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Date: 2023-~~05-25~~07-11

Analytical colorimetry — Part 4: Metamerism index for pairs of samples for change of illuminant

Analyse colorimétrique — Partie 4: Indice de métamérisme de paires ~~d'échantillon~~d'échantillons pour changement d'illuminant

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Content

~~Foreword~~ Error! Bookmark not defined.

~~Introduction~~ Error! Bookmark not defined.

~~1 Scope~~ Error! Bookmark not defined.

~~2 Normative references~~ Error! Bookmark not defined.

~~3 Terms and definitions~~ Error! Bookmark not defined.

~~4 Symbols and abbreviated terms~~ Error! Bookmark not defined.

~~5 Reference illuminant~~ Error! Bookmark not defined.

~~6 Test illuminant~~ Error! Bookmark not defined.

~~7 CIELAB coordinates *L**, *a**, *b**~~ Error! Bookmark not defined.

~~8 Metamerism index for change in illuminant~~ Error! Bookmark not defined.

~~8.1 General calculation methods~~ Error! Bookmark not defined.

~~8.2 Basic calculation of the metamerism index from colour differences~~ Error! Bookmark not defined.

~~8.3 Correction methods~~ Error! Bookmark not defined.

~~8.3.1 Additive correction~~ Error! Bookmark not defined.

~~8.3.2 Multiplicative correction~~ Error! Bookmark not defined.

~~8.3.3 Spectral correction~~ Error! Bookmark not defined.

~~8.4 Test report~~ Error! Bookmark not defined.

~~Annex A (informative) Calculation examples~~ Error! Bookmark not defined.

~~Bibliography~~ Error! Bookmark not defined.Foreword iv

Introduction v

1 Scope 1

2 Normative references 1

3 Terms and definitions 1

4 Symbols 2

5 Reference illuminant 3

6 Test illuminant 3

7 CIELAB coordinates *L**, *a**, *b** 4

8 Metamerism index for change in illuminant 4
8.1 General calculation methods 4
8.2 Basic calculation of the metamerism index from colour differences 5
8.3 Correction methods 6
8.3.1 Additive correction 6
8.3.2 Multiplicative correction 6
8.3.3 Spectral correction 7
8.4 Test report 11

Annex A (informative) Calculation examples 12

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Bibliography 26

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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 document 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~~www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 256, *Pigments, dyestuff and extenders*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 298, *Pigments and extenders*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

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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;
- Formula (1) has been updated to align with Formulae ~~~~ (2) and (4) to (24);
- the key of Figure A.1 has been updated.

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

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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~~www.iso.org/members.html.

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Introduction

This document distinguishes three kinds of metamerism of pairs of samples:

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. determined 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.

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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 where chromaticity coordinates of a pair of samples under reference conditions do not exactly match, this document gives guidance on which correction measures to take. 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 where two colours appear to be the same under a specific geometry for visual assessment and selected standard observer and standard illuminant pair, but are 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, *Colorimetry~~-~~ — Part~~-~~ 2: CIE standard illuminants*

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

CIE 015, *Colorimetry*

3 Terms and definitions

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

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

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- ISO Online browsing platform: available at ~~https://www.iso.org/obp~~https://www.iso.org/obp
- IEC Electropedia: available at ~~https://www.electropedia.org/~~https://www.electropedia.org/

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

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[SOURCE: CIE S 017:2020, 17-23-006]

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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^*~~

ΔE^*

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

3.4
reference illuminant

illuminant with which other illuminants are compared

[SOURCE: CIE S 017:2022, 17-22-108]

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~~

M_t

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colour difference ~~ΔE^*~~ ΔE^* (3.3) between the two samples under *test illuminant* (3.5) if ~~$\Delta E^* = 0$~~ $\Delta E^* = 0$ is observed under the *reference illuminant* (3.4)

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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

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

Table 1 — Symbols

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Symbol	Identification
X, Y, Z	standard tristimulus values of a measured object colour
~~X_n, Y_n, Z_n~~ X_n, Y_n, Z_n	standard tristimulus values of the used illuminant

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Symbol	Identification
~~$\bar{x}$, $\bar{y}$, $\bar{z}$~~ $\bar{x}$, $\bar{y}$, $\bar{z}$	colour-matching functions
~~L^*, a^*, b^*~~ L^* , a^*, b^*	basic coordinates of the CIELAB system
ΔL^*, Δa^*, Δb^*	differences between basic coordinates of the CIELAB system
~~M_t~~ M_t	metamerism index for change in illuminant
~~$\vec{N}, \vec{N}_\mathrm{f}, \vec{N}_\mathrm{r}$~~ $\vec{N}, \vec{N}_\mathrm{f}, \vec{N}_\mathrm{r}$	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
~~$\vec{W}$~~ $\vec{W}$	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	~~marks~~ colour under test illuminant
Index corr	corrected value
Index multipl	multiplicative correction
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 shall be chosen as reference illuminant in accordance with ISO/CIE 11664-2. Other reference illuminants required in special cases shall be 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/CIE 11664-2 and/or illuminants of the fluorescent lamp type, such as FL11 in accordance with CIE 015, shall be selected. The test illuminant used shall be indicated as an index to M, e.g. ~~M_A~~ M_A or ~~M_FL11~~ M_FL11.

When calculating the standard tristimulus values X, Y, Z under the selected test illuminants, the basic raster of wavelengths shall comply with those given in ISO/CIE 11664-2 or CIE 015 for A and D65, and in

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CIE 015 for FL11 and FL2. 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~~ M_t, is based on the CIELAB coordinates ~~L^*~~ L^*, ~~a^*~~ a^*, ~~b^*~~ b^* of samples~~ ~~1 and 2 which are compared. ~~L^*~~ L^*, ~~a^*~~ a^*, ~~b^*~~ b^* shall be calculated in accordance with ISO/CIE 11664-4 from the standard tristimulus values *X, Y, Z*. These values are derived from 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^*~~ L^*, ~~a^*~~ a^*, ~~b^*~~ b^* under the test illuminant, the respective standard tristimulus values ~~X_n~~ X_n, ~~Y_n~~ Y_n, ~~Z_n~~ Z_n of the entirely matt white surface shall be used ~~(see~~in accordance with 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~~ 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 according to 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 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

Metamerism implies no colour difference under the reference illuminant. The colour difference under the test illuminant is used as metamerism index. This index is described in Formula (1):

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

where

t ~~marks~~is the colour under test illuminant;

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

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