Les Industries Spectralux Inc.
Spectralux Industries Inc.
2750 Sabourin, Saint-Laurent (Québec) H4S 1M2 Canada
Tél.:(514) 332-0082 • Fax : (514) 332-3590 • www.spectralux.ca

Gaps in Road and Street Lighting

The spectral luminous efficiency functions of the human eye form the basis of all the lighting units of measurements. The terms photopic, scotopic and mesopic refer to three ranges of human vision adaptation level, which differ in anatomical response, spectrum and their effect on visual acuity.

According to the 9th edition of the Illuminating Engineering Society of North America (IESNA) Lighting Handbook, “The photopic luminous efficiency function applies to visual stimuli to the fovea and at luminance levels higher than approximately 3 candelas per square meter. The scotopic luminous efficiency function applies to visual stimuli in regions outside the fovea and to luminances below 0.001 candela per square meter. A family of mesopic luminous efficiency function is required for application to luminous stimuli between approximately 0.001 and 3 candelas per square meter”.

The luminance levels recommended by IESNA in its RP-8-00 publication for road and street lighting fall into the mesopic range 0.3 to 1.2 candela per square meter. However, the spectral mesopic efficiency function is not yet standardized by the Commission Internationale de l’Éclairage (CIE) and there are no mesopic commercially available instruments. In this paper, we will discuss the lack of proper tools to predict the lighting levels and to perform field verification in road and street lighting applications.

The photopic condition translates the ability of our eye’s cones to see in daylight. Scotopic condition refers to the ability of our eye’s rods to see in very low light levels. In road and street lighting applications, cones and rods are both active and under this condition neither the photopic nor the scotopic luminous efficiency function characterizes the spectral sensitivity of the visual system.

The IESNA RP-8-00 recommended practice defines the illuminance, the luminance and the

small target visibility criteria for designing continuous lighting systems for roads and streets. Although laboratory researches have shown that spectral effects of lighting on visual performance at mesopic light levels have a significant impact on the quality of the road and street lighting applications, the IESNA RP-8-00 recommended values are not related to any specific type of light sources and color of light sources.

At present, photometric instruments are built with filters following the photopic or the scotopic luminous efficiency function. Computer printouts are usually performed with photopic photometric data for ideal conditions to determine the illuminance, the luminance, the veiling luminance ratio and the small target visibility. In reality, there are many other factors which are very difficult to predict and to include in road and street lighting design, such as the pavement conditions, the background luminance and the effects of vehicles headlights.

Since the use of photopic photometric data is unsuitable for road and street lighting applications, calculated lighting quantities based on photopic data will not provide a proper basis for evaluating the visibility performance in road and street lighting applications.

The “IESNA LM-50-99 Guide for Photometric Measurement of Roadway Lighting Installations” defines the characteristics of the instruments for illuminance and luminance measurements, the location of test points and all the detailed procedures to follow in field verification. In fact, what can be really verified in road and street lighting applications?

Illuminance measurement can be checked on job site with proper photopic luxmeter to compare with computer printouts. Unfortunately, illuminance is not a good metrics to evaluate the quality of a road and street lighting application. Furthermore, there is no commercial available instrument to measure the veiling luminance ratio mentioned in the IESNA RP-8-00 recommended practice.

The major concerns for driving at nighttime are detection, reaction time, and recognition.

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All these tasks are related to mesopic luminance. Many researches have been done to define the spectral mesopic function efficiency, but none of the models proposed has been officially approved by the Commission Internationale de l'Éclairage (CIE). Are the IESNA luminance criteria specified in RP-8-00 clearly defined as mesopic? In the absence of the mesopic spectral luminous efficiency function, one can assume that the instrument for luminance measurement specified in the IESNA LM-50-99 is a photopic luminancemeter. If so, luminance measurement performed with photopic instrument can not be applied for road and street lighting applications because the spectral sensitivity of the visual system of the driver is under mesopic conditions at nighttime.
The last design criterion specified in the IESNA RP-8-00 is the small target visibility (STV). Existing software are using a visibility model based only on the influence of a fixed lighting system without the effects of vehicles headlights on pavement luminance, target luminance and glare. Even if they were taken into account in the small target visibility calculation algorithm, there is no commercial available instrument to measure the small target visibility.

Consequently, the only measurement that can be done in road and street lighting applications is the illuminance. The mesopic luminance levels, the veiling luminance ratio and the small target visibility recommended in IESNA RP-8-00 are not measurable. Insurance, engineering, lighting design and law acceptance are usually based on measurable and quantifiable values. The establishment of a standardized spectral mesopic luminous efficiency function will form a new measuring system and a new field verification method for road and street lighting applications.

As long as the spectral mesopic efficiency function is not standardized and mesopic instruments are not commercially available, photometric laboratories cannot issue appropriate mesopic data. This lack of standardization prevents the lighting industry from developing appropriate mesopic light sources and mesopic luminaires for road and street lighting applications.

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In establishing the standardized spectral mesopic luminous efficiency function, the Commission Internationale de l'Éclairage will define proper tools for the lighting industry. Road and street lighting field evaluation will then be possible and the lighting industry will benefit the potential energy saving and the improved safety in road and street lighting applications.

We understand that the consensus for the standardization of the spectral mesopic luminous efficiency function is not an easy task, but it is nevertheless time to give the lighting industry that so much needed tool initiated by Purkinje almost 200 years ago.

Chrisnel Blot
Spectralux Laboratory
President