# SLOVENSKI STANDARD
# oSIST prEN ISO/CIE 11664-2:2021

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**Kolorimetrija - 2. del: Standardizirana osvetljevala (iluminanti) CIE (ISO/CIE DIS 11664-2.2:2021))**

Colorimetry - Part 2: CIE standard illuminants (ISO/CIE DIS 11664-2.2:2021)

Farbmetrik - Teil 2: CIE Normlichtarten (ISO/CIE DIS 11664-2.2:2021)

Colorimétrie - Partie 2: Illuminants CIE normalisés (ISO/CIE DIS 11664-2.2:2021)



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# Colorimetry —

## Part 2:
## CIE standard illuminants

*Colorimétrie —*

*Partie 2: Illuminants CIE normalisés*

ICS: 17.180.20



Member bodies are requested to consult relevant national interests in ISO/TC 274 before casting their ballot to the e-Balloting application.



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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.



This document was prepared by the International Commission on Illumination (CIE) in cooperation with ISO/TC 274 “Light and Lighting”.

This first edition of ISO/CIE 11664-2 cancels and replaces ISO 11664-2:2007/CIE S 014-2:2006, which has been technically revised.

The main changes compared to the previous edition are as follows:

— CIE illuminant D50 has been included as CIE standard illuminant in this document because of its extensive use in the fields of graphic, arts and photography.

A list of all parts in the ISO/CIE 11664 series can be found on the ISO website and CIE website.

Any feedback or questions on this document should be directed to the CIE Central Bureau or to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Introduction

The illuminants defined in this document are as follows:

a) CIE standard illuminant A

CIE standard illuminant A is intended to represent typical tungsten-filament lighting. Its relative spectral power distribution is that of a Planckian radiator at a temperature of approximately 2 855,5 K. CIE standard illuminant A should be used in all applications of colorimetry involving the use of incandescent lighting, unless there are specific reasons for using a different illuminant. CIE standard illuminant A is used in photometry as primary reference spectrum for the calibration of photometric devices.

b) CIE standard illuminant D65

CIE standard illuminant D65 is intended to represent average daylight having a correlated colour temperature of approximately 6 500 K. CIE standard illuminant D65 should be used in all colorimetric calculations requiring representative outdoor daylight, unless there are specific reasons for using a different spectral power distribution. Variations in the relative spectral power distribution of daylight are known to occur, particularly in the ultraviolet spectral region, as a function of season, time of day, and geographic location. However, CIE standard illuminant D65 is used pending the availability of additional information on these variations.

c) CIE standard illuminant D50

CIE standard illuminant D50 is intended to represent daylight with a correlated colour temperature of approximately 5 000 K. CIE standard illuminant D50 should be used in colorimetric calculations where the use of such a correlated colour temperature is intended.



Values for the relative spectral power distribution of CIE standard illuminants A, D65 and D50 are given in this document at 1 nm intervals from 300 nm to 830 nm.



The term "illuminant" refers to a defined spectral power distribution, not necessarily realizable or provided by an artificial source. Illuminants are used in colorimetry to compute the tristimulus values of reflected or transmitted object colours under specified conditions of illumination. The CIE has also defined other illuminants, such as illuminant C, other D illuminants, and illuminants for LED and other electric light sources. These illuminants are described in Publication CIE 015, but they do not have the status of CIE standard illuminants. It is recommended that one of the three CIE standard illuminants defined in this document be used wherever possible. This will greatly facilitate the comparison of published results.

In most practical applications of colorimetry, it is sufficient to use the values of CIE standard illuminants A, D65 and D50 at less frequent wavelength intervals or in a narrower spectral region than defined in this document. Data and guidelines that facilitate such practice are provided in Publication CIE 015, together with other recommended procedures for practical colorimetry.

The term "source" refers to a physical emitter of light, such as a lamp or the sky. In certain cases, the CIE recommends laboratory sources that approximate the spectral power distributions of CIE illuminants. In all cases, however, the definition of a CIE recommended source is secondary to the definition of the corresponding CIE illuminant, because of the possibility that, from time to time, new developments will lead to improved sources that represent a particular illuminant more accurately or are more suitable for laboratory use.

CIE standard source A, the practical realization of CIE standard illuminant A, is described in this document. At present, there are no CIE recommended sources representing CIE standard illuminants D65 and D50.

# Colorimetry — Part 2: CIE standard illuminants

## 1 Scope

This document defines three CIE standard illuminants for use in colorimetry: CIE standard illuminant A for the representation of typical tungsten-filament lighting, CIE standard illuminant D65 for the representation of average daylight having a correlated colour temperature of approximately 6 500 K, and CIE standard illuminant D50 for the representation of daylight with a correlated colour temperature of approximately 5 000 K. Values of the relative spectral power distribution of the three illuminants are included in this document.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CIE S 017, *ILV: International Lighting Vocabulary*



ISO 23603/CIE S 012, *Standard method of assessing the spectral quality of daylight simulators for visual appraisal and measurement of colour*



BIPM *The International System of Units (SI), 9th edition, published on May 20, 2019*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE S 017 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

**3.1**
**CIE standard illuminant**
illuminant standardized by the CIE for the purpose of harmonization

[SOURCE: CIE S 017:2020, Entry 17-23-021, modified – notes to entry omitted]

**3.2**
**CIE standard source**
artificial source specified by the CIE whose radiation approximates a CIE standard illuminant

[SOURCE: CIE S 017:2020, Entry 17-23-022, modified – notes to entry omitted]

**3.3**
**daylight illuminant**
**D illuminant**
illuminant having the same or nearly the same relative spectral power distribution of the radiant flux as a phase of daylight

[SOURCE: CIE S 017:2020, Entry 17-23-020, modified – notes to entry omitted]

**3.4**
**illuminant**
radiation with a relative spectral power distribution defined over the wavelength range that influences object colour perception

[SOURCE: CIE S 017:2020, Entry 17-23-018, modified – notes to entry omitted]

**3.5**
**standard air**
dry air at 15 °C and 101 325 Pa, containing 0,045 % by volume of carbon dioxide

Note 1 to entry: This definition is intended for this document only.

# 4 CIE standard illuminant A

## 4.1 Definition



The relative spectral power distribution of CIE standard illuminant A, $S_A(\lambda)$, is defined by Formula (1) over the wavelength range 300 nm to 830 nm.



$$S_A(\lambda) = 100\left(\frac{560}{\lambda}\right)^5 \times \frac{\exp\frac{1{,}435\times10^7}{2\,848\times560}-1}{\exp\frac{1{,}435\times10^7}{2\,848\ \lambda}-1} \quad (1)$$

where $\lambda$ is the wavelength in nanometres and the numerical values in the two exponential terms are definitive constants originating from the first definition of illuminant A in 1931 (see also Annex C). This spectral power distribution is normalized to the value 100 (exactly) at the wavelength 560 nm (exactly).

Note 1 Table A.1 provides the relative spectral power distribution of CIE standard illuminant A to six significant digits, at 1 nm intervals. For practical purposes it suffices to use these tabulated values instead of the values calculated from Formula (1).

Note 2 Despite the fact that Formula (1) is based on Planck's equation for vacuum, the wavelengths are to be taken as being in standard air (see 3.5). This makes CIE standard illuminant A compatible with other CIE colorimetric and photometric data.

## 4.2 Theoretical basis

Formula (1) is equivalent to and can be derived from the expression

$$S_\lambda(\lambda) = 100\frac{M_{e,\lambda}(\lambda,T)}{M_{e,\lambda}(560,T)}, \quad (2)$$

where

$$M_{e,\lambda}(\lambda,T)=c_1\,\lambda^{-5}\left[\exp\left(\frac{c_2}{\lambda T}\right)-1\right]^{-1}, \quad (3)$$

$\lambda$ is the wavelength (in nm),

and the quotient $c_2/T$ is given by

$$\frac{c_2}{T}=\frac{14\,350\ \mu m\cdot K}{2\,848\ K}=\frac{1{,}435\times10^7}{2\,848}\,nm\,. \quad (4)$$

Since the numerical value of $c_1$ cancels out of Formula (2), this definition of CIE standard illuminant A involves no assumptions about the numerical values of $c_1$, $c_2$, and $T$ other than the quotient defined in Formula (4).

With the value of $c_2$ as defined in (BIPM, The International System of Units (SI), 9th edition), the assigned temperature for CIE standard illuminant A is 2 855,496 ... K, thus approximately 2 855,5 K.

Note More information regarding the historical changes to the temperature used to define CIE standard illuminant A can be found in Annex B.

# 5 CIE standard illuminant D65

## 5.1 Definition



CIE standard illuminant D65 is defined by the relative spectral power distribution values provided in Column 2 of Table B.1. The values are presented at 1 nm intervals over the wavelength range from 300 nm to 830 nm; the wavelength values given apply in standard air. If required, other intermediate values shall be derived by linear interpolation from the published values.



## 5.2 Experimental basis

The relative spectral power distribution of CIE standard illuminant D65 is based on experimental measurements of daylight in the wavelength range 330 nm to 700 nm, with extrapolations to 300 nm and 830 nm, as reported by Judd, MacAdam, and Wyszecki (Judd et al., 1964). The extrapolated values are believed to be sufficiently accurate for conventional colorimetric purposes, but are not recommended for non-colorimetric use.

## 5.3 Correlated colour temperature

CIE standard illuminant D65 has a nominal correlated colour temperature of 6 500 K.

NOTE Using the value of $c_2$ = 14 388 µm·K, specified in the International Temperature Scale of 1990, the definition of correlated colour temperature (CIE S 017, 17-23-068), and the relative spectral power distribution data of Table B.1, the correlated colour temperature of CIE standard illuminant D65 is found to be 6 502,712 K. Using the value of $c_2$ = 14 387,768 775 … µm·K, specified in the International System of Units (SI), 9th edition (2019), the definition of correlated colour temperature (CIE S 017, 17-23-068), and the relative spectral power distribution data of Table B.1, the correlated colour temperature of CIE standard illuminant D65 is found to be 6 502,608 K. The difference from the nominal correlated colour temperature of 6 500 K of CIE standard illuminant D65 is judged to be insignificantly small.