

# SOLAR LIGHT SnP Meter SL 3101

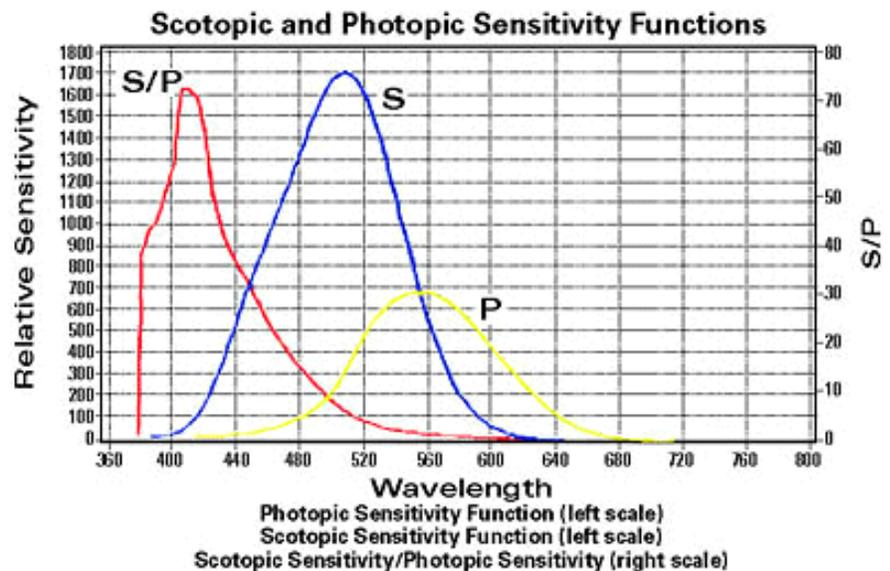
## The meaning behind the meter's measurements

### 1. What is scotopically enhanced lighting?

Scotopically enhanced lighting research suggests that certain lamps containing more blue in the spectrum will be more visually efficient than lamps with less scotopic content, even if they have the same (photopic) lumen and efficacy values. The use of scotopically enhanced lighting can therefore be used at lower energy levels while maintaining equal vision, or visual effectiveness.

The functioning factor used in scotopically enhanced lighting is called the S/P ratio, which evaluates the spectrum of any lamp on the basis of the Scotopic function in comparison to the Photopic function. This ratio is independent of lighting levels for fluorescent lamps, and can be provided by lamp manufacturers for any light source that they manufacture. For most fluorescent and HID lamps the S/P values vary between 0.8 and 2.5, with the higher values representing lamps with more blue in their spectrum.<sup>1</sup>

Human perception of light follows two distinct spectral response curves, depending on the light level. The spectral response curve that dominates during typical daytime conditions is the photopic response curve, and results from the “cones” in human eyes. During very low light conditions, perception follows the scotopic response curve, which in contrast results from the “rods” in the human eye.



The **peak spectral luminous efficacy** of the scotopic response curve (1700 lumens per watt, at 507 nanometers) is significantly greater than that of the photopic response curve (683 lumens per watt, at 555 nanometers)<sup>2</sup>.

Traditionally, light levels have only been measured in accordance with the photopic response curve. In recent years however, interest has grown in scotopic light due to the human eye's ability to perceive objects more clearly from sources with enhanced scotopic quality, particularly at night.<sup>3</sup>

## 2. S/P ratio

The factor S/P is the ratio of scotopic luminous quantity to photopic luminous quantity for the lamp spectral power distribution. From a given photopic quantity, the analogous scotopic quantity can be found by multiplying the photopic quantity by the value of the S/P ratio. Natural daylight has an S/P ratio of close to 2.5 which means that it is highly scotopically enriched.<sup>4</sup>

If the surfaces of the lighted space have relatively neutral color, the S/P values of the environmental illumination will be approximately independent of viewing direction and will have the same value as the illuminating source. Conveniently, most sources used in the workplace have a fixed S/P value that is a property of the source just as is the correlated color temperature (CCT) or the color rendering index (CRI). Typical S/P values for most lamps range from 1 to 2.3, except for HPS and LPS lamps which have S/P values of 0.6 and 0.4 respectively. The incorporation of rod effects into lighting practice is then achieved with the conventional light meter coupled with additional factors that depend on the S/P value for the source under consideration.<sup>2</sup>

## 3. Visually Effective Lumens

Light meters and photometric devices that measure light output are generally calibrated to the cone spectral sensitivity known as the photopic response. As a result, the light output of a lamp (lumens) is rated only in terms of its photopic content. Historically, the rod spectral sensitivity, known as the scotopic response, has generally not been considered relevant for interior lighting. However, many lighting professionals now believe that these photopic devices do not accurately reflect our perceptions of lit environments, and photopic lumens do not tell the whole story of a lamp's effectiveness.

To illustrate how ambient lighting applications depend on the S/P value, the following situations are considered.

**Application 1.** Ambient lighting also provides task lighting, and Visual Performance is important.

In this case, the lighting should be judged on the basis of achieving the clearest vision. Research has determined that the relevant photometric factor is the equivalent pupil luminance or illuminance which is given by the quantity

$$L_{ep} = [(S/P)^{0.78}],$$

where P is the photopic amount and the exponent (0.78) of the S/P value has been determined

empirically in laboratory studies. Consider the comparison of two T8, 32-watt (W) readily available fluorescent lamps costing about the same and with the same color rendering index (CRI) of 85. For this example, lamp A would have a correlated color temperature (CCT) of 3500 kelvin (K), and 2950 initial rated (photopic) lumens. Lamp B would have CCT of 5000 K and 2800 initial rated (photopic) lumens. The choice of lamp is generally made on grounds of luminous efficacy, which favors lamp A.

It is the *visually effective lumens* that should be compared, which means multiplying the photopic lumens by the factor  $(S/P)^{0.78}$ .

**Application 2.** Task lighting is provided independently as in a computer environment; Visual Performance is important. Any ambient lighting will produce some glare effects on a computer screen as well as desaturation of screen colors. Unfortunately, computer work without any surround illumination will cause pupils to become dilated, resulting in poorer vision and possibly visual fatigue due to the additional accommodative response needed to focus when pupils are larger, so working in a dark room is not a good option. Thus the best compromise for the ambient lighting is to provide the smallest pupils with the least amount of glare. This means that the ambient lighting needs to be judged purely on the basis of its scotopic content, i.e., the relevant lighting quantity is  $S = P(S/P)$ .

Example: Since a high value of CRI is less important in the computer environment, the comparison here is made between two T8, 32-W fluorescent lamps costing about the same and having the same CRI value of 75. Lamp A has a CCT of 3500 K, 2850 initial (photopic) lumens,  $S/P = 1.3$  Lamp B has a CCT of 6500K, 2700 initial (photopic) lumens,  $S/P = 2.15$ .

Conventional practice would lead to the selection of lamp A because of its higher efficacy. However, in the computer environment it is the scotopic lumens that should be considered, which for lamp A is 3705 and for lamp B is 5805. Lamp B operating at 64% of the power density of lamp A will provide the same amount of scotopic lumens. But because lamp B produces these scotopic lumens with fewer photopic lumens, lamp B will cause considerably less glare and desaturation.

**Visual Effectiveness calculation:**

$$L_{ep} = [(S/P)^{0.78}]$$

Also described as Pupil Lumens

#### **4. Perceived Brightness**

One of the specially enabled functions of the SnP Meter Model SL3101 is the display of certain illumination calculation values that aid in the assessment of lighting as it pertains to the capability of the human eye. The following sources are the foundation of these measurements.

From "*The Re-Engineering of Lighting Photometry*" by Sam Berman:

Because deciding which illumination is brighter is a much simpler task than determining the brightness equality between two different illuminations and because of various other experimental requirements, the evaluation of the precise combination of photopic and Scotopic that determine the "brightness lumen" in full field view remains ongoing. However from the studies mentioned above a rough estimate can be made of where brightness equality would occur. This yields an expression how brightness depends on the combination of Photopic and Scotopic

luminance namely  $P(S/P)^{0.5}$ . In terms of brightness perception this result suggests that 5000° CCT fluorescent lamps could operate with 14% less energy and achieve the same brightness perception as produced by CW lamps while the proposed lamp with the ratio S/P - 2.5 could operate at 30% lower energy while achieving the same brightness perception as CW illumination.<sup>5</sup>

Brightness figure calculation:

$$\text{Brightness} = P * (S/P)^{0.5}$$

## 5. Displaying the calculated values on the Solar Light SL-3101

Press the “**Calc**” key to display the Visual Effectiveness, Brightness and S/P Ratio calculated values. The display will cycle through the set of values by pressing the “**Calc**” key.

To show both the Photopic and the Scotopic readings at the same time press the “**Actual**” key.

Pressing the “**Units**” key toggles the units from lux to foot-candles (fc).

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<sup>1</sup> [Energy Conservation Using Scotopically Enhanced Fluorescent Lighting In an Office Environment](#) by Office of Energy Efficiency & Renewable Energy - U.S. Department of Energy

<sup>2</sup> “[The Coming Revolution in Lighting Practice](#)” , Sam Berman, 2000

<sup>3</sup> [Demonstration Assessment of Light Emitting Diode \(LED\) Street Lighting](#) by U.S Department of Energy and Pacific Gas & Electric Company in the City of Oakland CA.

<sup>4</sup> [Understanding The Difference Between Photopic And Scotopic Light](#). Energy & Environment Division, Lawrence Berkeley National Laboratory, University of California, Report No. LBL-36553, UC-1600, April 1995

<sup>5</sup> “The Re-Engineering of Lighting Photometry” , S. Berman, Journal of the Illuminating Engineering Society.