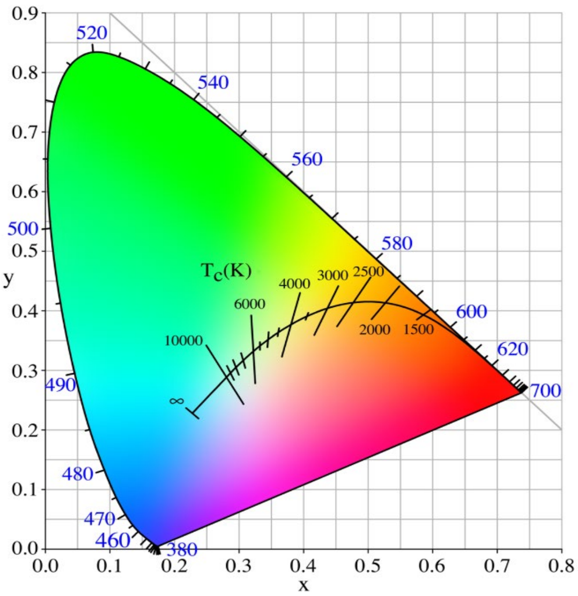


Image 1.10.1 – Planckian locus in the CIE 1931

Image 1.10.2 – Color Temperatures

1.11. Glare

Visual impairment caused by a bright source of light, directly visible or reflected by a surface. There are two types of glare:

• Discomfort glare causes an instinctive reaction to close the eyes and look away. This is the type of glare felt when exposed to a potent light or when the sun is directly visible through a window.

• Disability glare impairs vision, but does not cause the same reaction as discomfort glare. If a light source gets reflected on your laptop screen, for example, it does not bother your eyes but distinguishing objects on the screen may be impossible.

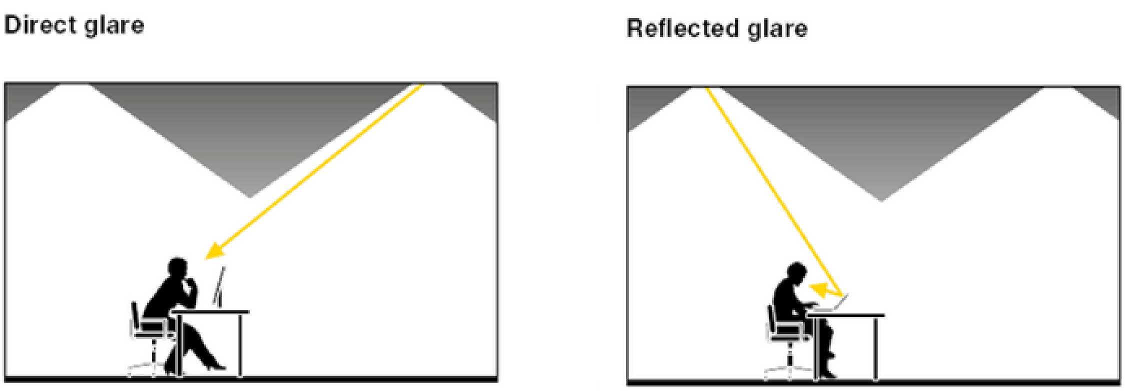


Image 1.11.1 – Direct Glare and Reflected Glare

1.12. UGR (Unified Glare Rating)

UGR (Unified Glare Rating) is a method of calculating glare from luminaires, light through windows and bright light sources.

The UGR rating helps to determine how likely a luminaire is to cause discomfort to those around it.

UGR is calculated by using an equation which takes into account a number of factors that may contribute to glare caused by a luminaire, such as the angle of the luminaire, the likelihood of glare and the luminance value (lumen output).

$$\textbf{UGR} = 8 \log \left[\frac{0.25}{L_b} \sum \left(\frac{L^2 \omega}{p^2} \right) \right]$$

L= The luminance value of the luminaire
Lb= The value of the background luminance
ω= The solid angle of the luminaire that is seen by the viewer
p= The Guth Index. Based on the likelihood of glare, also known as Visual Comfort Probability
Σ= Shows that the equation (shown above) includes all the fittings located within the area.

Image 1.12.1 – Equation used to Calculate the UGR

There are a number of different UGR limits that should not be exceeded in certain environments, these include:

UGR ≤ 16	Technical drawing
UGR ≤ 19	Reading, writing, training, meetings, computer-based work
UGR ≤ 22	Craft and light industries
UGR ≤ 25	Heavy industry
UGR ≤ 28	Railway platforms, foyers

1.13. Photometry

Photometry is the measurement of visible light based on the response of the average human observer.

Photometric Distribution;

1.13.1. Polar Luminous Intensity Graph (Image 1.13.1): The diagram illustrates the distribution of luminous intensity, in candelas, for the transverse (solid line) and axial (dashed line) planes of the luminaire. The curve shown provides a visual guide to the type of distribution expected from the luminaire e.g. wide, narrow, direct, indirect etc. in addition to intensity.

1.13.2. Cartesian Luminous Intensity Graph (Image 1.13.2): The diagram indicates the distribution of luminous intensity, in candelas of the luminaire. The curve shown provides a visual guide to the type of distribution expected from the luminaire e.g. narrow or wide beam etc, in addition to intensity. This diagram is useful when light intensity changes rapidly within a small angular area.

1.13.3. Illuminance Cone Diagram (Image 1.13.3): Usually used for spotlights or lamps with reflectors, the diagram indicates the maximum illuminance at different distances away from the lamp.

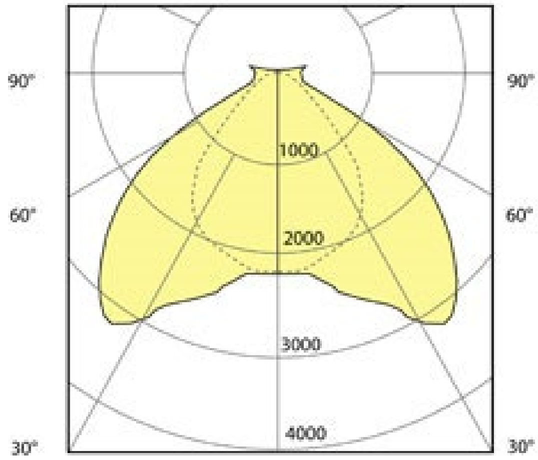


Image 1.13.1 – Polar Luminous Intensity Graph

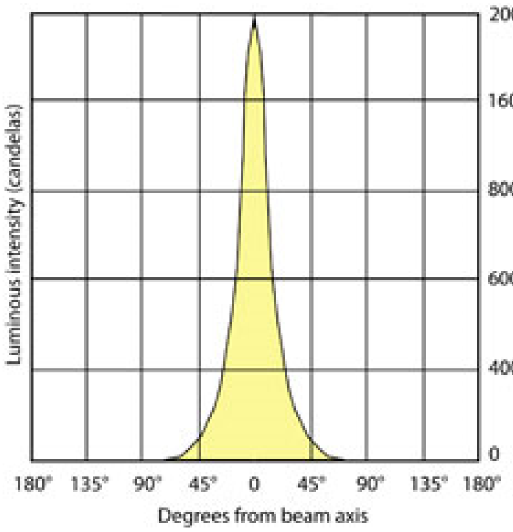


Image 1.13.2 – Cartesian Luminous Intensity Graph

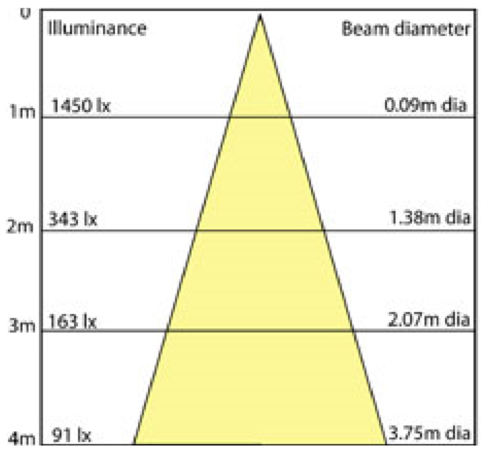


Image 1.13.3 – Illuminance Cone Diagram

2. IP ratings

IP (or "Ingress Protection") ratings are defined in international standard EN 60529 (British BS EN 60529:1992, European IEC 60509:1989). They are used to define levels of sealing effectiveness of electrical enclosures against intrusion from foreign bodies (tools, dirt etc) and moisture.

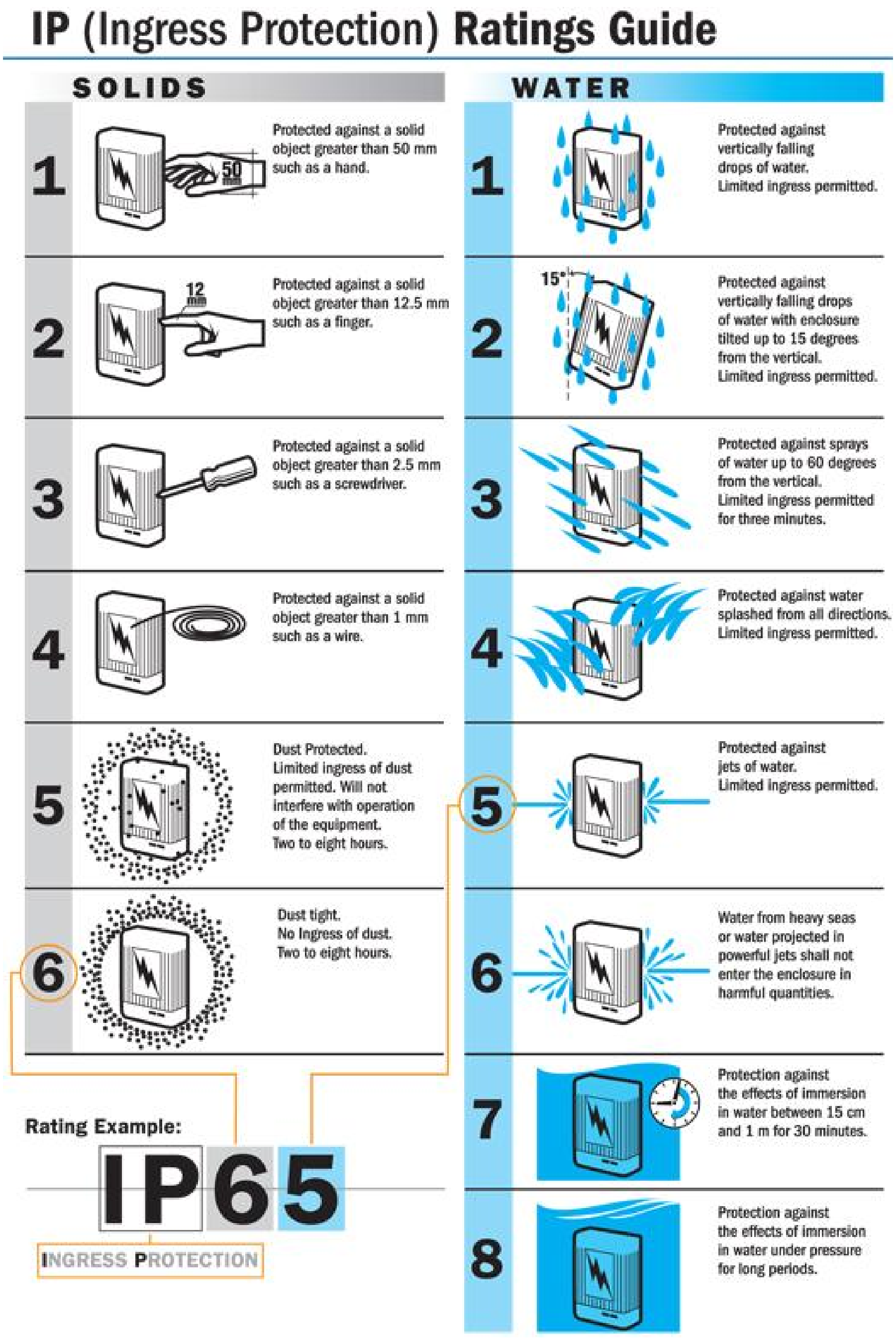


Image 2.1 – IP Rating Guide

3. Drivers

Piece of electronic equipment that transforms the main supply voltage into a lower DC voltage that is appropriate for LED lighting. Some LED lamps have a built-in driver, while others require one to be connected externally, just like the ballasts used by fluorescent and HID lamps.

4. Power Factor

Ratio of real power to apparent power drawn by lighting fixtures and other electrical devices. The real power is represented by the actual watts consumed, while the apparent power is the multiplication product of voltage and current, measured in volt-amperes.

5. Dimming Methods

There are 4 main types of dimming methods.

- Phase Dimming
- 0-10V Dimming
- DALI Dimming
- DMX Dimming

5.1.1. Phase Dimming:

Phase control is a dimming technique based on the electric wire that is often used for halogen and incandescent lamps. It “clips” part of the sine wave of the alternating current to dim the light. No control cable is required.

5.1.2. 0-10V Dimming:

0-10V dimming is commonly used for commercial fluorescent and LED installations and is one of the simplest and earliest commercial dimming methods. Control of the light is performed by a dedicated DC voltage signal that ranges from 0 to 10 volts. This allows the controlled light to operate at 100 percent light output when full voltage is passed (10V), 0% output when no voltage is passed (0V), and at any dimmed percentage in between based on the voltage level of the control signal. Light fittings cab be dimmed as a group in terms of looping group.

5.1.3. DALI Dimming

Digital Addressable Lighting Interface (DALI) is a two-way digital lighting control system protocol used in building automation in commercial applications. This is a flexible system with possibility to create separate lighting groups with easy wiring. The beauty of this method is that the fittings can be controlled with its individual address.

5.1.4. DMX Dimming

Digital Multiplexing (DMX) is a digital signal interface standard that came about due to the more rigorous needs of the theatrical lighting industry. Now increasingly used in architectural and accent lighting applications, it allows for digital communication of individual fixtures using a low voltage control signal. Up to 512 addresses can be using in a single DMX universe.

6. References

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