INTERNATIONAL STANDARD

ISO/CIE 19476

First edition
2014-06-01

Characterization of the performance of illuminance meters and luminance meters

Caractérisation des performances des luxmètres et des luminancemètres

Reference number
ISO/CIE 19476:2014(E)

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Published in Switzerland

Foreword

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ISO/CIE 19476 was prepared by CIE Technical Committee 2-40: *Characterizing the performance of illuminance and luminance meters*, as CIE S 023. The committee responsible for this document is ISO/TC 274, *Light and lighting.*

CIE S 023/E:2013

COMMISSION INTERNATIONALE DE L'ECLAIRAGE
INTERNATIONAL COMMISSION ON ILLUMINATION
INTERNATIONALE BELEUCHTUNGSKOMMISSION

International Standard

Characterization of the Performance of Illuminance Meters and Luminance Meters

Caractérisation des performances des luxmètres et des luminancemètres

Kennzeichnung der Güte von Beleuchtungsstärke- und Leuchtdichtemessgeräten

CIE Central Bureau, Vienna
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UDC:	535.24 535.241.5 535.241.535	Descriptor:	Photometry Quantities related to photometric and other measurements Calibration

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Foreword

International Standards produced by the Commission Internationale de l'Eclairage are concise documents on aspects of light and lighting that require a unique definition. They are a primary source of internationally accepted and agreed data which can be taken, essentially unaltered, into universal standard systems.

This CIE International Standard has been prepared by CIE Technical Committee 2-40[1] "Characterizing the Performance of Illuminance and Luminance Meters". It has been approved by the Board of Administration and Division 2 of the Commission Internationale de l'Eclairage as well as by the CIE National Committees. It is supposed to supersede CIE Publication 69-1987.

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[1] This TC was chaired by R. Rattunde † (DE) and P. Blattner (CH).
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CONTENTS

Characterization of the Performance of Illuminance Meters and Luminance Meters

1 Scope

This CIE International Standard is applicable to illuminance and luminance meters. The Standard defines quality indices characterizing the performance of such devices in a general lighting measurement situation, as well as measurement procedures for the individual indices and standard calibration conditions.

Measurements of illuminance or luminance and their accuracy are influenced by various parameters, such as operational conditions, properties of light sources, as well as characteristics of the applied photometers. The characteristics of these photometers alone do not allow the determination of the measurement uncertainty for a specific measurement task. Nevertheless, it is generally true that instruments with “better” characteristics in most cases produce smaller uncertainties than instruments with “worse” properties. This Standard has been written to:

- give clear and unambiguous definitions for the individual quality indices;
- define measurement procedures and methods for numerical evaluation of these quality indices;
- define calibration conditions for illuminance meters and luminance meters.

Where different, the definitions of the quality indices and the associated measurement procedures and methods for numerical evaluation given in this Standard supersede those given in CIE Publication 53-1982. CIE publication 69-1987 shall be superseded by this Standard.

2 Normative References

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CIE 202:2011 Spectral Responsivity Measurement of Detectors, Radiometers and Photometers

CIE S 017/E:2011 ILV: International Lighting Vocabulary

ISO 11664-2:2007/CIE S 014-2:2006 Colorimetry – Part 2: CIE Standard Illuminants

ISO 23539:2005/CIE S 010:2004 Photometry – The CIE System of Physical Photometry

CIE 198:2011 Determination of Measurement Uncertainties in Photometry

CIE 114/4-1994 CIE Collection in Photometry and Colorimetry - Distribution Temperature and Ratio Temperature

IEC 60051-1:1997 Direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts

ISO/IEC Guide 98-3:2008[1] Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

ISO/IEC Guide 99:2007[2] International Vocabulary of Metrology — Basic and General Concepts and Associated Terms (VIM).

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1 Also referred as JCGM 100:2008, available from BIPM webpage.

2 Also referred as JCGM 200:2008, available from BIPM webpage.

3 Definitions

For the purposes of this document, the terms and definitions given in CIE S 017/E:2011 (International Lighting Vocabulary) and the following apply.

3.1 General Definitions

3.1.1
measurement accuracy
closeness of agreement between a measured quantity value and a true quantity value of a measurand

Note 1 to entry: The concept 'measurement accuracy' is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it offers a smaller measurement error.

Note 2 to entry: The term "measurement accuracy" should not be used for measurement trueness and the term measurement precision should not be used for 'measurement accuracy', which, however, is related to both these concepts.

Note 3 to entry: 'Measurement accuracy' is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand.

[Source: ISO/IEC Guide 99:2007 (VIM), 2.13]

3.1.2
measurement error
measured quantity value minus a reference quantity value

Note 1 to entry: The concept of 'measurement error' can be used both

a) when there is a single reference quantity value to refer to, which occurs if a calibration is made by means of a measurement standard with a measured quantity value having a negligible measurement uncertainty or if a conventional quantity value is given, in which case the measurement error is known, and

b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the measurement error is not known.

Note 2 to entry: Measurement error should not be confused with production error or mistake.

[Source: ISO/IEC Guide 99:2007 (VIM), 2.16]

3.1.3
calibration
operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", nor with verification of calibration.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

[Source: ISO/IEC Guide 99:2007 (VIM), 2.39]

3.1.4
adjustment of a measuring system
set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment).

Note 2 to entry: Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment.

Note 3 to entry: After an adjustment of a measuring system, the measuring system must usually be recalibrated.

[Source: ISO/IEC Guide 99:2007 (VIM), 3.11]

3.1.5
(metrological) traceability
property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

Note 1 to entry: For this definition, a ‘reference’ can be a definition of a measurement unit through its practical realization, or a measurement procedure including the measurement unit for a non-ordinal quantity, or measurement standard.

Note 2 to entry: Metrological traceability requires an established calibration hierarchy.

Note 3 to entry: Specification of the reference must include the time at which this reference was used in establishing the calibration hierarchy, along with any other relevant metrological information about the reference, such as when the first calibration in the calibration hierarchy was performed.

Note 4 to entry: For measurements with more than one input quantity in the measurement model, each of the input quantity values should itself be metrologically traceable and the calibration hierarchy involved may form a branched structure or a network. The effort involved in establishing metrological traceability for each input quantity value should be commensurate with its relative contribution to the measurement result.

Note 5 to entry: Metrological traceability of a measurement result does not ensure that the measurement uncertainty is adequate for a given purpose or that there is an absence of mistakes.

Note 6 to entry: A comparison between two measurement standards may be viewed as a calibration if the comparison is used to check and, if necessary, correct the quantity value and measurement uncertainty attributed to one of the measurement standards.

Note 7 to entry: The ILAC considers the elements for confirming metrological traceability to be an unbroken metrological traceability chain to an international measurement standard or a national measurement standard, a documented measurement uncertainty, a documented measurement procedure, accredited technical competence, metrological traceability to the SI, and calibration intervals (see ILAC P-10:2002).

Note 8 to entry: The abbreviated term “traceability” is sometimes used to mean ‘metrological traceability’ as well as other concepts, such as ‘sample traceability’ or ‘document traceability’ or ‘instrument traceability’ or ‘material traceability’, where the history (“trace”) of an item is meant. Therefore, the full term of “metrological traceability” is preferred if there is any risk of confusion.

[Source: ISO/IEC Guide 99:2007 (VIM), 2.41]

3.1.6
photometer
instrument for measuring photometric quantities

[Source: CIE S 017/E:2011, 17-909]

Note 1 to entry: A photometer consists of a photometer head, a signal converter, an output device and a power supply. The different parts can be built to a single device or split into separate housings. Within this Standard, the term photometer refers to illuminance and luminance meters having a single detector that measures light spectrally integrated.

3.1.7
reference plane (of a photometer or light source)
plane associated with a photometer or a light source for the purpose of measuring the distance between them

Note 1 to entry: For a photometer this is the plane perpendicular to the optical axis of the photometer head at which the photometer or photometer head is calibrated. The reference plane of a photometer should ideally coincide with the effective reference plane.

3.1.8
effective reference plane (of a photometer)
plane perpendicular to the optical axis of the photometer head where the inverse square law holds when illuminance from a point source is measured and the distance to the source is measured from this plane

Note 1 to entry: The effective reference plane may vary with wavelength. In such a case the type of light source (i.e. CIE Standard Illuminant A) shall be stated together with the effective reference plane.

3.1.9
limiting photometric distance
shortest distance between the reference plane of a light source and the effective reference plane of a photometer, for a given acceptable error considering the photometric inverse square law

Note 1 to entry: The limiting photometric distance is determined mainly from the geometrical properties of the photometer and the source.

3.1.10
acceptance aperture
acceptance area of the photometer head of an illuminance meter or the measurement field of a luminance meter

Note 1 to entry: Usually the acceptance aperture is at the effective reference plane of the photometer.

3.2 Quality Indices

A set of quality indices is used to characterize the performance of photometers. Quality indices are physical quantities characterizing selected properties of a photometer. They are normalized response values, which do not describe errors directly and thus cannot be used for correction. The name for each index has been taken from the physical effect influencing its value to make it easier to memorize and understand its meaning

A quality index is symbolized by the symbol "f_x" where the subscript "x" specifies the considered property. The values are:

- evaluated by formulas specific for each property, from data determined under specified measurement conditions;
- stated as a percentage, with associated uncertainties; and
- ideally zero.

The quality indices of these photometers alone do not allow the estimation of the measurement uncertainty for a specific measurement task. Nevertheless, it is generally true that instruments with smaller f_x-values, in most cases, allow smaller measurement uncertainties than instruments with larger values.

3.2.1
initial adjustment index
f_{adj}
index describing the absolute relative deviation of the photometer indication from the corresponding reference value

3.2.2
general $V(\lambda)$ mismatch index
f_1'
index describing the deviation of the relative spectral responsivity of the photometer from the $V(\lambda)$ function

3.2.3
UV response index
f_{UV}
index describing the responsivity of the photometer to UV radiation

3.2.4
IR response index
f_{IR}
index describing the responsivity of the photometer to IR radiation

3.2.5 (illuminance meter only)
directional response index for illuminance
f_2
index describing the responsivity of the photometer to light incident at an angle other than normal (the cosine law for general purpose illuminance meters)

3.2.6 (illuminance meter only)
directional response index for spherical illuminance
$f_{2,0}$
index describing the responsivity of the photometer to light incident at an angle other than normal

3.2.7 (illuminance meter only)
directional response index for cylindrical illuminance
$f_{2,c}$ [1]
index describing the responsivity of the photometer to light incident at an angle other than normal

3.2.8 (illuminance meter only)
directional response index for semi-cylindrical illuminance
$f_{2,sc}$
index describing the responsivity of the photometer to light incident at an angle other than normal

3.2.9 (illuminance meter only)
directional response index for semi-spherical illuminance
$f_{2,2\pi}$
index describing the responsivity of the photometer to light incident at an angle other than normal

3.2.10 (luminance meter only)
directional response index for luminance
$f_{2,g}$
index describing the responsivity of the photometer to light incident at an angle other than normal

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[1] Previously used symbol $f_{2,z}$.