SLOVENSKI STANDARD
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Analizna kolorimetrija - 4. del: Metamerični indeks parov vzorcev pri spremembi vrste svetila (ISO/DIS 18314-4:2023)

Analytical colorimetry - Part 4: Metamerism index for pairs of samples for change of illuminant (ISO/DIS 18314-4:2023)

Analytische Farbmessung - Teil 4: Metamerie-Index von Probenpaaren bei Lichtartwechsel (ISO/DIS 18314-4:2023)

Analyse colorimétrique - Partie 4: Indice de métamérisme de paires d'échantillons pour changement d'illuminant (ISO/DIS 18314-4:2023)

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Analytical colorimetry —

Part 4: **Metamerism index for pairs of samples for change of illuminant**

Analyse colorimétrique —

Partie 4: Indice de métamérisme de paires d'échantillons pour changement d'illuminant

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Contents

Foreword

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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).

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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 Technical Committee ISO/TC 256, *Pigments, dyestuff and extenders*.

This second edition cancels and replaces the first edition (ISO 18314-4:2020), which has been technically revised.

The main changes are as follows:

— a brief introduction about differentiation between metamerism and paramerism has been added in 8.1;

— for consistency reasons with old formulas 2 and 4 and 24, the old formula 1 has been updated;

— the key of Figure A.1 has been updated;

— the document has been editorially revised.

A list of all parts in the ISO 18314 series can be found on the ISO website.

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

Introduction

For the phenomenon of metamerism of pairs of samples, three different kinds are distinguished:

a) Illuminant metamerism occurs if both of the object colours of a pair of samples are perceived as being the same only under a specific illuminant (e.g. under illuminant D65), while they differ under a different illuminant (e.g. illuminant A).

b) Observer metamerism occurs if the object colours of a pair of samples are perceived as being the same by one observer, while a different observer perceives a colour difference under the same illuminant and the same reference conditions.

NOTE 1 The observer metamerism is caused by differences between the distributions of spectral colour matching functions of different observers.

c) Field-size metamerism occurs if both of the object colours of a pair of samples are perceived as being the same on the retina for a size of an observation field (e.g. defined by the 2° standard observer), while they differ for a different observation field on the retina (e.g. 10°).

NOTE 2 The reason for field-size metamerism is based on the existent colour matching functions of an observer during an observation situation. The colour matching functions change with the size of the observation field on the retina. Such change of the observation field can also occur if, for example, the pair of samples is examined from different distances.

Analytical colorimetry —

Part 4:
Metamerism index for pairs of samples for change of illuminant

1 Scope

This document specifies a formalism for the calculation of the illuminant metamerism of solid surface colours. It cannot be applied to colours of effect coatings without metrical adaptation.

This document only covers the phenomenon of metamerism for change of illuminant, which has the greatest meaning in practical application. In the case of chromaticity coordinates of a pair of samples under reference conditions that do not exactly match, recommendations are given on which correction measures are to be taken. Regarding the reproduction of colours, the metamerism index is used as a measure of quality in order to specify tolerances for colour differences between a colour sample and a colour match under different illumination conditions.

The quantification of the illuminant metamerism of pairs of samples is formally performed by a colour difference assessment, for which tolerances that are common for the evaluation of residual colour differences can be used.

NOTE In the colorimetric literature and textbooks, the term geometric metamerism is sometimes used for the case that two colours appear to be the same under a specific geometry for visual assessment and selected standard observer and standard illuminant pair, but is perceived as two different colours at changed observation geometry. The term geometric metamerism is different to metamerism described 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.

ISO/CIE 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO/CIE 11664-2:—,[1)] *Colorimetry — Part 2: CIE standard illuminants*

ISO/CIE 11664-4, *Colorimetry — Part 4: CIE 1976 L*a*b* colour space*

CIE 015, *Colorimetry*

CIE S 017, *International Lighting Vocabulary*

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 https://www.electropedia.org/

1) Under preparation. Stage at the time of preparation: ISO/CIE DIS 11664-2:2020.

3.1
metamerism
property of spectrally different colour stimuli that have the same tristimulus values in a specified colorimetric system

[SOURCE: CIE 017:2016, 17-23-006]

3.2
paramerism
characteristic of a pair of samples with spectral colour stimulus functions which have different fundamental colour stimulus functions as well as different residuals or metameric black values within the visible spectral range

Note 1 to entry: Parameric objects are characterized by the fact that they reflect colour stimuli of different spectral power distribution functions under a specified standard illuminant, which cause approximately the same colour perception under the selected observation conditions.

3.3
colour difference
ΔE^*
difference between two colour stimuli, defined as a distance between the points representing them in a specified colour space

[SOURCE: CIE 017:2016, 17-22-041, modified — symbol ΔE^* was amended, "Euclidean" and Note 1 to entry have been deleted.]

3.4
reference illuminant
illuminant with which other illuminants are compared

[SOURCE: CIE S 017:2016, 17-22-109 17]

3.5
test illuminant
illuminant, for which the *colour difference* (3.3) between the two samples to be tested is assessed

3.6
metamerism-index for change in illuminant
M_t
colour difference ΔE^* (3.3) between the two samples under *test illuminant* (3.5) if $\Delta E^* = 0$ is observed under the *reference illuminant* (3.4)

3.7
correction method
algorithm for theoretically eliminating a *colour difference* (3.3) of the pair of samples under the *reference illuminant* (3.4)

4 Symbols and abbreviated terms

For the application of this document, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbol	Identification
X, Y, Z	Standard tristimulus values of a measured object colour
X_n, Y_n, Z_n	Standard tristimulus values of the used illuminant
$\bar{x}$, $\bar{y}$, $\bar{z}$	Colour-matching functions

Table 1 *(continued)*

Symbol	Identification
L^*, a^*, b^*	Basic coordinates of the CIELAB system
ΔL^*, Δa^*, Δb^*	Differences between basic coordinates of the CIELAB system
M_t	Metamerism index for change in illuminant
$\vec{N}$, $\vec{N}_f$, $\vec{N}_r$	Vector of the radiometric function of a sample with associated fundamental colour stimulus (f) and metameric black (r)
λ	Wavelength
S	Relative spectral distribution function of an illuminant
$\vec{W}$	Vector of the standard tristimulus values
w	Integration weights for the calculation of the standard tristimulus values
A	Matrix of the integration weights w for the calculation of the standard tristimulus values
R	Projection matrix
I	Identity matrix
Index spl	Sample
Index std	Standard
Index t	Test illuminant
Index corr	Corrected value
Index f	Fundamental colour stimulus
Index r	Metameric black values (residuals)
Index ref	Reference illuminant
Index T	Transposed matrix

5 Reference illuminant

The standard illuminant D65 is chosen as reference illuminant in accordance with ISO/CIE 11664-2. Other reference illuminants required in special cases shall be particularly specified.

6 Test illuminant

The selection of the test illuminant depends on the application. If the test illuminants are not particularly specified, standard illuminant A in accordance with ISO 11664-2 and/or illuminants of the fluorescent lamp type, such as FL11 in accordance with CIE 015, shall preferably be selected. The test illuminant used shall be indicated as an index to M, e.g. M_A or M_{FL11}.

When calculating the standard tristimulus values X, Y, Z under the selected test illuminants, the basic raster of wavelengths given in ISO 11664-2 or CIE 015 for A and D65, and in CIE 015 for FL11 and FL2 shall be complied with. In cases of missing measuring values of the standard or sample for these wavelengths, these values shall be interpolated and/or extrapolated.

7 CIELAB coordinates L^*, a^*, b^*

The metamerism index M_t is based on the CIELAB coordinates L^*, a^*, b^* of samples 1 and 2 which are to be compared. L^*, a^*, b^* is calculated in accordance with ISO/CIE 11664-4 from the standard tristimulus values X, Y, Z of the sample for the CIE 1964 10° standard observer in accordance with ISO/CIE 11664-1 for the reference illuminant and the selected test illuminant. If calculating L^*, a^*, b^* under the test illuminant, the respective standard tristimulus values X_n, Y_n, Z_n of the entirely matt white surface shall be used (see CIE 015). For the standard illuminants A and D65 or for the illuminant recommendation FL11, the standard tristimulus values X_n, Y_n, Z_n of the entirely matt white surface apply in accordance with Table 2.

Table 2 specifies standard tristimulus values for the frequently used standard illuminants D65 and A as well as illuminant FL11 and both of the standard observers in accordance with CIE 015.

Table 2 — Standard tristimulus values

Standard tristimulus values	2° standard observer			10° standard observer		
	Illuminant					
	D65	A	FL11	D65	A	FL11
X_n	95,04	109,85	100,96	94,81	111,14	103,86
Y_n	100,00	100,00	100,00	100,00	100,00	100,00
Z_n	108,88	35,58	64,35	107,32	35,20	65,61

For fluorescent samples, the illuminant used for measurement shall be adjusted as close as possible to that illuminant for which the standard tristimulus values are to be determined.

NOTE In contrast to non-fluorescent samples, the calculation of metamerism indices for fluorescent samples is erroneous if the samples are measured only under one illuminant.

8 Metamerism index for change in illuminant

8.1 General calculation methods

According to 3.1, metamerism implies no colour difference under reference illuminant. The colour difference under test illuminant is used as metamerism index. This index is descripted in Formula (1):

$$M_t = \sqrt{\left(\Delta L_t^*\right)^2 + \left(\Delta a_t^*\right)^2 + \left(\Delta b_t^*\right)^2} \quad (1)$$

where

t is the test colour;

ΔL_t^* $= L_{spl,corr,t}^* - L_{std,t}^*$;

Δa_t^* $= a_{spl,corr,t}^* - a_{std,t}^*$;

Δb_t^* $= b_{spl,corr,t}^* - b_{std,t}^*$.

In case of a small colour difference already present under reference illuminant conditions, the colour difference at change of illuminant is called paramerism. To eliminate the effect of the difference under reference illuminant a mathematically corrected virtual sample is created having no remaining colour difference under the reference illuminant

Three different correction methods for calculating a metamerism index in the case of paramerism have been proposed in References [6] to.[13] All methods assume that, for practical cases, there might be already a small difference between the colours of the sample and the standard even under the reference illuminant from the very beginning, due to problems of fabrication. In the case of two methods, called the additive and the multiplicative correction, these inherent colour differences often merge with the difference introduced by the change of the illuminant. The third method, the spectral correction, works

