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TECHNICAL
SPECIFICATION

Household electric appliances – Specification of the properties of a digital system for measuring the performance

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HOUSEHOLD ELECTRIC APPLIANCES –

**Specification of the properties of a digital system
for measuring the performance**

FOREWORD

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IEC 63350 has been prepared by subcommittee SC 59K: Performance of household and similar electrical cooking appliances, of IEC technical committee TC 59: Performance of household and similar electrical appliances. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
59K/350/DTS	59K/356/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

In this document, the following print types are used:

- terms defined in Clause 3: **bold type**.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at https://www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at https://www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

IEC subcommittee 59K has agreed to make a collection of existing and future requirements on a **digital system** used in testing the performance of appliances under the scope of SC 59K, cooking appliances.

This document bundles the generic requirements given in IEC 60350-1 and IEC 60350-2 that are updated, aligned, and supplemented by further requirements. The reference colour system is changed from a proprietary colour system to the standardized and widely used CIELAB-based reference colour system.

The intention with this publication is to ensure that using a **digital system**, which complies with the stated requirements and described methods, leads to reproducible results.

Currently, this document focuses on test methods described in IEC 60350-1 and IEC 60350-2 but further applications based on visually detectable performance criteria might be supplemented.

HOUSEHOLD ELECTRIC APPLIANCES –

**Specification of the properties of a digital system
for measuring the performance**

1   Scope

This document specifies generic requirements for creating a **digital system** that is used for measuring the characteristics of visually detectable performance, such as browning intensity and lightness.

It defines the metrological requirements of this **digital system** and demonstrates the procedures for compliance. The **digital system** contains the measuring instrument, the software, and the reference materials necessary to realize the measurement process.

References to this document can be made by a customer when specifying the **digital system** and by the suppliers when specifying products offered.

Interested parties can agree to use this document as an input for satisfying measurement management system requirements in any activities.

NOTE 1   The principles of ISO 10012 are followed to ensure the capability of the systems.

NOTE 2   Possible suppliers for the recommended **digital system** can be found in the supplementary file located at: https://www.iec.ch/sc59k/supportingdocuments

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 15, *Colorimetry*

ISO 12647-7, *Graphic technology – Process control for the production of half-tone colour separations, proof and production prints – Part 7: Proofing processes working directly from digital data*

ISO 15076-1, *Image technology colour management – Architecture, profile format and data structure – Part 1: Based on ICC.1:2010*

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:

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

3.1
digital system
system that is used for measuring the characteristics of visually detectable performance

3.2
assessment area
area of the **digital system** within which the requirements stated in this document shall be met and the **items under test** are positioned

3.3
shade chart
sample representing the reference values for the colour and lightness recognition and used for calibration of the **digital system**

3.4
items under test
IUT
objects positioned in the **assessment area** for evaluation

EXAMPLE 1   Shortbread, small cakes, broccoli, white bread, in accordance with IEC 60350-1.

EXAMPLE 2   Floured disc, in accordance with IEC 60350-2.

3.5
terms and definitions of international lighting vocabulary
L*   CIELAB lightness

a*, b*   CIELAB a*, b* coordinates

C^*_{ab} CIELAB chroma

h_{ab} CIELAB hue angle

ΔL^* CIELAB lightness difference

ΔE^*_{ab} CIELAB colour difference

ΔE_{00} CIEDE2000 colour difference

4   Test setup

4.1   Illumination

The measurement is taken under an illumination similar to the CIE Standard Illuminate used for the definition of the **shade charts** (see Clause 5).

The maximum calculated deviation of rendering the **shade charts** under the used light shall be $\Delta L^* \leq 1$ for a measurement system for lightness recognition, and $\Delta E_{00} \leq 5$ for a measurement system for colour recognition.

To calculate the deviation of the colour rendering, the 10° tristimulus values of the reference colours shall be calculated with the spectral distribution of the reference colours defined in the corresponding performance test for the relative spectral power distribution of CIE D65 and the relative spectral power distribution of the test setup illumination. The calculation shall be performed from 400 nm to 700 nm with a step of increment no more than 10 nm.

Test setup illumination spectral power distribution measurement is made on the central axis of the beam, and with the sensing surface normal to this direction. The spectroradiometer sensing surface is placed at a distance which ensures sufficient light for a measurement to be taken

while eliminating any stray light. The light shall stabilise before measurements are made (e.g. stable temperature).

Spectral distribution of the reference colours for the calculation shall be acquired with a diffuse eight-degree geometry, specular component included measurement mode (di:8°) spectrometer in accordance with CIE 15.

NOTE 1   Necessary information on calculating the tristimulus, spectral distribution of D65, L*, a*, b* and ΔE_{00} can be found in the ISO 11664 series.

An Excel[1] evaluation program, which corresponds to the described method, is available as an example for the automatic calculation of the deviation of the colour rendering for measured light spectra from at least 400 nm to 700 nm with a step of increment 10 nm; see Annex D. This document includes the light spectra of the proposed reference colours of this document and the light spectra of the CRI calculation colours (CIE 15).

NOTE 2   The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments.

4.2   Measurement environment

During the measurements, no movable items other than the **IUT** shall be near or inside the **assessment area**. The **assessment area** shall be kept as constant as possible since every item can alter the illumination by absorption or reflection.

5   Determination of shade charts

5.1   Principals of shade creation

Shade charts represent the reference values for the colour and lightness recognition. Since the recognition is based on classes, the **shade chart** shall represent the centre point of each class.

For recognition based on 1-dimensional classes (e.g. L*), the values of the defined reference colour shall be in the centre of the boundaries of each class. This is achieved by mathematically creating the reference colours along a line in the 3-dimensional CIELAB colour space.

For recognition based on multiple dimensions within the CIELAB colour space, the defined reference colours shall be located with equal distances within a space defined by at least 3 coordinates. The equal distancing between the defined colours shall be based on at least two values of the CIELAB system (ISO/CIE 11664-4). This results in a colour gradient with a linear step size in at least 2 dimensions.

Defined colours shall be printed in accordance with the proof process described in ISO 12647-7 on matt proofing paper simulating PS5 (print substrate 5 in accordance with ISO 12647-2) as spot colours. The printed colour samples shall be calibrated with a diffuse eight-degree geometry, specular component included measurement mode (di:8°) spectrometer CIE 15 and shall be in a range of $\Delta L^* \leq 1,5$ if used as reference colours for the lightness recognition and $\Delta E_{00} \leq 5$ if used as reference colours for the colour recognition.

Proof process defined in ISO 12647-7 is referring to spectral measurement defined in ISO 13655 which is (45°:0°) or (0°:45°) geometry and D50 reference illumination. For proper colour communication, conversion of the colour information to a reference colour space

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[1]   Excel is the trade name of a product supplied by Microsoft Corporation. This information is given for the convenience of users of this standard and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

described in ISO 15076-1 is necessary. Converted values and the applied conversion models for the exemplary **shade charts** shown in this document can be found in Annex B and Annex C.

Created **shade charts** shall be within the limits of the sRGB colour space.

NOTE 1   Requirements for colour measuring instruments in accordance with CIE 15 for (di:8°) and (45°:0°) or (0°:45°) geometry can be found in Annex A.

NOTE 2   Necessary information on transforming the CIEXYZ colour space to sRGB can be found in IEC 61966-2-1 and transforming the CIELAB colour space to the CIEXYZ colour space can be found in ISO 11664-4.

5.2   Brown shade charts

Brown **shade charts** are used to verify the lightness recognition of the digital measurement system. The relevant value for the brown **shade charts** is L^*.

The ΔL^* of each defined colour step shall be equal. To achieve a linear colour gradient between the defined colours the $\begin{pmatrix} L^* \\ a^* \\ b^* \end{pmatrix}$ coordinates shall lie on a line that connects at least 2 (maximum 4) reference colours within the 3-dimensional CIELAB colour space. This results in a uniform Euclidean distance (ΔE^*_{ab}) of the points that lie on the same line.

As an example, the calculated values of 14 reference colours located on 2 lines based on 3 L^*, a^* and b^* coordinates are shown in Table 1.

In the example, the 3 defined $\begin{pmatrix} L^* \\ a^* \\ b^* \end{pmatrix}$ coordinates are $\begin{pmatrix} 27,8 \\ 6,4 \\ 4,4 \end{pmatrix}$, $\begin{pmatrix} 60,7 \\ 16,4 \\ 33,0 \end{pmatrix}$, $\begin{pmatrix} 88,9 \\ 2,9 \\ 27,0 \end{pmatrix}$.

Table 1 – Brown shade charts with class limits

Shade No.	L*	a*	b*	∆L*	Lower L* limit for shade class	Upper L* limit for shade class	∆E*ab	R	G	B
17	27,8	6,4	4,4		0	30,15		78	62	59
16	32,5	7,9	8,5	4,7	30,15	34,85	6,4	93	72	63
15	37,2	9,3	12,6	4,7	34,85	39,55	6,4	109	82	67
14	41,9	10,7	16,7	4,7	39,55	44,25	6,4	125	92	71
13	46,6	12,1	20,8	4,7	44,25	48,95	6,4	141	102	76
12	51,3	13,6	24,8	4,7	48,95	53,65	6,4	157	113	80
11	56,0	15,0	28,9	4,7	53,65	58,35	6,4	174	124	84
10	60,7	16,4	33,0	4,7	58,35	63,05	6,4	190	135	88
9	65,4	14,1	32,0	4,7	63,05	67,75	5,3	200	148	101
8	70,1	11,9	31,0	4,7	67,75	72,45	5,3	210	162	115
7	74,8	9,6	30,0	4,7	72,45	77,15	5,3	219	177	128
6	79,5	7,4	29,0	4,7	77,15	81,85	5,3	229	191	142
5	84,2	5,1	28,0	4,7	81,85	86,55	5,3	238	205	156
4	88,9	2,9	27,0	4,7	86,55	100,00	5,3	248	220	171

The proof process defined in ISO 12647-7 is referring to the spectral measurement defined in ISO 13655, which is (45°:0°) or (0°:45°) geometry and D50 reference illumination. For proper colour communication, conversion of the colour information to a reference colour space described in ISO 15076-1 is necessary. Converted values and the applied conversion models for the **shade charts** shown in Table 1 can be found in Annex B.

5.3 Green shade charts

Green **shade charts** are used to verify the colour recognition of the digital measurement system. The relevant value for the green **shade charts** is CIELAB hue angle (h_{ab}) which is the arcus tangent of b* and a* axis in the CIELAB colour space in degrees.

The CIELAB hue angle difference of each defined colour step shall be equal. For each defined CIELAB hue angle step, a linear colour gradient between the defined colours the HLC (h_{ab}, L* and C^*_{ab}) coordinates shall lie on a line that connects at least 2 reference points.

Mathematically created colours within a radius of $\Delta E^*_{ab} \leq 2,5$ towards each other are not considered for the printing process, since these differences cannot be adequately reproduced by the proof printing process.

As an example, the calculated values of 43 reference colours located on 7 lines based on 3 HLC coordinates are shown in Table 2.

Fix points of the individual colour gradients are set by h_{ab}, L^* and C^*_{ab}

The example colour gradient coordinates in $\begin{pmatrix} h_{ab} \\ L^* \\ C^*_{ab} \end{pmatrix}$, are from $\begin{pmatrix} h_{ab} \\ 25 \\ 10 \end{pmatrix}$, $\begin{pmatrix} h_{ab} \\ 60 \\ 60 \end{pmatrix}$ where the defined

CIELAB hue angle steps for the green shades are from $h_{ab} = 88°$ to $h_{ab} = 130°$ with a step size of 7°, giving a total of 7 individual colour gradients.

The colours on the colour gradients can be extracted by defining either L^* or C^*_{ab} steps. As an example, colours are extracted from the colour gradients with an L^* step size of 5 are calculated and shown in Table 2.

The step size of 5 results in 49 colours, of which 6 have to be disregarded since the distance between the colours is $\Delta E^*_{ab} \le 2,5$.

The proof process defined in ISO 12647-7 is referring to spectral measurement defined in ISO 13655, which is (45°:0°) or (0°:45°) geometry and D50 reference illumination. For proper colour communication, conversion of the colour information to a reference colour space described in ISO 15076-1 is necessary. Converted values and the applied conversion models for the exemplary **shade charts** shown in Table 2 can be found in Annex C.

Table 2 – Green shade charts

Shade	h_{ab}	L^*	a^*	b^*	C^*_{ab}	R	G	B
a1	130°	55,0	−34,0	40,5	52,9	91	146	56
a2	130°	50,0	−29,4	35,0	45,7	86	131	55
a3	130°	45,0	−24,8	29,6	38,6	80	116	54
a4	130°	40,0	−20,2	24,1	31,4	74	102	53
a5	130°	35,0	−15,6	18,6	24,3	67	89	51
a6	130°	30,0	−11,0	13,1	17,2	61	75	49
a7	130°	25,0	−6,4	7,7	10,0	54	62	47
b1	123°	55,0	−28,8	44,3	52,9	104	143	48
b2	123°	50,0	−24,9	38,3	45,7	96	129	49
b3	123°	45,0	−21,0	32,4	38,6	88	115	49
b4	123°	40,0	−17,1	26,4	31,4	80	101	49
b5	123°	35,0	−13,2	20,4	24,3	72	87	48
c1	116°	55,0	−23,2	47,5	52,9	116	141	41
c2	116°	50,0	−20,0	41,1	45,7	107	127	44
c3	116°	45,0	−16,9	34,7	38,6	97	113	45
c4	116°	40,0	−13,8	28,3	31,4	87	100	46
c5	116°	35,0	−10,7	21,8	24,3	77	86	46
c6	116°	30,0	−7,5	15,4	17,2	68	73	46
c7	116°	25,0	−4,4	9,0	10,0	58	61	45
d1	109°	55,0	−17,2	50,0	52,9	128	138	36
d2	109°	50,0	−14,9	43,2	45,7	116	125	39
d3	109°	45,0	−12,6	36,5	38,6	105	111	42
d4	109°	40,0	−10,2	29,7	31,4	93	98	43

Shade	h_{ab}	L*	a*	b*	C^*_{ab}	R	G	B
d5	109°	35,0	−7,9	23,0	24,3	82	85	44
e1	102°	55,0	−11,0	51,7	52,9	138	135	32
e2	102°	50,0	−9,5	44,7	45,7	125	122	36
e3	102°	45,0	−8,0	37,7	38,6	112	109	40
e4	102°	40,0	−6,5	30,8	31,4	100	96	42
e5	102°	35,0	−5,1	23,8	24,3	87	84	43
e6	102°	30,0	−3,6	16,8	17,2	74	72	44
e7	102°	25,0	−2,1	9,8	10,0	62	60	44
f1	95°	55,0	−4,6	52,7	52,9	148	132	30
f2	95°	50,0	−4,0	45,6	45,7	134	119	35
f3	95°	45,0	−3,4	38,4	38,6	120	107	39
f4	95°	40,0	−2,7	31,3	31,4	105	94	41
f5	95°	35,0	−2,1	24,2	24,3	91	82	43
g1	88°	55,0	1,8	52,8	52,9	158	128	30
g2	88°	50,0	1,6	45,7	45,7	142	116	35
g3	88°	45,0	1,3	38,6	38,6	127	104	39
g4	88°	40,0	1,1	31,4	31,4	111	92	41
g5	88°	35,0	0,8	24,3	24,3	96	81	43
g6	88°	30,0	0,6	17,1	17,2	81	70	44
g7	88°	25,0	0,3	10,0	10,0	65	59	44

6 Measurements

6.1 Verification of evenness

The lightness value L* of a uniform-coloured **shade chart** shall be measured over the entire surface to be analysed, for example, the size of the baking sheet or one circular object with a diameter of (68 ± 2) mm. The **shade chart** shall be coloured in shade number 10 (in accordance with ISO 12647-7), which is defined in Table 1.

The mean value of the lightness value L* over the entire surface is determined. More than 90 % of the entire surface may deviate from the mean value by up to ± 2,2 %. Less than 10 % of the entire surface may deviate by up to ± 3,5 %.

The entire surface is divided into 1 cm^2 sections. None of the mean values of the 1 cm^2 sections shall deviate by more than ± 2,2 % of the mean value of the entire surface.

NOTE 1 Shade number 10 is used to check the quality of the illumination as it is the most desired shade.

NOTE 2 Each **IUT** can be measured separately.

NOTE 3 Squared colour samples with a length of (60 ± 2) mm and width of (60 ± 2) mm could be used as well.

NOTE 4 The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments

6.2 Lightness recognition (L* values)

6.2.1 Description of the test samples

Flat circular printed colour samples in accordance with ISO 12647-7 with a diameter of (68 ± 2) mm in every shade number defined in Table 1 are used. They are placed at a height of the top side of the **IUT** (± 50 mm), in order to ensure that the light conditions and the focal length which will be used during the assessment are comparable.

Squared colour samples with a length of (60 ± 2) mm and width of (60 ± 2) mm could be used alternatively.

NOTE   The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments

6.2.2 Procedure

The shade numbers defined in Table 1 shall be confirmed in all positions of the **assessment area**. This is ensured using the following check.

The lightness value L* of the calibrated colour samples shall be measured in several positions within the **assessment area**. The positions are defined as follows.

The width and the depth of the **assessment area** are measured in mm. The minimal number of positions along its sides is calculated by dividing the width and depth by 140 and then adding 0,5.

The numbers are rounded up to give a whole number of positions. Multiply the positions from the depth and the width to give the total number for the whole **assessment area**.

The first and last positions per row and column shall touch two of the borders of the **assessment area**. The remaining positions are distributed evenly on the **assessment area.**

Example:

A width of 470 mm divided by 140 mm equals 3,4, adding 0,5 equals 3,9. This gives 4 positions per row.

A depth of 370 mm divided by 140 mm equals 2,6, adding 0,5 equals 3,1. This gives 4 positions per column.

Therefore, the total number of positions in the **assessment area** is 16.

NOTE   Annex E shows exemplary sketches for the correct positioning.

6.2.3 Evaluation (requirements and tolerances)

The CIE lightness value L* of each of the calibrated colour samples shall be measured with the deviations of ± 2,0 to the calibrated values of the calibrated measured colour sample of the same shade.

6.3 Colour recognition (L*, a*, b* values)

6.3.1 Description of the test samples

Flat circular printed colour samples (in accordance with ISO 12647-7) with a diameter of (68 ± 2) mm in every shade number defined in Table 2 are used. They are placed at a height of the top site of the **IUT** (± 50 mm), to ensure that the light conditions and the focal length, which will be used during the assessment, are comparable.

Squared colour samples with a length of (60 ± 2) mm and width of (60 ± 2) mm could be used alternatively.

NOTE   The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments

6.3.2   Procedure

The shade numbers defined in 5.3 shall be confirmed in all positions of the surface to be assessed. This is ensured using the following check.

The L*, a* and b* of the calibrated colour samples shall be measured in several positions within the **assessment area**. The same positions are applied as defined in 6.2.2.

6.3.3   Evaluation (requirements and tolerances)

The L*, a*, and b* of the calibrated colour samples shall be measured with an average deviation of $\Delta E_{00} \leq 2,5$ and a maximum deviation of $\Delta E_{00} \leq 5$ to the calibrated values of the calibrated measured colour sample of the same shade.

6.4   Verification of the measurement area

6.4.1   General

This test shows the ability to ensure that only the surface of the **IUT**, e.g. the surface of toast slices or the bottom surface of small cakes, is taken into account and not the side areas or shadows.

6.4.2   Description of the test samples

Squared colour samples with a length of (60 ± 2) mm, a width of (60 ± 2) mm and a height of (10 ± 2) mm coloured in every shade number defined in Table 1 are used.

NOTE   The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments

6.4.3   Procedure

The top surface area of the defined squared colour samples shall be confirmed in all positions of the surface to be assessed. This is ensured using the following check.

The top surface area shall be measured in all positions of the surface to be assessed. The same positions are applied as defined in 6.2.2.

6.4.4   Evaluation (requirements and tolerances)

The evaluated surface of the squared colour samples shall be indicated and shall only include the top surface of the squared colour samples. It shall be within the range of 100 % to 95 % of the top surface area calculated by the dimensions of the squared colour samples.

6.5   Verification of the resolution

To ensure a sufficient resolution, use a test chart showing at least three pairs of black and white lines with a thickness of 1 mm each. The black lines have a lightness value L* of maximum 30, the white lines have a lightness value L* of at least 90. The lightness value of each single line is measured and stated, once in the horizontal direction and once under an angle of 45°. The resolution is sufficient if the measured lightness value L* of each black line does not exceed 45 and the measured lightness value L* of each white line exceeds 85.

Test chart shall be printed in accordance with ISO 12647-7 on matt proofing paper simulating PS5 (print substrate 5 in accordance with ISO 12647-2).

NOTE   The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments

6.6 Verification of rectilinear projection

To ensure sufficient rectilinear projection over the entire surface to be analysed, the number of evaluated pixels of the defined shapes from 6.2 or 6.3 of the same shade shall be within ±2 % of the mean number of evaluated pixels of all defined measurement positions (defined in 6.2.2) of one shade.

6.7 Verification of the 3-dimensional shapes

A cone-shaped colour sample (shape as defined in Figure 1) printed in shade number 10 (see 5.2) in accordance with ISO 12647-7 on matt proofing paper simulating PS5 (print substrate 5 in accordance with ISO 12647-2) and cut to the indicated shape to form a cone is used. It is placed at a height of the **IUT** (± 20 mm) in the corners of the **assessment area** (where the outermost objects to be evaluated are positioned during the measurement), as well as in the centre. The lightness value is measured in 13 sections as defined in Figure 2. The mean value of the lightness values of all sections in each position is calculated. The extreme values may deviate by ±4 % of the mean value.

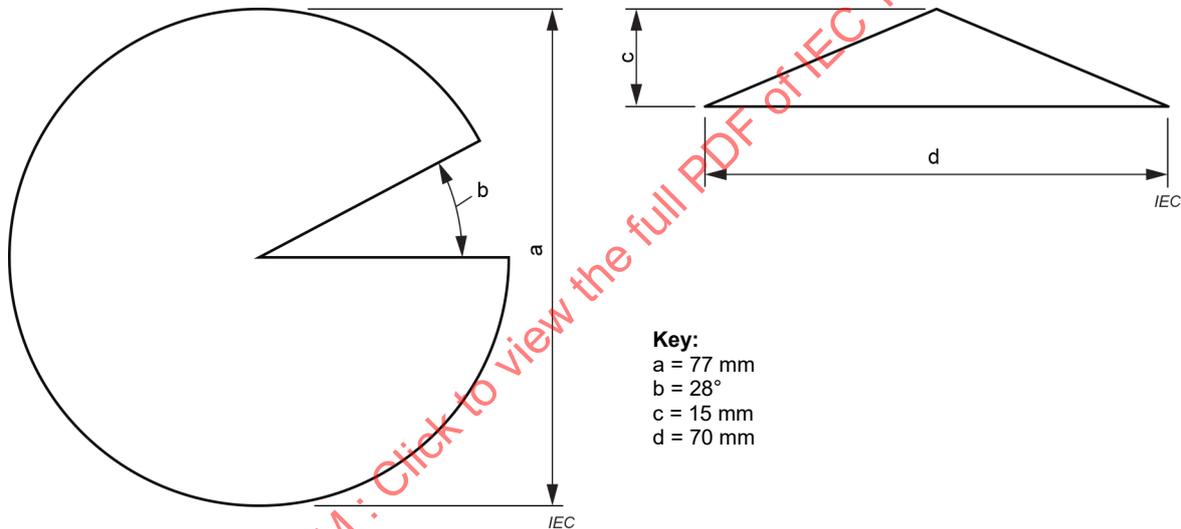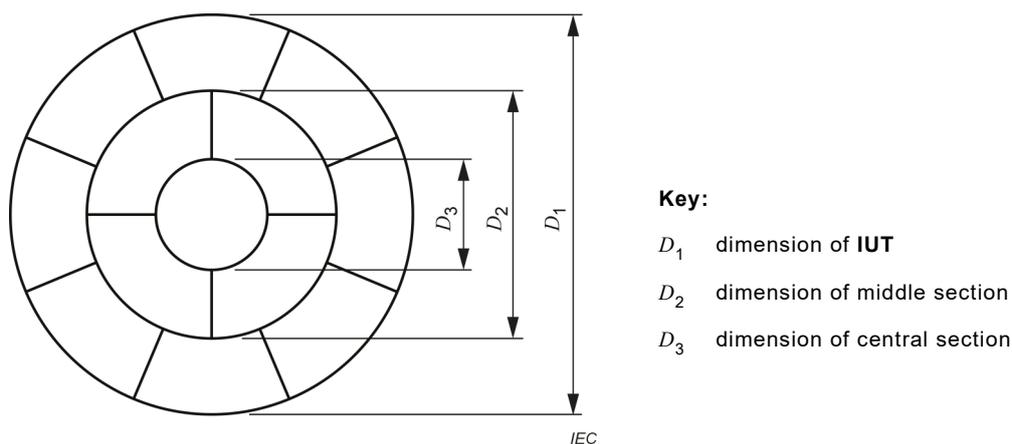NOTE   The supplementary file for the described method is located at:
https://www.iec.ch/sc59k/supportingdocuments

Key:
a = 77 mm
b = 28°
c = 15 mm
d = 70 mm

Figure 1 – Cone shape of colour sample

Key:

D_1 dimension of **IUT**

D_2 dimension of middle section

D_3 dimension of central section

$$D_2 = \frac{\sqrt{5}}{\sqrt{13}} \times D_1 \approx 0,6 \times D_1 \qquad D_3 = \frac{1}{\sqrt{13}} \times D_1 \approx 0,3 \times D_1$$

Figure 2 – 13 sections of the colour sample

7 Data to be recorded (raw data)

7.1 Purpose

These data to be recorded are requested to ensure that the **digital system** complies with the stated specifications of this document. For specific applications with this **digital system**, the data to be recorded should be defined within the product-specific document.

7.2 LAB

The CIELAB colour space values L*, a*, b* and their standard deviation within the evaluated segment shall be recorded for each evaluated pixel.

7.3 HLC

The CIELAB hue angle values (h_{ab}) in degrees, CIELAB chroma (C^*_{ab}) and their standard deviation within the evaluated segment shall be recorded.

7.4 ΔE_{00} for the test sample

The ΔE_{00} in relation to the specified reference colour of the corresponding verification test shall be recorded.

7.5 Dimensions (in mm)

Dimensions of evaluated segments shall be stated in mm^2.

7.6 Specified measurement areas

To be able to review the correct selection of the **assessment area** that is evaluated, the image that is used for the evaluation shall be provided unaltered and with the indicated specific measurement area.

8 Consideration of tolerances

8.1 General

The crucial measurement values of the described **digital systems** are summarized in colour information based on the CIELAB colour space and length information based on the corresponding SI unit.

8.2 Calculation of differences in colour and its components

Measurement uncertainties of imaging systems are described in ΔE, which is in the case of ΔE^*_{ab}, the Euclidian distance of 2 colours in the 3-dimensional CIELAB colour space or ΔE_{00}, which is a further refinement of the ΔE^*_{ab} to achieve better perceptual uniformity.

$$\Delta E^*_{ab} = \sqrt{\left(L^*_2 - L^*_1\right)^2 + \left(b^*_2 - b^*_1\right)^2 + \left(a^*_2 - a^*_1\right)^2} \qquad (1)$$

where

ΔE^*_{ab} is the Euclidian distance between 2 colours in the 3-dimensional CIELAB colour space;

L^*_1 is the lightness of colour one;

L^*_2 is the lightness of colour two;

a^*_1 is the colour value of colour one on the a* axis of the CIELAB colour space;

a^*_2 is the colour value of colour two on the a* axis of the CIELAB colour space;

b^*_1 is the colour value of colour one on the b* axis of the CIELAB colour space;

b^*_2 is the colour value of colour two on the b* axis of the CIELAB colour space.

The maximum possible difference of CIELAB chroma based on a given ΔE^*_{ab} shall be calculated by assuming a constant L^*.

To express the maximum possible difference of the CIELAB hue angle, the outermost possible intersection of the hue angle (line) with a given ΔE^*_{ab} with constant L* (circle) shall be calculated.

As an example, the maximum possible CIELAB hue angle deviations inside a given ΔE^*_{ab} and CIELAB chroma are shown in Table 3.

Table 3 – Maximum CIELAB hue angle distance inside different ΔE*ab ranges

C^*_{ab}	Max CIELAB hue angle distance at ΔE^*_{ab}					
	0,5	1,0	1,5	2,0	2,5	3,0
5	5,7	11,3	16,7	21,8	26,5	30,9
10	2,8	5,7	8,5	11,3	14,0	16,7
15	1,9	3,8	5,7	7,5	9,5	11,5
20	1,4	2,8	4,3	5,7	7,1	8,6
25	1,1	2,2	3,4	4,5	5,7	6,8
30	0,9	1,9	2,8	3,8	4,7	5,7
35	0,8	1,6	2,4	3,2	4,0	4,8
40	0,7	1,4	2,1	2,8	3,5	4,3
45	0,6	1,2	1,9	2,5	3,1	3,8
50	0,5	1,1	1,7	2,2	2,8	3,4
55	0,4	1,1	1,5	2,0	2,6	3,1
60	0,4	0,9	1,4	1,9	2,5	2,8

NOTE ΔE_{00} can be calculated by calculation method of ISO/CIE 11664-6.

8.3   Distance information

The minimum achievable distance resolution is 1 mm based on the test described in 6.5. Differences due to optical distortion over the entire surface to be analysed can be ±2 % based on the test described in 6.6.

Annex A
(normative)

Colour-measuring instrument

Many cases of measurement disagreement can be traced to the comparison of data measured under different conditions. The instruments and their settings shall comply with the information given below.

The colour-measuring instruments (see Figure A.1) referred to as (di:8°) for calibrating the reference colours conform to CIE 15 and shall have the following specification:

- measuring geometry: diffuse, 8° vertical deviation
- measuring aperture: diameter (12 ± 4) mm
- calibration standard: white, pressed barium sulphate (BaSO4), polytetrafluorethylene (PTFE) or equivalent
- standard illuminant: D 65
- standard observer: 10°
- wavelengths range: 400 nm ≤ λ ≤ 700 nm
- wavelength interval: ≤ 10 nm
- evaluation: CIEXYZ (CIE 1931) / CIELAB (CIE 1976)

Key

1 detector

2 illumination source

3 shutter

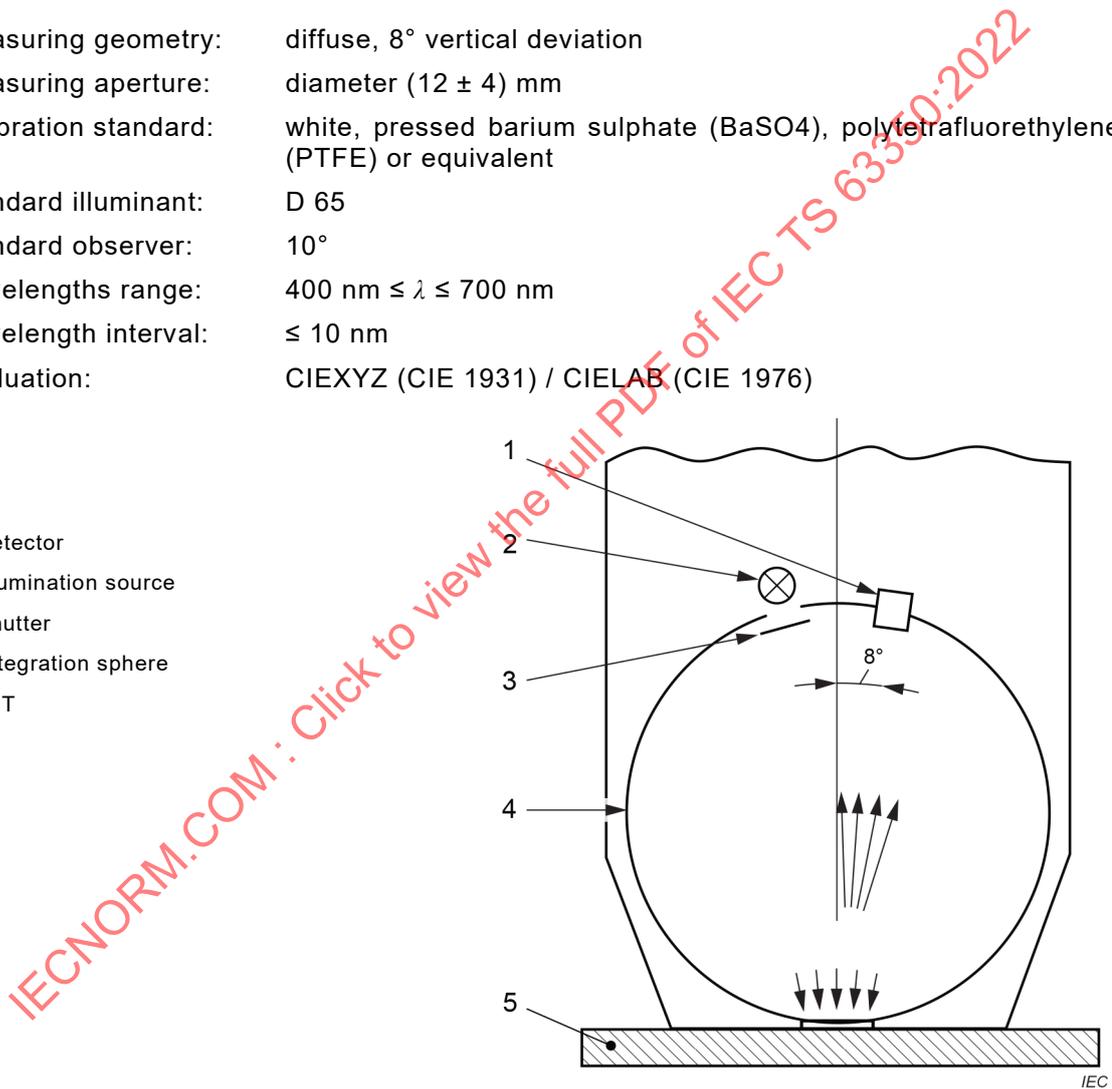4 integration sphere

5 IUT

Figure A.1 – Colour measuring instrument di:8°

The colour-measuring instruments (see Figure A.2) referred to as 45°:0° or 0°:45° conform to CIE 15 and ISO 13655 for the proof printing process in accordance with ISO 12647-7 and shall have the following specification:

– measuring geometry: unidirectional, 45°:0° or 0°:45° vertical deviation
– measurement condition: M1
– calibration standard: white, pressed barium sulphate (BaSO4), polytetrafluorethylene (PTFE) or equivalent
– standard illuminant: D 50
– standard observer: 2°
– wavelengths range: 400 nm ≤ λ ≤ 700 nm
– wavelength interval: ≤ 10 nm
– evaluation: CIEXYZ (CIE 1931) / CIELAB (CIE 1976)
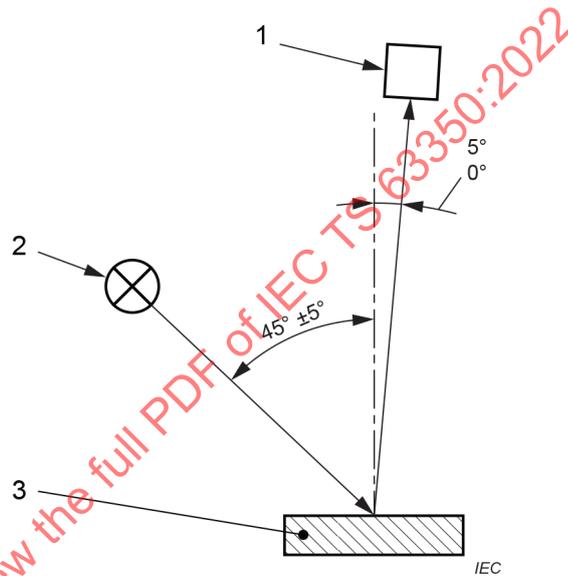
Key

1 detector

2 illumination source

3 IUT

Figure A.2 – Colour measuring instrument 45°:0°

Annex B
(informative)

Brown shade charts

Table B.1 shows example L*a*b* values for the **shade charts** developed in D65 (di:8°) and converted into D50 M1 (0°:45°) for a matt proofing substrate (ISO 12647-7).

Table B.1 – CIELAB Values for the brown shade charts

Shade No.	D65 (di:8°)			D50 M1 (0°:45°)		
	L*	a*	b*	L*	a*	b*
17	27,8	6,4	4,4	27,5	7,9	4,8
16	32,5	7,9	8,5	32,4	9,7	9,0
15	37,2	9,3	12,6	37,4	11,4	13,2
14	41,9	10,7	16,7	42,3	13,1	17,3
13	46,6	12,1	20,8	47,3	14,8	21,4
12	51,3	13,6	24,8	52,2	16,6	25,5
11	56,0	15,0	28,9	57,1	18,2	29,6
10	60,7	16,4	33,0	62,1	19,9	33,7
9	65,4	14,1	32,0	66,8	17,2	32,5
8	70,1	11,9	31,0	71,5	14,7	31,3
7	74,8	9,6	30,0	76,2	12,0	30,0
6	79,5	7,4	29,0	80,9	9,4	28,8
5	84,2	5,1	28,0	85,6	6,8	27,6
4	88,9	2,9	27,0	90,3	4,2	26,3

The proof process defined in ISO 12647-7 refers to spectral measurement defined in ISO 13655, which is (45°:0°) or (0°:45°) geometry and D50 reference illumination. For proper colour communication, conversion of the colour information to a reference colour space described in ISO 15076-1 shall be carried out.

The conversion model used for example shades in Table B.1 is shown here:

$$L^*_{45°:0°} = 1,0256*L^*_{di:8°} + 0,0375*a^*_{di:8°} + 0,0046*b^*_{di:8°} - 1,3972$$

$$a^*_{45°:0°} = -0,0457*L^*_{di:8°} + 1,0349*a^*_{di:8°} - 0,0573*b^*_{di:8°} + 2,2405 \qquad \text{(B.1)}$$

$$b^*_{45°:0°} = -0,0121*L^*_{di:8°} + 0,0709*a^*_{di:8°} + 0,9859*b^*_{di:8°} + 0,2033$$

where

$L^*_{45°:0°}$ is the lightness of the colour in D50 45°:0° measurement condition;

$a^*_{45°:0°}$ is the colour value of colour two on the a* axis of the CIELAB colour space in D50 45°:0° measurement condition;

$b^*_{45°:0°}$ is the colour value of colour two on the b* axis of the CIELAB colour space in D50 45°:0° measurement condition;

$L^*_{di:8°}$ is the lightness of the colour in D50 di:8° measurement condition;

$a^*_{di:8°}$ is the colour value of colour two on the a* axis of the CIELAB colour space in D50 di:8° measurement condition;

$b^*_{di:8°}$ is the colour value of colour two on the b* axis of the CIELAB colour space in D50 di:8° measurement condition;

NOTE 1   Conversion of standard illumination (e.g. D65 to D50) can be achieved by chromatic adaption transformation.

NOTE 2   Spectra from 400 nm to 700 nm of the defined colours with a step of increment 10 nm can be found in the file referenced by Annex D.