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TECHNICAL NOTE

Specifying Product Performance for Mesopic Applications

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The following members of TC 2-65 “Photometric measurements in the mesopic range“ took part in the preparation of this Technical Note. The committee comes under Division 2 “Physical measurement of light and radiation”.

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Summary

This Technical Note gives guidance on specifying the performance of lighting products for applications such as lighting of roads and pedestrian areas at night, where the eye is adapted to mesopic conditions. It can be used in conjunction with CIE 191:2010 (CIE, 2010a), which gives details of the method to be used to calculate mesopic quantities. This Technical Note does not give guidance relating to how to choose the most suitable lighting product for any particular application; such information is available in the relevant specification standards and application guides, including CIE 206:2014 (CIE, 2014).

1 Introduction

Information relating to the performance of lighting products (lamps, luminaires, etc.) has traditionally been given in terms of photopic quantities, corresponding to well-lit environments where an observer is adapted to a relatively high luminance level. However, many lighting products are intended for use in applications involving lower light levels, such as lighting of roads and pedestrian areas at night. In these situations the visual adaptation often falls in the mesopic regime (luminance in the range 0,005 $cd \cdot m^{-2}$ to 5 $cd \cdot m^{-2}$) and hence performance information expressed in terms of photopic values does not correlate well with the true visual effectiveness. This Technical Note gives guidance on specifying the performance of lighting products for such applications. It can be used in conjunction with CIE 191:2010 (CIE, 2010a), which gives details of the method to be used to calculate mesopic quantities (referred to as the MES2 system in CIE 191).

2 Basic product information

It is important to appreciate that the performance of the eye varies with the visual adaptation conditions and therefore these adaptation conditions are critical for any measurement or specification that is intended to correlate with visual performance. In other words, it is the **adaptation of the eye** that determines the relevant spectral weighting function that should be used when determining photometric quantities or making photometric measurements. This means, for example, that different luminous flux values may be calculated for a lamp depending on the adaptation conditions under which it is used, even though the radiant flux from the lamp remains the same. For this reason, it is recommended that mesopic quantities are not used for product specification purposes; only the relevant photopic quantity and the scotopic to photopic (S/P) ratio of the source (symbol R_{SP}) should be quoted. For example, the performance of a lamp intended for use in a street lighting luminaire can be described in terms of its photopic luminous flux and its S/P ratio, coupled with supplementary information on photopic luminous intensity distribution and colour rendering if required.

3 Supplementary information for mesopic applications

Although the performance of a product is fully described by use of just the relevant photopic quantity and the S/P ratio, there may be instances where additional information is advantageous, e.g. in order to facilitate simple comparisons between products intended for mesopic applications, such as road lighting products. In this case it is recommended that (in addition to the relevant photopic quantity and the S/P ratio of the source) a mesopic enhancement factor $F_{mes}(L_{v,adapt}; R_{SP})$ should be quoted for a set of specified photopic adaptation luminances, where $F_{mes}(L_{v,adapt}; R_{SP})$ is the factor by which the magnitude of a photopic quantity should be multiplied in order to determine the magnitude of the corresponding mesopic quantity at the stated photopic adaptation luminance ($L_{v,adapt}$ in $cd \cdot m^{-2}$), and where the S/P ratio of the adaptation field is the same as the S/P ratio of the

product considered (R_{SP})[1]. (Note that the mesopic enhancement factor is sometimes referred to as the effective luminance factor, e.g. in IES TM-12-12 (IES, 2012)). It is important that both the photopic adaptation luminance and the S/P ratio are stated whenever a mesopic enhancement factor is quoted, in order to avoid any possibility of confusion.

For example, consider a source with an S/P ratio of 2,00 which is used to provide a photopic adaptation luminance of 0,100 cd·m^{-2}. Under the CIE system for mesopic photometry (CIE, 2010a), this means that the adaptation coefficient is 0,473 and the mesopic luminance of the adaptation field is 0,131 cd·m^{-2}. The mesopic enhancement factor in this case is 0,131/0,100, or 1,31. If the same source is used to provide a photopic adaptation luminance of 0,300 cd·m^{-2}, this would lead to an adaptation coefficient of 0,619 and a mesopic luminance of 0,360 cd·m^{-2}, i.e. a mesopic enhancement factor of 1,20.

Where a product is intended for a clearly identified application for which specific adaptation luminances are defined (e.g. as given in CIE 115:2010 (CIE, 2010b)), the mesopic enhancement factor for those specific conditions may usefully be given. In a more general situation, it may be convenient to give the mesopic enhancement factor for specific photopic adaptation luminances of 0,010 cd·m^{-2}, 0,030 cd·m^{-2}, 0,100 cd·m^{-2}, 0,300 cd·m^{-2}, 1,00 cd·m^{-2} and 3,00 cd·m^{-2}. A standardized method for presentation of such data is suggested in Table 1. The same information may also be presented graphically, as in Figure 1.

Table 1 – Recommended presentation of information on products intended for illumination purposes in the mesopic region (example is for product with photopic luminous flux of 1 000 lm and S/P ratio of 2,00)

Φ_v	1 000 lm
R_{SP}	2,00
F_{mes}(0,010;2,00)	1,66
F_{mes}(0,030;2,00)	1,47
F_{mes}(0,100;2,00)	1,31
F_{mes}(0,300;2,00)	1,20
F_{mes}(1,00;2,00)	1,10
F_{mes}(3,00;2,00)	1,03

[1] It is important to note that this is a gross simplification of the true situation for any real lighting installation. In practice, the S/P ratio of the adaptation field will depend not only on the spectral power distribution of the light source considered but also, for example, on the spectral characteristics of surfaces within the adaption field that reflect light towards the observer and the spectral distributions of any other light sources that are present. If information is available that allows the true adaptation conditions to be determined, then this should be used to calculate the relevant mesopic quantities. However, where this information is not available, as is generally the case at the design stage of a lighting installation, the simplest approach is to assume that the S/P ratio of the adaptation field is the same as the S/P ratio of the product considered.

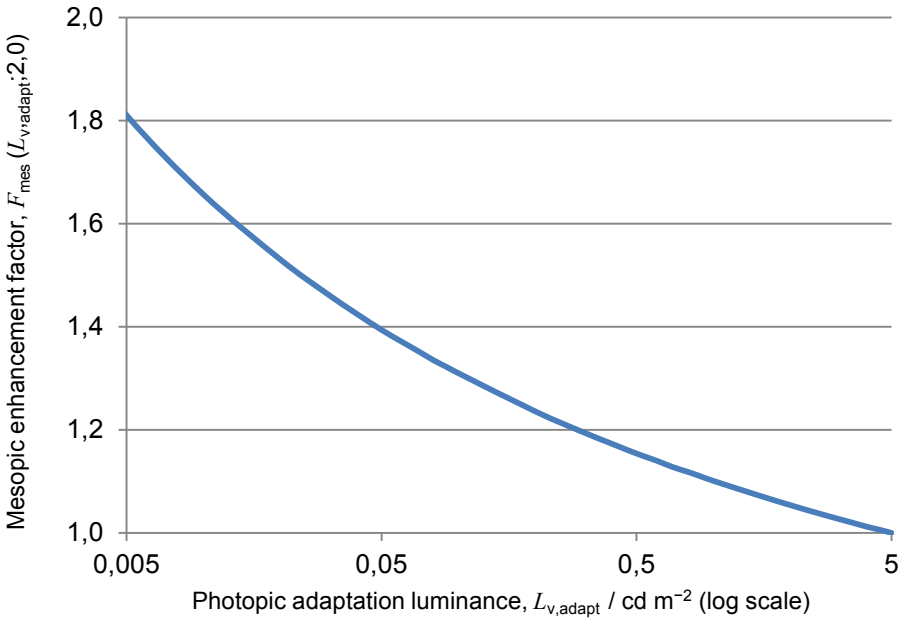

Figure 1 – Graphical presentation of information on products intended for illumination purposes in the mesopic region (example for product with photopic luminous flux of 1 000 lm and S/P ratio of 2,0)

4 Specifying performance of products not intended for illumination purposes

Mesopic quantities are only relevant for products specifically intended for illumination purposes. The use of mesopic quantities is not appropriate in other cases and hence only photopic quantities should be given in datasheets associated with products that are not intended to provide illumination. Likewise the S/P ratio is not relevant for such products and should therefore not be quoted. Examples include:

- Products that are intended to be viewed under on-axis (foveal) conditions, such as traffic signs. In this situation the photopic spectral luminous efficiency function applies for all adaptation levels and mesopic quantities are therefore irrelevant.
- Products such as emergency indicator lights, which may be viewed in the periphery under mesopic adaptation conditions but are not intended to provide illumination. Here the adaptation conditions are independent of the properties of the product; instead the visual adaptation is governed by the ambient illumination within the relevant visual adaptation field.

5 Practical implementation of the CIE system for mesopic photometry

It should be noted that although products intended for illumination purposes under mesopic adaptation conditions are already appearing in the market place, and their performance can be specified as described above, some issues remain to be resolved in relation to the practical implementation of the CIE system for mesopic photometry, e.g. how to determine the adaptation field, for what tasks and applications mesopic quantities should be used, and what changes should be made to specification standards for mesopic applications such as road lighting in order to take account of the system for mesopic photometry. Work is in progress within CIE JTC 1(D1/D2/D4/D5) to develop further recommendations to address these issues. In addition, factors such as the potential for increased glare from ‘mesopically-enhanced’ lighting (i.e. lighting with a relatively high blue content) need to be taken into account when choosing the most appropriate light source for any given application; these considerations are being addressed by Division 4, e.g. in CIE TC 4-33 Discomfort Glare and Road Lighting.

References

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