

CIE2012 Workshop on

## Mesopic Photometry and its Application

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### Abstract

CIE 191:2010 defines a new system for photometry, which provides a method for making measurements across all lighting levels, from the photopic through to the scotopic and including the mesopic range. This offers the potential for new approaches to the specification and measurement of lighting in the mesopic region, particularly for road lighting, which takes account of the changes in the spectral luminous efficiency of the average human observer in the mesopic region.

The CIE system for mesopic photometry was specifically designed to ensure that it is fully compatible with the present system for photometry. It describes spectral luminous efficiency,  $V_{\text{mes}}(\lambda)$ , in the mesopic region as a linear combination of the  $V(\lambda)$  and  $V'(\lambda)$  functions, with a gradual transition between them from an upper luminance limit of  $5 \text{ cd m}^{-2}$  to a lower luminance limit of  $0.005 \text{ cd m}^{-2}$ . A simple iterative procedure is used to calculate the luminance between these limits, which requires knowledge of the photopic luminance and the S/P (scotopic to photopic) ratio of the luminance field being evaluated. The system is described mathematically by the equation:

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

where  $m$  is a coefficient the value of which depends on the average luminance of the adaptation field and  $M(m)$  is a normalising function such that  $V_{\text{mes}}(\lambda)$  attains a maximum value of 1.

Thus for luminances above  $5 \text{ cd m}^{-2}$  there is no change required to existing practice, in terms of either the (photopic) values currently specified in various standards and recommendations, or the measurement instrumentation and procedures. Similarly for values below  $0.005 \text{ cd m}^{-2}$  there should, in theory, be no need for any changes to existing practice, although it should be noted that measurements made at these levels have generally been made using instrumentation designed for the photopic region, and indeed many specifications requiring these low light levels currently quote photopic, rather than scotopic, values. In the region between  $0.005 \text{ cd m}^{-2}$  and  $5 \text{ cd m}^{-2}$  the new system allows for a gradual shift in the relative proportions of the scotopic and photopic weighting functions used. In this region there will be changes necessary to the instrumentation used, the measurement procedures adopted, and the values that are measured / specified.

The apparent simplicity of this approach masks what is potentially the most challenging aspect of using the system for practical measurements, namely: what is meant by the 'adaptation field', which is needed to determine the value of  $m$ ? In any typical night-time driving environment, the luminance is not constant across the whole visual field, but instead varies significantly depending on where in the scene the measurements are made. Even if we take an average luminance measurement over a defined field of view, and take this to represent the adaptation conditions of a driver on this road, we are left with the problem of where to centre this field of view: the direction of view of the driver is not static but is continually moving within the scene. Furthermore, there will generally be regions of higher and lower luminance on the road, depending on the position of the road lighting luminaires, and as a result the luminance is continually changing as the driver moves along the road, even if the direction of gaze is fixed. In order to make measurements in the field, as necessary to confirm the performance of a new road lighting installation, for example, it will be necessary for the appropriate measurement conditions to be defined. CIE TC2-65, 'Photometric measurements in the mesopic range' is considering such questions, but will need considerable input and guidance from Divisions 1 and 4. This workshop will provide an opportunity to explore this problem, and related issues, and the results will be used to help direct TC2-65 in its work, and to inform the work of JTC-1, "Implementation of CIE 191 Mesopic Photometry in Outdoor Lighting".