The Language of Light

A Pacific Energy Center Factsheet

Pacific Gas and Electric Company
Pacific Energy Center

Introduction

Without a source of light, we cannot see; without surfaces to reflect light, there is nothing to see. To understand this relationship between a source of light, the surfaces that reflect light, and how we see light, we need a new language. Quantifying and qualifying the nature of light within a space calls for a basic understanding of certain lighting terms.

What is a Lumen?

Figure 1. The Lumen

The lumen is the unit that quantifies the total amount of light emitted by a source. This unit is typically used to rate the output of lamps. For example, the flame of a candle generates about 12 lumens. A standard 60-watt incandescent lamp, is rated at 890 lumens.

What is a Candela?

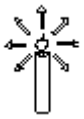

Figure 2. The Candela

The candela is the unit used to measure the intensity of light in a particular direction. The familiar candle flame generates one candela in all directions. (The candle is actually the historical basis for defining the candela.) Candela are used to rate the output of luminaires and can also be used to rate the output of certain kinds of lamps where directional light output is a concern.

What is a Footcandle?

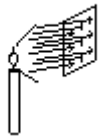

Figure 3. The Footcandle

The footcandle is the unit for illuminance, the amount of light that falls on a surface. It is equal to the number of lumens striking a surface, divided by the area of the surface. Footcandle values can be determined for both horizontal surfaces, like a desktop, and vertical surfaces, like a chalkboard.

Understanding the Unit Sphere

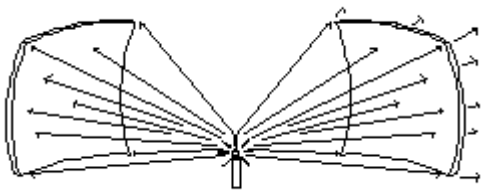

Figure 4. The Unit Sphere

The unit sphere is a sphere with a one-foot radius, which defines the relationship between lumens, candela, and footcandles. Imagine a candle flame centered within a sphere that is one foot in radius. That point source, of uniform intensity equal to one candela, produces an amount of light flowing through one square foot of the sphere's area that is defined as one lumen. The amount of light falling on that one square foot of the sphere is equal to one footcandle. Since the area of the sphere is equal to 4π, then the amount of light flowing through the sphere is 4π lumens, or about 12.57 lumens. In other words, a one candela source produces 12.57 lumens and an illuminance of one footcandle at a distance of one foot.

What are Photometric Measurements?

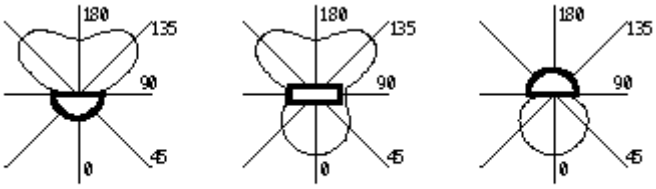

Figure 5. Typical Candlepower Distribution Curves

Photometric measurements indicate how a particular lamp or luminaire "sends out" light. The actual photometric data describe a luminaire's light distribution in terms of intensity (candela) and direction (degrees). Graphic representation of this information, referred to as a photometric distribution or candlepower distribution curves, provides intuitive information, indicating how the luminaire will perform in a space. The actual candela values enable calculations to predict light levels and/or brightness levels within a space.

What is Brightness?

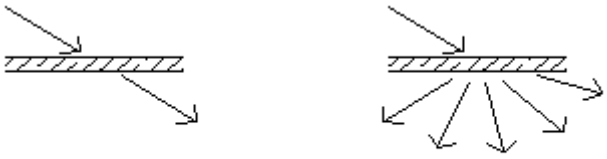

Figure 6. Directional Light Quantified by Luminance and Diffuse Light Quantified by Exitance

Brightness is the subjective impression of the amount of light leaving a surface and reaching the eye. Since brightness is based on human response and is dependent on the adaptation level of the eye, it cannot be directly measured. To determine brightness, lighting designers use luminance and exitance values, which can be measured or calculated. Luminance values are measured in candela/sq. ft. and are used to measure light leaving a surface in a directional manner. Exitance values are measured in lumens/sq. ft., but

relate to light leaving a surface in a diffuse manner. Comparing luminance or exitance values of surfaces within the field of view allows lighting designers to determine the overall comfort of a lighting system.

What is Contrast?

Contrast is the difference between the brightness of an object compared to that of its immediate background. Objects with high contrast are easier to see than objects with low contrast.

What is Glare?

While some contrast is helpful to our visual system, excessive contrast causes glare. An extremely bright object against a dark background causes discomfort and can interfere with our visual perception. This discomfort or interference with our visual perception is generically termed glare. There are many types of glare (high angle direct, low angle direct, reflected or veiling reflections, and VDT screen glare), and in most situations, glare is something we would like to eliminate. In some cases, however controlled glare creates a sense of brilliance or sparkle. Finding the balance between glare and sparkle is a critical element of good lighting design.

What is the Reflectance of a Surface?

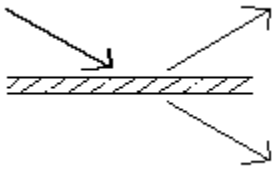

Figure 7. Reflected and Transmitted Light

Reflectance is the fraction of light reflected from a surface compared to the amount of light falling on that surface. Dark and/or textured surfaces absorb a lot of light and therefore have low reflectances, while light and/or smooth surfaces reflect light and therefore have high reflectances. Reflectance is a property of the surface material and is independent of the amount of light that reaches the surface.

What is Transmittance?

Transmittance is the fraction of light that passes through an object compared to the amount of light falling on that object. It is an important property to consider for glazing design since the transmittance will impact the amount of daylight available for natural illumination. Like reflectance, transmittance is a property of the surface material and is independent of the amount of light that reaches the object. (See Figure 7.)

What is Specularity?

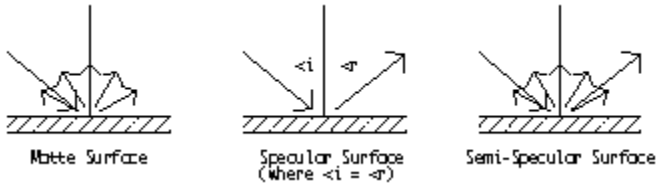

Figure 8. Surface Specularity

Specularity describes the nature of reflected or transmitted light. A specular surface reflects light in a directional manner such that the angle of reflection is equal to the angle of incidence. A mirror is a specular surface. In contrast, a matte surface, such as a swatch of fabric, reflects light in a non-directional manner. Most surfaces are semi-specular. They reflect some light specularly and some light diffusely. Since semi-specular surfaces are difficult to describe mathematically, they are typically treated intuitively in lighting design practice.

What is Efficacy?

Efficacy, measured in lumens/watt, describes how efficiently a light source converts electric power to light. A standard 100-watt incandescent lamp produces 17.5 lumens/watt. High pressure sodium, one of the most efficacious light sources, provides up to 110 lumens/watt.

What is Luminaire Efficiency?

Luminaire efficiency describes how many of the lamp lumens exit the luminaire. In other words, some of the lumens generated by the lamp(s) are trapped in the luminaire.

Efficiency is expressed as a percentage of the lumens leaving the luminaire as compared to the lumens generated by the lamp(s). Luminaire efficiency alone does not describe how effectively the luminaire directs light in a space.

In Conclusion

Understanding the language of light allows us to evaluate and communicate the interaction between sources and surfaces. Good lighting design depends on this process.

For More Information

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