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SIMPLIFIED METHOD TO DETERMINE THE SPECTRAL MISMATCH CORRECTION OF COMMERCIAL ILLUMINANCE METERS

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ABSTRACT

Photometric quantities accuracy measured with illuminance meters is determined by the value of the spectral mismatch correction factor ($F(S_t)$), which is defined as a function of spectral power distribution of light sources, besides relative spectral responsivity of the illuminance meter used. Then appropriate determination of F factor is limited to suitably equipped laboratories.

In this work a simplified method to directly determine the illuminance responsivity to light sources other than illuminant A of commercial illuminance meters, whereby knowledge of the relative spectral responsivity of the illuminance meter to be calibrated is not necessary, is presented. The method has been proved to be useful for illuminance meters with different degrees of spectral mismatch from $V(\lambda)$ function and to different spectral power distributions.

Keywords: mismatch correction factor, illuminance meter, illuminance responsivity

1. INTRODUCTION

In order to measure photometric quantities with an illuminance meter, its illuminance responsivity should be precisely calibrated. Illuminance meters are calibrated using incandescent lamps operated at 2856K (Illuminant A) [1].

When the illuminance meter is to be used for measurements with other light sources without correcting the response, an error occurs due to the spectral mismatch to the $V(\lambda)$ function. According to the CIE [2], this error is corrected by a spectral mismatch correction factor, F, given by:

$$F(S_t(\lambda)) = \frac{\int_\lambda S_A(\lambda)s_{rel}(\lambda)d\lambda \int_\lambda S_t(\lambda)V(\lambda)d\lambda}{\int_\lambda S_A(\lambda)V(\lambda)d\lambda \int_\lambda S_t(\lambda)s_{rel}(\lambda)d\lambda} \quad (1)$$

where $S_t(\lambda)$ is the spectral power distribution of the test lamp, $S_A(\lambda)$ is the spectral data of the CIE Illuminant A, and $s_{rel,}(\lambda)$ is the relative spectral responsivity of the illuminace meter. Factor F multiplies the illuminance measured by the test meter to obtain the true illuminance.

In order to quantify or correct for this error, the spectral power distribution of the test lamp, as well as the relative spectral responsivity of the illuminance meter must be known.

It is possible to find bibliography [3,4] where typical spectral power distribution of the different light sources used in lighting is provided, but the relative spectral responsivity of the particular illuminance meter must be measured in order to determine the corresponding factor F. Then determination of the spectral mismatch correction factor is limited to a suitably equipped laboratory.

This work presents a simplified method to determine the illuminance responsivity to light sources other than illuminant A of commercial illuminance meters, whereby knowledge of the relative spectral responsivity of the illuminance meter to be calibrated is not necessary. Therefore it can be used by not highly equipped laboratories for the calibration of meters designed for field use (class B and C illuminance meters).

The method has been applied to different light sources typically used in illumination areas, and to illuminance meters with different degree of spectral mismatch from the $V(\lambda)$ function (class A, B and C photometers). Differences, with respect to the recommended method[2], lower than 1 % have been obtained in all cases.

2. METHOD DESCRIPTION

The method proposed in this work consists of determining the luminous responsivity of the illuminance meter (for a specific light source) rather than calculating the mismatch correction factor (1), which is an equivalent way.

Luminous responsivity is defined as the quotient between the meter's response and the photometric quantity of interest, illuminance in this case. The responsivity may be determined in different ways. One of them is to compare the response of a test meter with that of a standard meter under the same illumination.

The Illuminance responsivity (for a specific light source) is then found as the ratio of the test illuminance meter's response to the illuminance measured by the standard photometer, determined as the ratio of its luminous response to its responsivity. The expression for the calculation is:

$$R_{vt}(S_t) = \frac{Y_{vt}}{Y'_{vs}} \times R'_{vs} \times F'_s(S_t) \qquad (2)$$

where Y_{vt} is the luminous signal (for a particular light source S_t) from the illuminance meter to be calibrated, Y'_{vs} is the luminous signal (for the same light source S_t) from the standard photometer, R'_{vs} is the standard photometer illuminance responsivity under illuminant A, and F'_s is the corresponding F factor of the standard photometer for the light source S_t.

With this method the test meter illuminance responsivity, for any light source, is obtained directly by comparison. Only the luminous responsivity under illuminant A of the standard photometer must be known, as well as its corresponding factor F for each particular light source.

The method has been applied to several illuminance meters with different degrees of spectral mismatch to the V(λ) function:

- LMT2: Photometer head manufactured by LMT, 30 mm in diameter, partial filtering with cosine diffuser . f_1' =2,2%.
- B360: Commercial illuminance meter manufactured by LMY; 30 mm in diameter, partial filtering with cosine diffuser. f_1' = 2,2%
- FOTI: Photometer head manufactured by LMT, 15 mm in diameter, total filtering with diffuser (without cosine response). f_1' = 1,4%.
- 11504: Commercial illuminance meter manufactured by UDT, 20 mm in diameter, total filtering without diffuser. f_1' = 8,2%.

A class L photometer (f_1' = 1,35%) has been used as standard in this work, whose repsonsivity was derived from our illuminance scale realised as explained in [5].

3. LIGHT SOURCES USED

Different types of light sources, typically used on illumination areas, were used in the experiments to determine illuminance responsivities of the photometer listed before, for every illuminant. The set of sources is formed by fluorescent lamps, white sodium, high - pressure mercury and metal halide lamps. Their normalized spectral power distributions (SPD), measured in our facilities, are presented in Fig.1

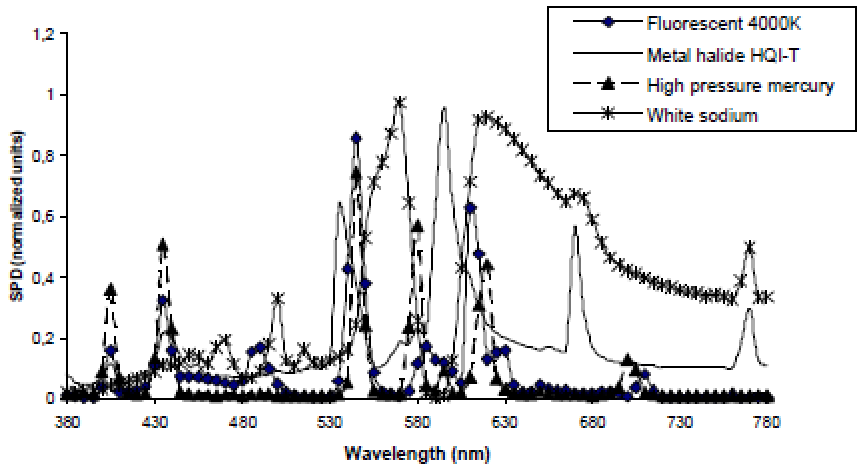

Figure 1.- Normalized Spectral Power Distribution (SPD) curves of light sources

4. METHOD VALIDATION

A traditional way to validate alternative measurement methods is to compare the results obtained in their application with those obtained with a standard method. We have compared the results obtained with this method with those obtained by applying the standard CIE method (eq. 1):

- First the illuminance responsivity to illuminant A for all the mentioned illuminance meters was calibrated.
- Then the relative spectral responsivity of each test meter was measured in our facilities, and the factor *F* according to (1) was calculated for every meter and SPD.
- Illuminance responsivity for the different light sources was obtained with the proposed method (eq. 2) and compared with the results obtained with the standard method.

Figure 2 shows the ratio between the illuminance repsonsivity obtained by the proposed method and that obtained with the standard CIE method. As it can be seen, differences lower than 1% have been obtained for all the light sources tested, even for the case of illuminance meters with poor V(λ) matching. For most cases, the difference is within ± 0,5%, which is well below the uncertainty of the respective responsivity values.

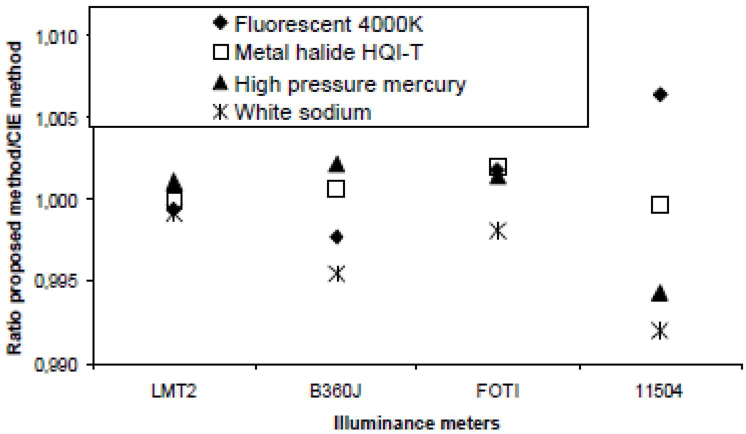

Figure 2.- Ratio of the illuminance responsivity obtained with the proposed method to the CIE method, for different light sources

5. CONCLUSIONS

A simplified method to directly determine the illuminance responsivity to light sources other than illuminant A of commercial illuminance meters is presented. In this method it is not neccesary to know the spectral relative responsivity of the test meter. Therefore it can be used by not highly equipped laboratories for the calibration of meters designed for field use (class B and C illuminance meters).

The method has been applied to different light sources typically used in illumination areas, and to different illuminance meters with different degrees of spectral mismatch to the V(λ) function (class A, B and C photometers). Differences, with respect to the recommended method, lower than 1 % have been obtained in all cases, below the combined uncertainty of the comparison.

REFERENCES

[1].- OHNO, J. *NIST Measurement* Services: *Photometric Calibrations* . NIST special publication 250-37, 1997.

[2].- CIE 69 – 1987 *Methods of characterizing illuminance meters and luminance meters: Performance characteristics and specifications*.

[3].- SAMETOGLU, F. Relation between the illuminance responsivity of a photometer and the spectral power distribution of a source. *Optical Engineering*., 2007,**46**, 1-12.

[4].- CIE D002- 2004 *Disc versión of CIE colorimetric and colour rendering data (CIE 13.3-1995 and CIE 15:2004).*

[5].- CAMPOS, J., CORRONS, A., PONS, A. and CORREDERA, P. Realization of the Candela from a partial filtering V(λ) detector traceable to a cryogenic radiometer. *Metrologia*, 1996, **32**, 675-679.

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