SLOVENSKI STANDARD
SIST EN 4706:2019

01-september-2019

Aeronavtika - LED barvna razvrstitev in svetlost

Aerospace series - LED colour and brightness ranking

Luft- und Raumfahrt - LED Farb- und Helligkeitsklassifizierung

Série aérospatiale - Classement de couleur et brillance des LED

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ICS:

17.180.20	Barve in merjenje svetlobe	Colours and measurement of light
49.095	Oprema za potnike in oprema kabin	Passenger and cabin equipment

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English Version

Aerospace series - LED colour and brightness ranking

Série aérospatiale - Classement de couleur et brillance des LED

Luft- und Raumfahrt - LED Farb- und Helligkeitsklassifizierung

This European Standard was approved by CEN on 6 August 2018.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Page

European foreword

This document (EN 4706:2019) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2019, and conflicting national standards shall be withdrawn at the latest by December 2019.

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Introduction

The chromaticity coordinates and brightness of LEDs of the same type have variations caused by the manufacturing process; this applies to white LEDs and coloured (monochrome) LEDs. Therefore LEDs have to be selected by the manufacturer into “Colour ranks”. Also the brightness of LEDs has certain variations, therefore the LEDs are also selected into “Brightness ranks”.

The step width of these ranking systems depends on the manufacturer and the LED type. For certain applications, e.g. inside an aircraft cabin, a high quality light is demanded, so a manufacturer independent standardization is desirable.

The purpose of this standard is to provide a simple classification system to enable the end user to define lighting colour accuracy.

The decimal sign in this document is a comma.

1 Scope

This document defines selection ranks for LED Luminaires, and LEDs including OLEDs for the use in aircraft lighting. The size of these ranks is defined by the use of grades. This European Standard is valid for photopic light levels only.

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.

IEC 60050-845:1987, *International electrotechnical vocabulary — Chapter 845: Lighting*

CIE 013.3:1995, *Method of measuring and specifying colour rendering properties of light sources* 1)

D. L. MacAdam, *Specification of small chromaticity differences* 2)

3 Terms and definitions

For the purposes of this standard, the following terms and definitions apply.

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

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

- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
Light Emitting Diode
LED
solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

3.2
Organic Light Emitting Diode
OLED
organic solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

3.3
colour space
description model to define colours in a two-dimensional (colour without intensity, e.g. xy space CIE 1931) or three-dimensional space, (colour and intensity, e.g. Yxy CIE 1931)

1) Published by International Commission on Illumination (CIE), Kegelgasse 27, A-1030 Vienna, Austria.

2) Published in the Journal of the Optical Society of America, vol 32, No. 5, May 1942, pp 247-274, and in vol 1, No. 1, Jan. 1943, pp 18-26.

3.4
LED luminaire
device based on LEDs as light source including optics, electronics and cooling equipment enclosed in a housing

3.5
CIE 1931 colour space
description of a two-dimensional colour space for light colours

Note 1 to entry: In the CIE 1931 diagram the chromaticity coordinates *x* and *y* describe the chromaticity locus in the diagram. For this standard the CIE 1931 2° observer is applicable.

Note 2 to entry: CIE 015 provides more information about the CIE 1931 colour space.

3.6
chromaticity coordinate
two-dimensional data representation of the colour in the corresponding colour space, e.g. *x* and *y* for the CIE 1931

3.7
MacAdam ellipses
area in the corresponding colour space (e.g. CIE 1931) in which all colours have the same visual impression to an observer as the colour in the centre of this area

Note 1 to entry: The borderline of the ellipse represents the just noticeable colour difference. Based on experimental data, originally 25 MacAdam ellipses were defined in the CIE 1931 colour space. In the experiment an observer had a given colour and was able to modify the chromaticity locus of a second colour. The chromaticity loci, where the observer determined a difference between the two colours were recorded. When all these points were plotted in the CIE 1931 diagram, they created an ellipse around the chromaticity locus of the given colour. The size and the orientation of the ellipses are different for different colours.

[SOURCE: D. L. MacAdam]

3.8
Standard Deviation of Colour Matching
SDCM
metric of the distance between light colours at photopic light level, that describes approximately the perceptual distance between two chromaticity loci as a multiple of the MacAdam ellipses for these chromaticity loci

Note 1 to entry: *n* SDCM means that the distance between the two chromaticity loci is *n*-times the radius of the appropriate MacAdam ellipse in that direction. The centre of the ellipse is given by the chromaticity locus of the reference colour. Two chromaticity loci on opposite points of the MacAdam ellipse have a distance of (2 *n*) SDCM. The SDCM calculation between two chromaticity loci may be non-linear, dependent on the selected colour space. Therefore distances are limited to less than 10 SDCM.

Note 2 to entry: For this document the calculated data from the MacAdam ellipses has been used.

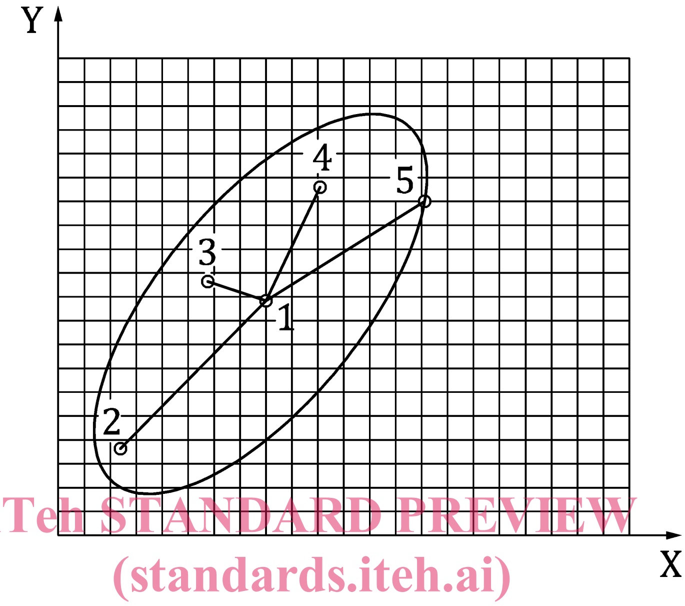
3.9
chromaticity coordinate distance
R
perceived chromaticity coordinate distance between any chromaticity loci and the target chromaticity locus in the corresponding colour space which is expressed in SDCM values

Note 1 to entry: The maximum chromaticity coordinate distance between any two chromaticity loci is the full diameter $2 \times R$ of the corresponding n-times scaled MacAdam ellipse:

R is the function which describes the radius of an n-times scaled MacAdam ellipse:

$$R = n \times \text{SDCM}$$

Figure 1 shows the chromaticity coordinate distance in a n SDCM ellipse.



Key

1 Target chromaticity locus

2 Colour 1

3 Colour 2

4 Colour 3

5 Limit $R = n \times$ SDCM

X Chromaticity coordinate x

Y Chromaticity coordinate y

Figure 1 — Chromaticity coordinate distance in a *n* SDCM ellipse

3.10
Colour Temperature
CT
temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus (unit: K)

[SOURCE: IEC 60050-845:1987]

3.11
Correlated Colour Temperature
CCT
temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions (unit: K)

[SOURCE: IEC 60050-845:1987]

3.12
Colour Rendering Index
CRI
quantitative measure of the ability of a light source to reproduce the colours of a specified set of eight test colour samples in comparison with an ideal or natural light source as described in CIE 013.3:1995

Note 1 to entry: The average colour rendering index for R1 to R8 is described with R_a.

3.13
colour R9
additional red test colour sample complementing CRI value

4 Chromaticity classification

4.1 Chromaticity loci coordinates of white LEDs

The notation of a chromaticity consists of the letter "S" (for Solid State Lighting) and the value of the adjacent colour temperature, e.g. "S 4000". The chromaticity loci are derived from the intersection between the Judd's isotemperature lines (colour temperature line) and the black body curve.

The standardized chromaticities for white LEDs have the chromaticity coordinates *x* and *y* from CIE 1931, see Table 1. In IEC 60081:2002 and NEMA ANSI C78.377:2015 similar values are defined for *x* and *y*, but these standards do not include coordinates for all chromaticities listed in Table 1. A short code is proposed for product labelling.

Table 1 — Chromaticity loci of white LEDs

Standardized chromaticity and short code	CCT Kelvin	*x*	*y*	Name
S 6500	6 500	0,314	0,324	daylight
S 5700	5 700	0,329	0,342	–
S 5000	5 000	0,345	0,352	neutral white
S 4500	4 500	0,361	0,364	–
S 4000	4 000	0,380	0,377	warm white
S 3500	3 500	0,405	0,391	–
S 3000	3 000	0,437	0,404	–
S 2700	2 700	0,460	0,411	incandescent

4.2 Colour tolerances of monochromatic LEDs

The chromaticity of monochromatic LEDs in lighting units may be application specific and the chromaticity of multi-colour applications is usually adjustable, so in some applications the exact chromaticity is less important than the chromaticity coordinate distance between different lighting units.

In special applications it is necessary that different lighting units always produce a specific colour. The names of these colours and their wavelength intervals are listed in Table 2. The provided tolerances apply for any specific dominant wavelength within the defined intervals.

Table 2 — Monochromatic LED tolerance classification

			Dominant wavelength tolerance for a given *n* nm							
Colour	**Wavelength interval** nm	*n*	0,5	1	1,5	2	2,5	3	6	> 6
		Short code	C1	C2	C3	C4	C5	C6	C7	C8
blue	420 to < 490	—	± 1	± 2	± 3	± 4	± 5	± 6	± 12	> 12
cyan	490 to < 510		± 1	± 2	± 3	± 4	± 5	± 6	± 12	> 12
green	510 to < 565		± 1	± 2	± 3	± 4	± 5	± 6	± 12	> 12
yellow	565 to < 590		± 0,5	± 1	± 1,5	± 2	± 2,5	± 3	± 6	> 6
amber	590 to < 615		± 1	± 2	± 3	± 4	± 5	± 6	± 12	> 12
red	615 to 700		± 1,5	± 3	± 4,5	± 6	± 7,5	± 9	± 18	> 18

4.3 Chromaticity coordinate distance

The chromaticity coordinate distance is stated in *R*. The chromaticity coordinate distance is divided into grades, which are listed in Table 3. A short code is proposed for product labelling.

Table 3 — Colour locus tolerance classification

	SDCM							
R	0,5	1	1,5	2	2,5	3	6	> 6
Short code	C1	C2	C3	C4	C5	C6	C7	C8

Figure 2 shows some chromaticity coordinate distances for S 4000 as examples. Figure 3 shows the relation between 3 SDCM and $\Delta F = 6$. The SDCM value corresponds to the radius of the ellipse, while the ΔF value corresponds to the diameter of the ellipse. In the Annex A all ΔF ellipses of the white chromaticity loci listed in Table 1 are shown.

$$\Delta F = 2 \times R$$

where

R is the chromaticity coordinate distance.