SLOVENSKI STANDARD
SIST EN 4828:2023

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Aeronavtika - Toplotni premik LED-svetilk - Razvrstitev in merilne metode

Aerospace series - Thermal drift of LED luminaires - Classification and measuring methods

Luft- und Raumfahrt - Thermische Drift von LED Leuchten - Klassifizierung und Messmethoden

Série aérospatiale - Dérive thermique des luminaires à LED - Classification et méthodes de mesure

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ICS:

29.140.99	Drugi standardi v zvezi z žarnicami	Other standards related to lamps
49.095	Oprema za potnike in oprema kabin	Passenger and cabin equipment

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Aerospace series - Thermal drift of LED luminaires - Classification and measuring methods

Série aérospatiale - Dérive thermique des luminaires à LED - Classification et méthodes de mesure

Luft- und Raumfahrt - Thermische Drift von LED Leuchten - Klassifizierung und Messmethoden

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

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European foreword

This document (EN 4828:2022) 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 document has received the approval of the National Associations and the Official Services of the member countries of ASD-STAN, 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of an identical text or by endorsement, at the latest by May 2023, and conflicting national standards shall be withdrawn at the latest by May 2023.

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Introduction

Since LEDs are very susceptible to thermal changes, the chromaticity and luminous flux of an LED luminaire are affected by both its own and its ambient temperature. Variations in temperature can result in variations of luminous flux and chromaticity that in turn can negatively influence the quality of illumination. An example of this is visible differences in chromaticity and luminance of adjacent luminaires.

These differences depend on the utilized LED types and can be compensated to a certain extent by electronic means within the device.

By introducing a measurement method, the functional link between temperature variation and thermal drift of chromaticity and luminous flux in aircraft applications can be quantified. The aim of this method is to ensure a homogenous appearance of LED light units by considering thermal effects.

1 Scope

This document defines terms and specifies measuring methods and settings for the classification of the thermal behaviour of LED and OLED luminaires in the aircraft cabin regarding chromaticity and brightness characteristics. This document is intended for luminaires that are designed to provide photopic vison.

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.

EN 13032-4, *Light and lighting — Measurement and presentation of photometric data of lamps and luminaires — Part 4: LED lamps, modules and luminaires*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 https://www.electropedia.org/

3.1
chromaticity
colour valences that only differ in luminance

3.2
chromaticity coordinate
two-dimensional data representation of the colour in the corresponding colour space, e.g. x and y for the CIE 1931

[SOURCE: EN 4706:2019, 3.6]

3.3
CIE 1931 colour space
description of a two-dimensional colour space for light colours

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

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

[SOURCE: EN 4706:2019, 3.5]

3.4
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)

[SOURCE: EN 4706:2019, 3.3]

3.5
illuminance
measure of the total luminous flux incident on a surface, per unit area

Note 1 to entry: The unit is lx.

3.6
LED luminaire
device based on LEDs as light source including optics, electronics and cooling equipment enclosed in a housing

[SOURCE: EN 4706:2019, 3.4]

3.7
light emitting diode
LED
solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

Note 1 to entry: The term LED in the following context includes organic LED (OLED).

[SOURCE: EN 4706:2019, 3.1 modified — Note 1 to entry has been added.]

3.8
MacAdam ellipse
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: MacAdam, D.L.]

3.9
organic light emitting diode
OLED
organic solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

[SOURCE: EN 4706:2019, 3.2]

3.10
standard deviation of colour matching
SDCM
metric of the difference between chromaticities 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 nonlinear, 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.

[SOURCE: EN 4706:2019, 3.8 modified — “light colours” has been replaced by “chromaticities” in the definition text.]

3.11
thermal drift
variation in chromaticity and luminous flux due to altering temperature

4 Classification references

4.1 General

The luminous flux and colour performance of the LED lighting device shall be classified depending on the ambient temperature from −15 °C to 55 °C. The ambient temperature is the temperature in thermal equilibrium in the installation space of the device.

It shall be specified whether the LED lighting device is a single or multi primary solution.

4.2 Reference temperature

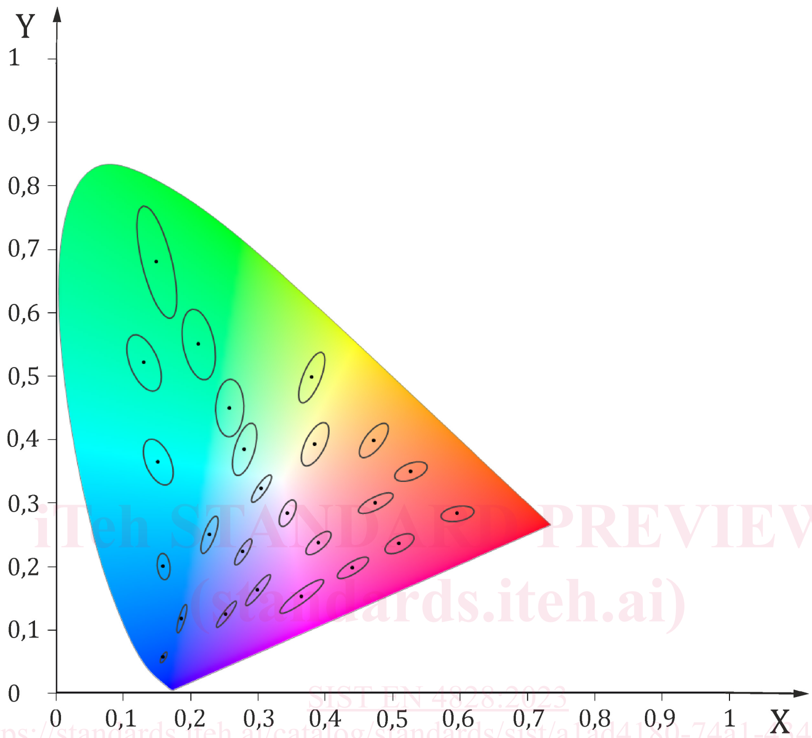
For the classification of the device properties three ambient temperature ranges are specified: Low temperature from −15 °C to < 10 °C, normal operation from 10 °C to 40 °C and high temperature from > 40 °C to 55 °C. According to those ranges, 5 reference temperatures are specified as thermal measuring conditions, see Table 1.

Table 1 —Thermal measurement conditions

	Low temperature °C	**Normal operation** °C	**High temperature** °C
Measurement conditions	−15	10, 25, 40	55

4.3 Reference chromaticity coordinates

The chromaticity classification of the luminaires (see 5.2) is based on MacAdam ellipses using SDCM to quantify chromaticity deviations. Since MacAdam ellipses are only defined for specific chromaticity coordinates (see Figure 1), the interpolation method described in Annex A shall be used. For white tones, described by (correlated) colour temperatures, white colour ellipses, e.g. S 4000, can be used alternatively.



Key

X chromaticity coordinate *x*

Y chromaticity coordinate *y*

Figure 1 — 25 MacAdam ellipses (shown 10 times enlarged)

5 Classification categories

5.1 Luminous flux classification

The luminous flux performance of the LED lighting devices shall be classified for three temperature ranges, see Table 1. All values shall be denoted in relation to the luminous flux at a temperature of 25 °C:

flux indicator (T) = flux (T)/flux (25 °C)

The flux indicator can be calculated by the ratio of any photometric parameter that is proportional to flux such as illuminance, luminance and luminous intensity.

The flux performance is determined by different flux classifications FXY. F indicates the flux indicator whereas X corresponds to the temperature range and Y to the flux variation in percent. The flux variation shall be quantified in a 1 % step grid.

Table 2 shows an example of flux classification.

Table 2 — Examples of luminous flux classification

Ambient temperature	Light fixture type A		Light fixture type B	
	Flux variation	Flux classification	Flux variation	Flux classification
L = −15 °C to < 10 °C	1 ± 20 %	FL20	1 ± 10 %	FL10
N = 10 °C to 40 °C	1 ± 10 %	FN10	1 ± 5 %	FN5
H = > 40 °C to 55 °C	1 ± 15 %	FH15	1 ± 8 %	FH8

In the typical aircraft illumination environment unintended luminous flux variations of max. ±10 % are not considered disturbing and below ±5 % hardly visible. In the example in Table 2 the light fixture type B performs better compared to type A.

5.2 Chromaticity classification

The chromaticity performance of the LED lighting devices shall be classified for three temperature ranges, see Table 1. The classification shall use the maximal chromaticity variation measured in SDCM rounded up to the next integer. Table 3 provides examples of chromaticity classification.

Table 3 — Examples of chromaticity classification

Ambient temperature	Light fixture type A		Light fixture type B	
	Measured chromaticity variation	Chromaticity classification	Measured chromaticity variation	Chromaticity classification
L = −15 °C to < 10 °C	3,1 SDCM	CL4	3,4 SDCM	CL4
N = 10 °C to 40 °C	3,0 SDCM	CN3	1,8 SDCM	CN2
H = > 40 °C to 55 °C	3,5 SDCM	CH4	2,7 SDCM	CH3

The chromaticity performance is determined by different chromaticity classifications CXn. C indicates the performance parameter chromaticity variation, whereas X corresponds to the temperature range and n to the SDCM multiplication factor. Since n is rounded up to the next integer, the chromaticity variation shall be quantified in a one-step SDCM grid. The given SDCM values are relative to the reference value at a temperature of 25 °C, i.e. for class CN3 the chromaticity distance between the chromaticity coordinates at 25 °C and the chromaticity coordinates at the reference temperature shall be ≤ 3 SDCM for 10 °C to 40 °C. Of the two examples above the light fixture type B is better compared to type A.

6 Labelling of the luminaire

In order to categorize the equipment, only the classification of the normal temperature range from 10 °C to 40 °C shall be used. A labelling of the LED lighting devices shall be realized, according to Table 4, e.g. RGB CN3 LN10. RGB indicates the primaries used in the luminaire, CN3 the chromaticity deviation below 3 SDCM and LN10 an intensity variation below 10 %.

This labelling shall be visible within associated paperwork, e.g. functional descriptions, and on the packaging.

A labelling of the equipment itself is recommended.