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TECHNICAL NOTE

Interim Recommendation for Practical Application of the CIE System for Mesopic Photometry in Outdoor Lighting

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The following members of JTC 1 "Implementation of CIE 191:2010 Mesopic Photometry in Outdoor Lighting" took part in the preparation of this Technical Note. The committee comes under Division 1 "Vision and Colour", Division 2 "Physical Measurement of Light and Radiation", Division 4 "Lighting and Signalling for Transport", and Division 5 "Exterior Lighting and Other Applications".

Authors:**Mucklejohn, S.A. (Chair)****United Kingdom**

Goodman, T.M.

United Kingdom

Uchida, T.

Japan

Advisor:

Donners, M.

Netherlands

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Summary

This Technical Note defines the method for calculating the adaptation coefficient to be used in conjunction with the equations of the mesopic photometry system defined in CIE 191:2010 (CIE, 2010), which describes the recommended system for mesopic photometry and is based on visual performance. This Technical Note is intended to be applicable to outdoor lighting for drivers, motorcyclists, cyclists and pedestrians. It is not applicable to other outdoor lighting, such as aviation or maritime lighting. This Technical Note provides the recommended method for calculating the spectral luminous efficiency function for mesopic vision and the associated mesopic quantities.

1 Introduction

Mesopic vision is defined as vision intermediate between photopic and scotopic vision (CIE, 2011). In mesopic vision, both the cones and rods are active; photopic vision, on the other hand, is dominated by cone activity, and in scotopic vision only the rods are active. Mesopic lighting applications are those for which our visual system is operating in a mesopic state, i.e. where both rods and cones contribute to visual functions. However, it is not straightforward to determine whether and how this condition is satisfied in any given practical situation. One important issue is that the range of light levels encountered in the visual environment can vary significantly, frequently extending from low mesopic to high photopic values, with the result that the adaptation condition is difficult to assess. A further complication is that the concentration of rods and cones varies throughout the retina, and most lighting applications involve a range of visual tasks which require both foveal and peripheral vision. In pure foveal vision only the cones are active and the spectral luminous efficiency for photopic vision, $V(\lambda)$, characterizes spectral sensitivity at all light levels (Goodman, 1997, He et al., 1997, Eloholma et al., 1998, Goodman et al., 2007, CIE 191, 2010). However, the involvement of foveal vision in a given application does not mean that only cone activity needs to be considered, as in most applications the surrounding periphery needs to be taken into account as well; in other words mesopic spectral luminous efficiency functions are frequently needed. The question, then, becomes: How to determine the relevant spectral weighting function? This Technical Note provides a recommendation for calculating this.

One particularly important application is road and street lighting for drivers, motorcyclists, cyclists and pedestrians, since the visual environment in night-time traffic conditions falls largely in the mesopic region. The design criteria for average road surface luminances given by current road lighting recommendations for various classes of roads are between $0,3 \text{ cd}\cdot\text{m}^{-2}$ and $2,0 \text{ cd}\cdot\text{m}^{-2}$ for motorized traffic (CIE 115, 2010). For conflict zones and pedestrian/low speed traffic, the design criteria, given in illuminance, are $2,0 \text{ lx}$ to 50 lx (CIE 115, 2010), which are also considered to be in the mesopic range.

The recommended system for mesopic photometry describes spectral luminous efficiency for mesopic vision, $V_{\text{mes},m}(\lambda)$, as a linear combination of the spectral luminous efficiency function for photopic vision, $V(\lambda)$, and the spectral luminous efficiency function for scotopic vision, $V'(\lambda)$, and establishes a gradual transition between these two functions throughout the mesopic region that depends on the visual adaptation conditions. The system is of the form:

$$M(m) V_{\text{mes},m}(\lambda) = m V(\lambda) + (1-m) V'(\lambda) \quad \text{for } 0 \leq m \leq 1 \quad (1)$$

and

$$L_{\text{mes}} = \frac{K_{\text{cd}}}{V_{\text{mes},m}(\lambda_0)} \int V_{\text{mes},m}(\lambda) L_e(\lambda) d\lambda \quad (2)$$

where:

m is the adaptation coefficient the value of which depends on the visual adaptation conditions;