INTERNATIONAL STANDARD

IEC 61966-9

Second edition
2003-11

Multimedia systems and equipment –
Colour measurement and management –

Part 9:
Digital cameras

Systèmes et appareils multimédia –
Mesure et gestion de la couleur –

Partie 9:
Appareils numériques de prise de vue

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

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MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 9: Digital cameras

FOREWORD

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International Standard IEC 61966-9 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

This second edition cancels and replaces the first edition published in 2000. This edition includes the following significant technical changes from the previous edition.

a) In the light of issuing IEC 61966-2-2, the relevant reference IEC 61966-2-1 in Annex C has been replaced by IEC 61966-2-2 together with sRGB by scRGB.

b) The previous Annex C has been replaced by the new Annex C where the previous Figure C.1 has been deleted.

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The text of this standard was submitted to the national committees for voting under the Fast Track Procedure as the following documents:

CDV	Report on voting
100/666/CDV	100/722/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IEC 61966 consists of the following parts, under the general title *Multimedia systems and equipment – Colour measurement and management:*

- Part 1: General
- Part 2-0: Colour management
- Part 2-1: Colour management – Default RGB colour space – sRGB
- Part 2-2: Colour management – Extended RGB colour space – scRGB
- Part 3: Equipment using cathode ray tubes
- Part 4: Equipment using liquid crystal display panels
- Part 5: Equipment using plasma display panels
- Part 6: Front projection displays
- Part 7-1: Colour printers – Reflective prints – RGB inputs
- Part 7-2: Colour printers – Reflective prints – CMYK inputs
- Part 8: Multimedia colour scanners
- Part 9: Digital cameras
- Part 10: Quality assessment – Colour image in network systems
- Part 11: Quality assessment – Impaired video in network systems

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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

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MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 9: Digital cameras

1 Scope

This part of IEC 61966 is applicable to the assessment of colour reproduction of digital cameras used in open computer systems and similar applications.

A series of methods and parameters for colour measurements and management for use in multimedia systems and equipment is applicable to the assessment of colour reproduction.

This standard deals with digital cameras to capture colour still images and moving images for use in multimedia applications.

The methods of measurement standardized in this standard are designed to make possible the objective performance assessment and characterization of the colour reproduction of digital cameras which can capture colour still and moving images, and output colour information corresponding to red – green – blue digital image data. The measured results are intended to be used for the purpose of colour management in multimedia systems, typically in the Internet.

This standard defines test charts, measurement conditions and methods of measurement, so as to make possible the colour management in open multimedia systems and comprehensive comparison of the results of measurements for assessment of digital cameras.

Colour control within digital cameras is outwith the scope of this part. It does not specify limiting values for various parameters.

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2 Normative references

The following referenced documents are indispensable for the application 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 (IEV) – Chapter 845: Lighting*.

IEC 61146-1:1994, *Video cameras (PAL/SECAM/NTSC) – Methods of measurement – Part 1: Non-broadcast single-sensor cameras*

IEC 61966-2-1:1999, *Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB*

ISO 2813:1994, *Paints and varnishes – Determination of specular gloss of non-metallic paint films at 20 degrees, 60 degrees and 85 degrees*

ISO/CIE 10527:1991, *CIE standard colorimetric observers*

CIE 17.4:1987, *International lighting vocabulary*

3 Terms and definitions

For the purposes of this document, the definitions in IEC 60050-845 and CIE 17.4, as well as the following definitions, apply.

3.1
colour control
conversion of equipment-dependent colour-image data to equipment-independent data for a specific colour space including tone characteristics

3.2
digital camera
electronic imaging equipment which can capture colour still and moving images, and outputs digital image data for red – green – blue channels either by itself or using incorporated colour control software

4 Conditions

4.1 Environmental conditions

All measurements specified in this standard shall be carried out in a dark room.

Electric power to a digital camera under test shall be supplied using an a.c. adapter or batteries recommended by the manufacturer.

The mains voltage and frequency applied to the a.c. adapter shall be at the rated value specified by the manufacturer of the digital camera. When the mains voltage fluctuates, a stabilizer shall be used to attain a stability value of ±5 % of the rated value.

Other environmental conditions such as temperature and relative humidity shall be reported, together with the results of measurement.

For additional environmental conditions not specified in this subclause, if any, the specifications of the manufacturer of the digital camera shall be taken into account.

4.2 Conditions of measurements

4.2.1 Measurement arrangement

Unless otherwise specified, a shooting object shall be a test chart with the dark box shown in Figure 1. The specifications for the centre hole of the chart are given in Figure 3. Relative positions shall be selected to prevent unnecessary glare from the diffuser.

NOTE The spectral light source consisting of the lamp, the iris, the monochromator, the optical fibre and the diffuser may be configured in other ways, provided that the required specifications are met.

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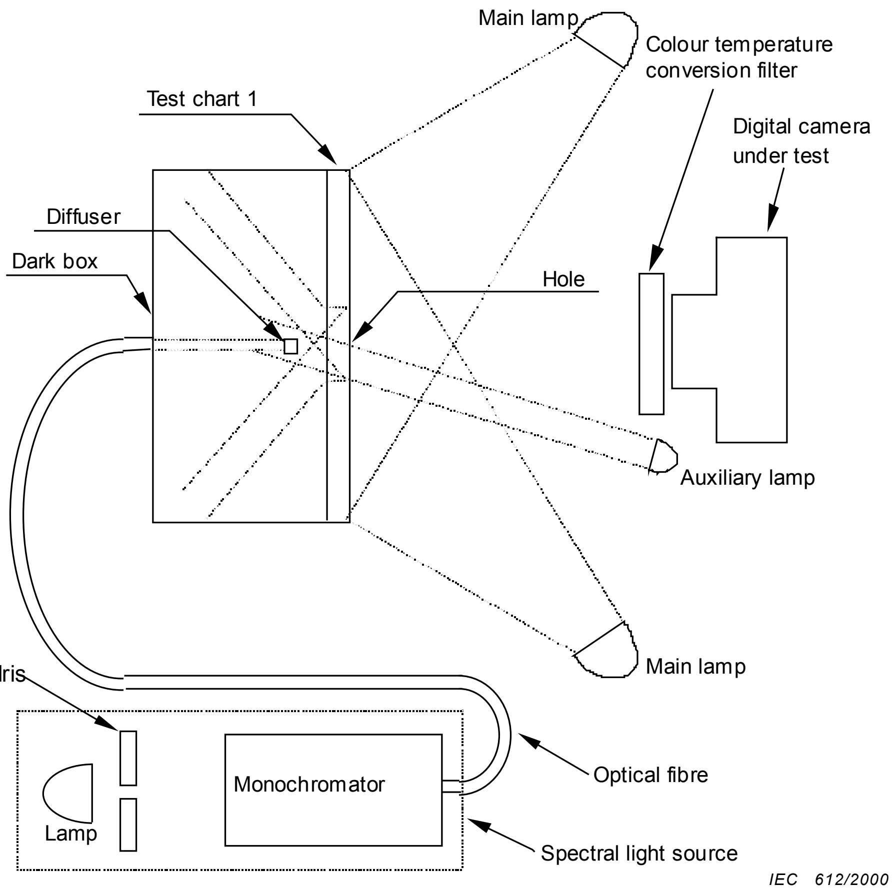

Figure 1 – Equipment arrangement for measurements

4.2.2 Illumination

Illumination of the test charts shall be performed by two or four main lamps and one auxiliary lamp depending on the characteristics to be measured. Incident lights from the main lamps shall be 45° relative to the surface of the test chart. An auxiliary lamp to illuminate the diffuser in Figure 1 is used only for the measurement specified in Clause 7. The diffuser shall not be directly illuminated by the main lamps. The main lamps and the auxiliary lamp shall be halogen lamps with a well-regulated power supply.

The correlated colour temperature of the lamps shall be 3 100 K ± 100 K as specified in IEC 61146-1. The non-uniformity of illumination shall be less than 5 %. The average illuminance on the test chart shall be 2 000 lx ± 100 lx.

4.2.3 Shooting conditions

The optical axis of the digital camera under test shall coincide with the normal to the test chart.

If the digital camera under test is equipped with a zoom lens, the distance between the test chart and the digital camera under test, unless otherwise specified, shall be approximately 1,5 m. The zooming shall be adjusted so that the horizontal and vertical markers fit within the full frame of an image area.

If the digital camera under test is not equipped with a zoom lens, the distance between the test chart and the digital camera under test, unless otherwise specified, shall be adjusted so that the horizontal and vertical markers fit within the full frame of an image area.

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4.2.4 Digital image data

The red – green – blue data necessary for the calculation and characterization of the digital camera under measurement shall be acquired and recorded depending on the cases described below.

a) If red – green – blue digital image data are obtained direct from the digital camera under test, the values shall be recorded.

b) If red – green – blue digital image data are not directly obtainable, they should be calculated by the manufacturer's driver software.

c) If red – green – blue digital image data are calculated by any independent application software on the digital camera under measurement, the name and version of the software shall be reported together with the values.

5 Measurement equipment

5.1 Spectral light source

The spectral light source consists of a halogen lamp powered by a well-regulated d.c. electric power source, an iris, a monochromator and an optical fibre with a diffuser as in Figure 1. Specifications of the constituent parts of the equipment arrangement should be as follows.

a) Output of spectral light source

   1) Diameter of the diffuser: approximately $\frac{1}{45}h$

   2) Radiance: more than 10 mW/sr/m^2

   3) Stability of light output: within ±0,5 %

   NOTE An integrating sphere may be incorporated to increase uniformity.

b) Monochromator

   1) Wavelength range: including from 380 nm to 780 nm

   2) Spectral bandwidth: 5 nm (FWHM[1)]), triangle

   3) Wavelength accuracy: ±0,5 nm

   4) Stray light: less than 10^{-4}

   NOTE Higher-order spectra from the monochromator should be removed.

5.2 Colour temperature conversion filter

The amount of reciprocal correlated colour temperature change shall be –140 MK^{-1} in order to achieve 5 500 K ± 300 K.

5.3 Dark box

The dark box for the measurements should be as shown in Figure 2. The reflectance of the inside of the dark box shall be less than 2 %. The accuracy of the dimensions should be within $\pm\frac{1}{50}h$. The geometrical specification of the holes whose positions are designated by "0" shall be as in Figure 3.

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1) FWHM stands for full-width half maximum.

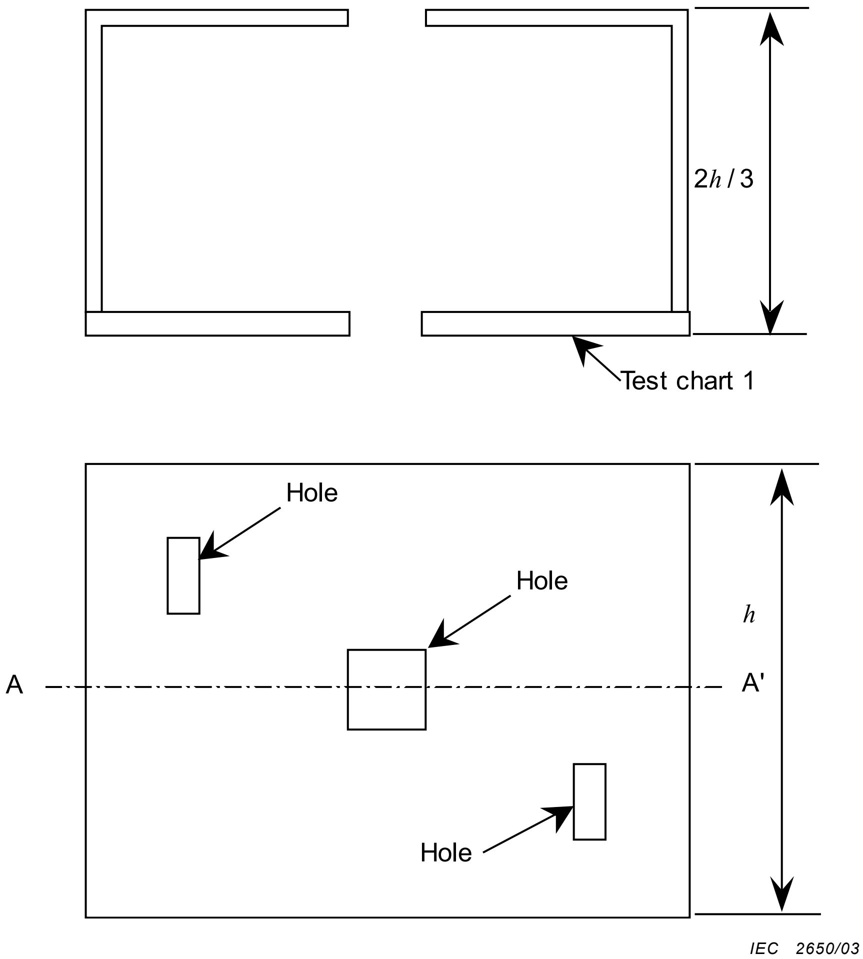

Figure 2 – Dark box

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5.4 Test charts

a) The specular gloss at 60° shall be less than 2,5 %, according to ISO 2813, for all test charts. The geometric specification of the test charts shall be as shown in Figures 3, 4 and 5. The accuracy of the dimensions should be within $\pm\frac{1}{50}h$.

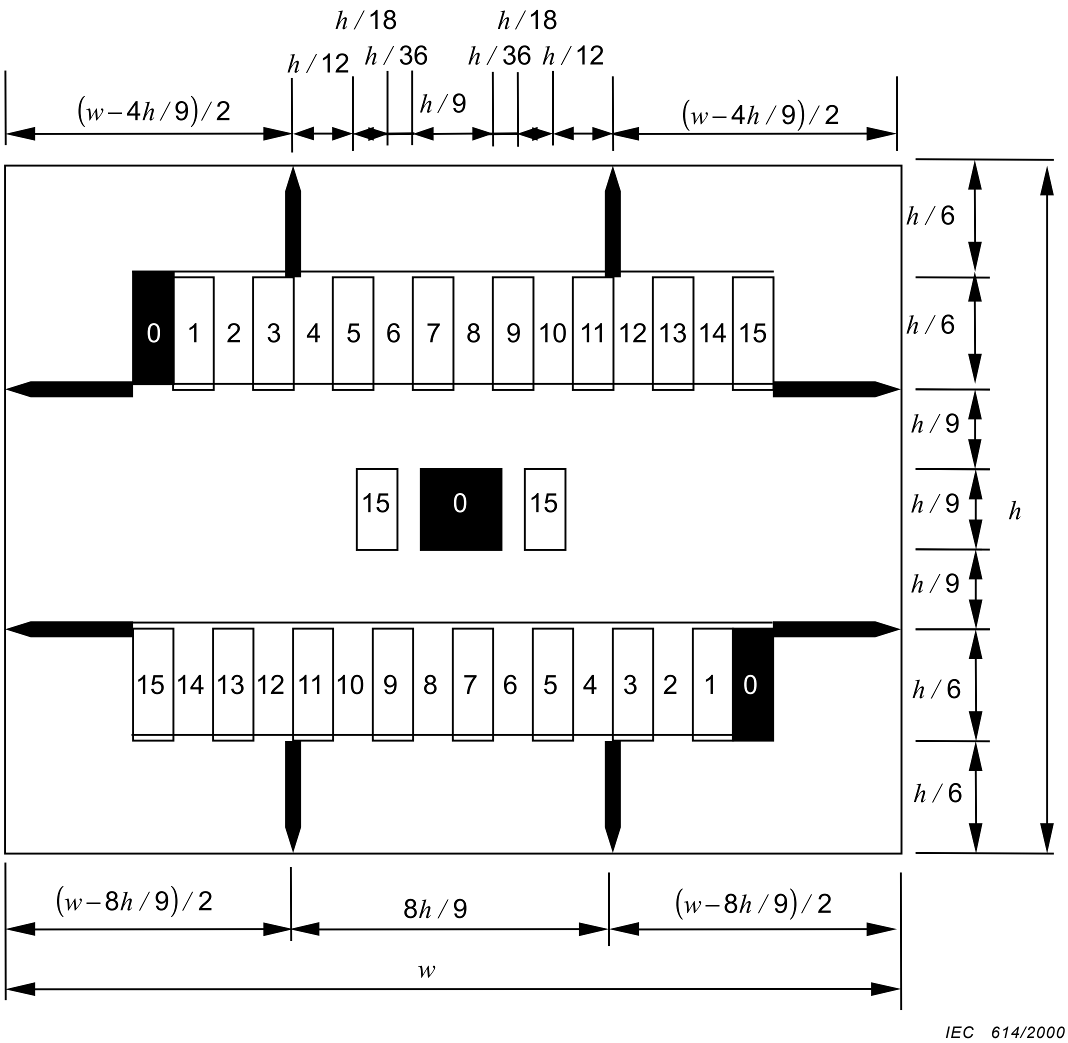

Figure 3 – Test chart 1

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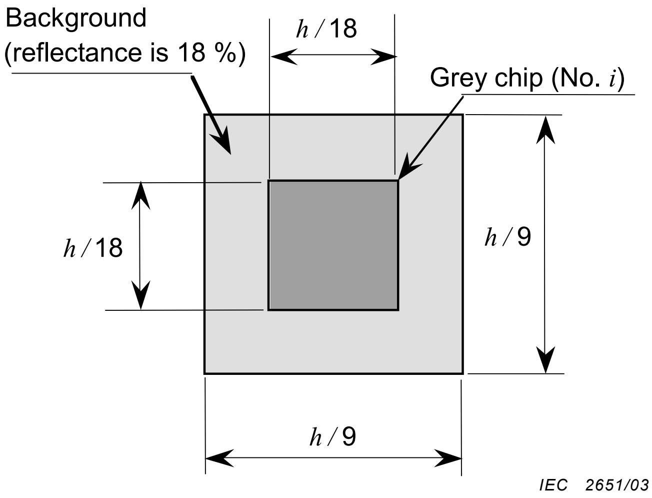

Figure 4 – Test chart 2 with replaceable chip i

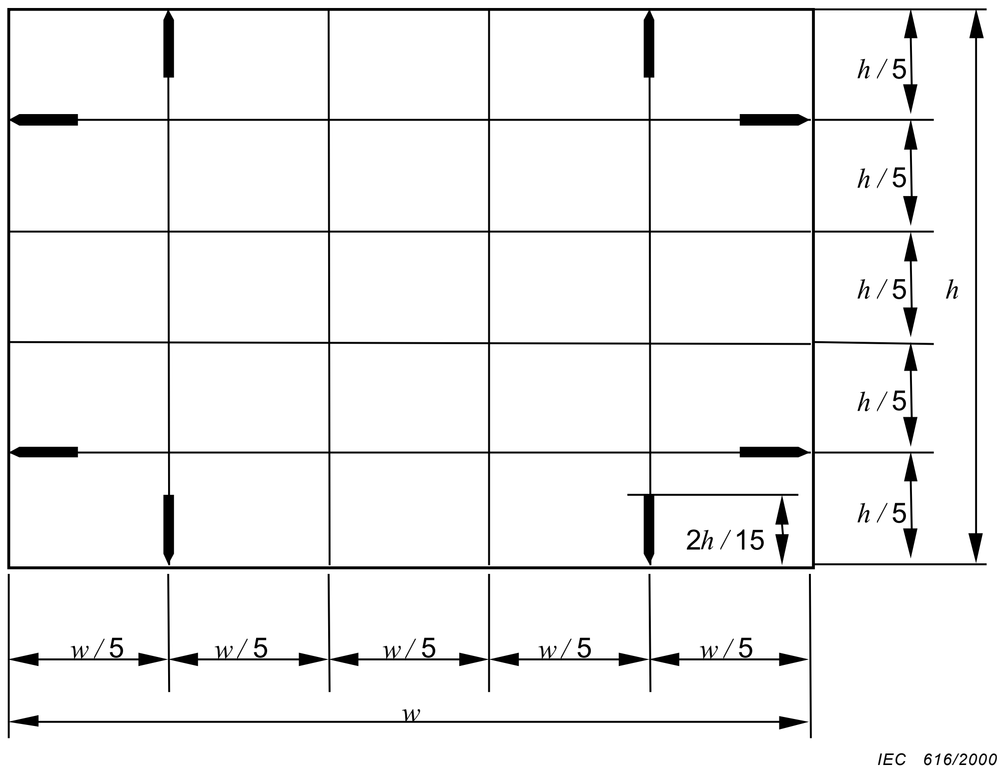

Figure 5 – Test chart 3

b) Test chart 3 in Figure 5 shall be the white chart with a nominal reflectance of 88,1 %. It shall be superimposed with a rectangular grid. The designation of position j in Figure 5 shall be numbered from the top left to the bottom right for the centre of each rectangular area as j = 1 to 25.

c) The reflectances of the grey steps in test chart 1 shall have the values specified in Table 1, where the positions designated by “0” are holes.

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Table 1 – Nominal reflectances of the grey-scale section and the grey chips

i	**Reflectance (%)**
0	0,0(hole)
1	2,0
2	4,0
3	6,0
4	8,0
5	10,3
6	14,7
7	19,8
8	25,8
9	32,5
10	39,9
11	48,1
12	57,0
13	66,6
14	77,0
15	88,1
Background	18,0

5.5 Radiance meter

A radiance meter with the following specification should be used for the measurements of the output from the spectral light source.

a) Wavelength range: from 380 nm to 780 nm
b) Measurable range: from 1 μW/sr/m^2 to 1 W/sr/m^2
c) Relative accuracy: ±5 % (from 380 nm to 780 nm)
d) Linearity: ±2 %
e) Measurement resolution: less than 0,5 %

NOTE 1 Radiance can be measured with an irradiance meter at a known distance from a source. A spectro-radiometer in radiance geometry can also be used to measure radiance.

NOTE 2 If a wavelength range beyond the specification in a) is required from the results reported in Clause 7, the wavelength range should be from 360 nm up to a wavelength where a response of less than 5 % of the maximum is observed.

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5.6 Spectro-radiometer

A spectro-radiometer with the following specification should be used for the measurement for a built-in electronic flash in Clause 8.

a) Wavelength range: from 380 nm to 780 nm
b) Field of view: between 0,1° and 2,0°
c) Wavelength uncertainty: less than 0,5 nm throughout the wavelength range
d) Scanning interval: 5 nm or less
e) Bandpass: 5 nm or less
f) Repeatability: less than 0,5 % in radiance at each wavelength

NOTE 1 A temporal integration capability for measuring flashing lights is required.

NOTE 2 If a wavelength range beyond the specification in a) is required from the results reported in Clause 8, the wavelength range should be from 360 nm up to a wavelength where a response of less than 5 % of the maximum is observed.

NOTE 3 Periodic calibration should be carried out with a standard optical source of known spectral power distribution.

NOTE 4 Further technical details of the design, characterization, and calibration of spectro-radiometers can be found in CIE 63 [7], CIE 105 [8] and JIS Z 8724 [3][1].

5.7 Luminance meter

The luminance meter should have the following specifications for the measurement of luminance in Clause 7. A colorimeter with luminance output in Y can also be used.

a) Field of view: any value between 0,1° and 2,0°
b) Spectral responsivity: compliant to the CIE 2° colour-matching function, $\bar{y}(\lambda)$, as defined in ISO/CIE 10527
c) Repeatability: less than 0,5 %

6 Tone characteristics

6.1 Characteristics to be measured

The relationship between the luminance of the shooting object and the digital image data at the centre of the image shall be measured.

6.2 Measurement conditions

The arrangement of the equipment should be as in Figure 1. The optical fibre shall be removed and the hole on the rear side of the dark box shall be covered with a lid similarly painted as the inside of the dark box. The auxiliary lamp shall be switched off.

Two separate measurements, with the colour temperature conversion filter in front of the lens for 5 500 K and without for 3 100 K, shall be conducted.

NOTE Additional conditions of correlated colour temperature may be set according to the needs.

[1] Figures in square brackets refer to the bibliography.

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6.3 Method of measurement

a) Test chart 2 with the grey chip i shall sequentially be inserted into the front hole at the centre of test chart 1 for i = 0 to 15. The reflectances of the grey chips shall be as shown in Table 1.

NOTE The grey chip for i = 0 is a hole without a grey chip.

b) The luminance L_i of the grey chip i shall be measured using the luminance meter and test chart 1 shall be shot by the digital camera under test.

c) The mean values corresponding to the grey chip i mounted at the centre, D'_{R_i}, D'_{G_i} and D'_{B_i}, of red – green – blue digital image data shall be recorded.

d) The mean values $E^R_{i_j}$, $E^G_{i_j}$ and $E^B_{i_j}$ corresponding to step j of the upper grey steps with the grey chip i mounted at the centre shall also be noted for red – green – blue image data, respectively.

6.4 Presentation of results

a) The recorded data shall be compensated for, in order to eliminate any autonomous exposure control or errors of a mechanical shutter of the digital camera under test as follows.

$$D_{R_i} = \frac{1}{2^n - 1}\left(\frac{E^R_{8_{j+1}} - E^R_{8_j}}{E^R_{i_{j+1}} - E^R_{i_j}} \left(D'_{R_i} - E^R_{i_j} \right) + E^R_{8_j} \right) \times 100 \quad (\%) \qquad (1)$$

where

j is the step number of the grey steps in which the inequality $E^R_{i_j} < D'_{R_i} < E^R_{i_{j+1}}$ holds;

n is the number of bits in each channel.

A similar compensation shall be conducted for recorded data D'_{G_i} and D'_{B_i} to obtain D_{G_i} and D_{B_i}, respectively, for green and blue channels.

b) The measured and calculated data L_i, D_{R_i}, D_{G_i}, D_{B_i} for i = 0 to i = 15 shall be reported as in Table 2, together with the effective correlated colour temperature of the illumination.

c) The results shall also be reported as a graphical representation, as shown in Figure 6, where the horizontal axis is the luminance L_i and the vertical axis is for D_{R_i}, D_{G_i} and D_{B_i}. The correlated colour temperature shall also be reported.

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Table 2 – Example of tone characteristics
(correlated colour temperature: 5 500 K)

i	*L* (cd/m²)	D_R (%)	D_G (%)	D_B (%)
0	1,37	0,00	0,00	0,00
1	5,17	3,83	4,00	3,94
2	8,57	9,45	9,34	9,31
3	12,3	16,4	16,7	16,5
4	15,9	21,6	21,6	21,5
5	20,5	27,3	27,2	27,2
6	27,9	36,0	36,1	36,1
7	37,5	45,3	45,5	45,2
8	49,2	55,2	55,5	55,2
9	60,8	63,6	63,7	63,4
10	75,1	72,4	72,3	72,2
11	91,4	79,9	80,0	79,7
12	107,2	85,5	85,5	85,2
13	123,1	89,8	89,5	89,6
14	143,3	94,0	94,0	93,9
15	164,5	96,8	96,8	96,8

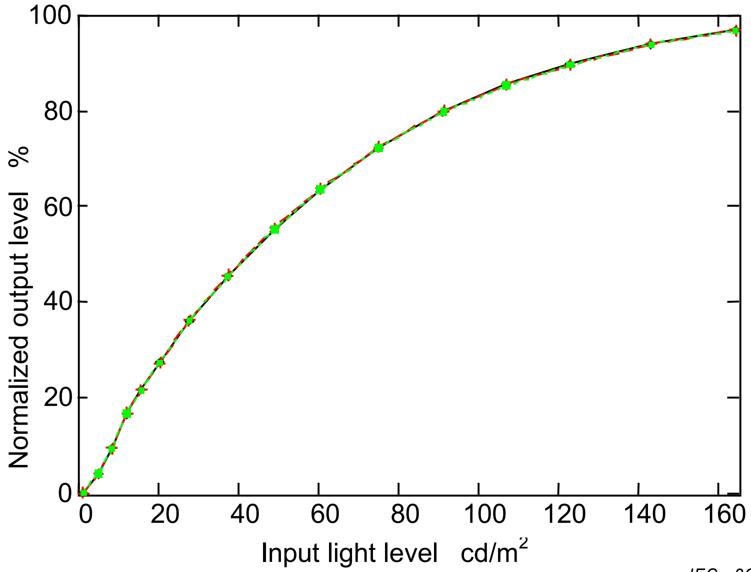

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Figure 6 – Example plot of tone characteristics
(correlated colour temperature: 5 500 K)

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7 Spectral responsivity characteristics

7.1 Characteristics to be measured

The relationship between wavelength λ of monochromatic incident light and red – green – blue digital image data obtained from the digital camera shall be measured.

7.2 Measurement conditions

a) The arrangement of equipment should be as shown in Figure 1. The optical fibre connected to the spectral light source shall be inserted into the dark box from the rear side. All measurement and shooting by the digital camera shall be conducted through the correlated colour conversion filter wherever applicable.

NOTE 1 Illumination with a correlated colour temperature of 3 100 K is normally achieved without the correlated colour conversion filter in front of the lens.

NOTE 2 Additional correlated colour temperatures may be set according to the needs.

b) The intensity of the auxiliary lamp, with the iris in front of the monochromator shut, shall be adjusted so that digital image data corresponding to the diffuser is around 20 % of a full data range of the digital camera. If underflows are observed in the data processing in 7.4c), the value of 20 % should be increased.

NOTE The lower intensity of the auxiliary lamp is better for measurement accuracy.

c) The iris in front of the monochromator shall be adjusted once so that the maximum data in red – green – blue channels are between 70 % and 80 % inclusive of the full scale on condition that the auxiliary lamp in Figure 1 is switched on. It shall be kept unchanged after this adjustment.

7.3 Method of measurement

a) The measurement shall be conducted for both illuminations with effective correlated colour temperatures of 5 500 K and 3 100 K.

b) The radiance $L(\lambda_i)$ on the diffuser from the spectral light source shall be measured using the radiance meter with the auxiliary lamp switched off. When the measurement is conducted for 5 500 K, the colour conversion filter shall be inserted between the diffuser and the radiance meter.

c) The auxiliary lamp shall then be switched on and the iris in front of the monochromator shall be shut. The digital image data corresponding to the diffuser shall be recorded in pixel by pixel as three sets of data D''_{R0}, D''_{G0} and D''_{B0} for red – green – blue channels, respectively.

d) Test chart 1, in which the centre portion illuminated by the spectral light source from the back and by the auxiliary lamp from the front, shall be shot by the digital camera under test at each wavelength λ_i, where i = 1 to 81, corresponding to the wavelength from 380 nm to 780 nm with an interval of 5 nm.

e) The pixel-by-pixel output data corresponding to the diffuser shall be recorded as $D''_R(\lambda_i)$, $D''_G(\lambda_i)$ and $D''_B(\lambda_i)$ for red – green – blue channels, respectively.

f) The mean values $F^R_{i_j}$, $F^G_{i_j}$ and $F^B_{i_j}$ corresponding to step j of the upper grey steps, with the monochromatic radiation at wavelength λ_i at the centre of test chart 1, shall also be noted for red – green – blue image data, respectively, for j = 0 to 15.

g) The auxiliary lamp shall be switched off and test chart 2 with the grey chip 8 shall be inserted into the front hole at the centre of test chart 1. Spectral distribution characteristics $L_8(\lambda_i)$ shall be measured using a spectro-radiometer, where i = 1 to 81, corresponding to the wavelength from 380 nm to 780 nm with an interval of 5 nm.

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NOTE If the wavelength range beyond the specification is required from the results reported in 7.4, it should be from 360 nm up to a wavelength where response less than 5 % will be observed.

7.4 Presentation of results

a) The recorded pixel-by-pixel data $D''_R(\lambda_i)$ shall be compensated to eliminate any autonomous exposure control or errors due to a mechanical shutter of the digital camera under test as follows:

$$D'_R(\lambda_i) = \frac{E^R_{8_{j+1}} - E^R_{8_j}}{F^R_{i_{j+1}} - F^R_{i_j}}\left(D''_R(\lambda_i) - F^R_{i_j}\right) + E^R_{8_j} \tag{2}$$

where the index j is the step number of the grey steps in which the inequality $F^R_{i_j} < D''(\lambda_i) < F^R_{i_{j+1}}$ holds.

A similar compensation shall be conducted to the recorded data $D''_G(\lambda_i)$ and $D''_B(\lambda_i)$ to obtain $D'_G(\lambda_i)$ and $D'_B(\lambda_i)$ respectively, for green and blue channels.

b) The pixel-by-pixel digital image data D' shall be linearized using the results reported in 6.4 for the tone characteristics, and averaged over the centre portion of the digital image corresponding to the monochromatic radiation at wavelength λ_i to get $L_R(\lambda_i)$, $L_G(\lambda_i)$, $L_B(\lambda_i)$ as follows:

$$\begin{aligned} L_R(\lambda_i) &= \overline{f_R^{-1}(D'_R(\lambda_i)) - f_R^{-1}(D'_{R_0})} \\ L_G(\lambda_i) &= \overline{f_G^{-1}(D'_G(\lambda_i)) - f_G^{-1}(D'_{G_0})} \\ L_B(\lambda_i) &= \overline{f_B^{-1}(D'_B(\lambda_i)) - f_B^{-1}(D'_{B_0})} \end{aligned} \tag{3}$$

where $f_R^{-1}(\ )$, $f_G^{-1}(\ )$ and $f_B^{-1}(\ )$ are the inverse relations of the tone characteristics for red – green – blue channels, respectively.

NOTE For practical calculation of the inverse relationship, see Annex B.

c) To take the radiance of the spectral light source $L(\lambda_i)$ into account, $R_C(\lambda_i)$, $G_C(\lambda_i)$ and $B_C(\lambda_i)$ shall be calculated by the following formulae:

$$\begin{aligned} R_C(\lambda_i) &= p_R \frac{L_R(\lambda_i)}{L(\lambda_i)} \\ G_C(\lambda_i) &= p_G \frac{L_G(\lambda_i)}{L(\lambda_i)} \\ B_C(\lambda_i) &= p_B \frac{L_B(\lambda_i)}{L(\lambda_i)} \end{aligned} \tag{4}$$

where p_R, p_G, p_B are coefficients to align the chromaticity coordinate value to the neutral point in the coordinate. For the determination of the coefficients, see Annex D.

d) The spectral responsivity characteristics $R_C(\lambda_i)$, $G_C(\lambda_i)$ and $B_C(\lambda_i)$ shall be reported in electronic form together with the effective correlated colour temperature.

e) They shall also be plotted as curves as shown in Figure 7 with the correlated colour temperature.

NOTE Recommended use of the reported results for colour management is described in Annex C.

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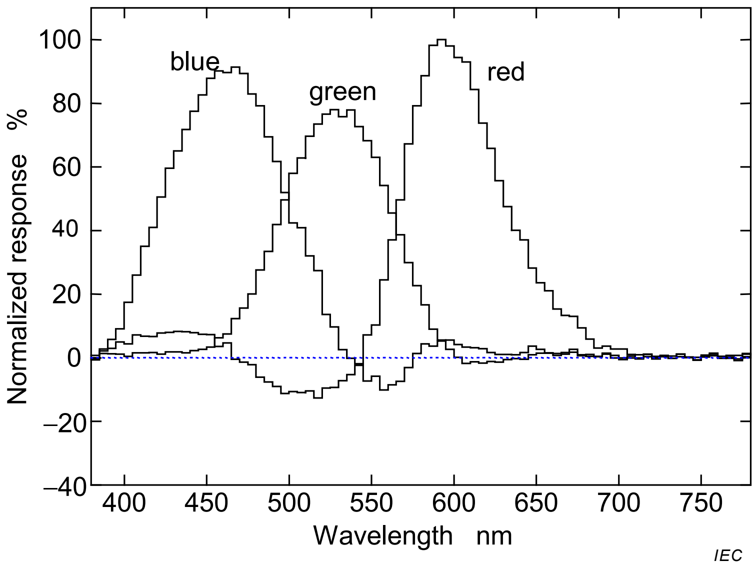

Figure 7 – Example of spectral responsivity characteristics
(correlated colour temperature: 5 500 K)

NOTE An alternative method based on digital image data acquired by shooting a set of colour chips with known spectral reflectance may be used to estimate the spectral responsivity. The details are given in IEC 61966-8.

8 Spectral distribution of built-in electronic flash

8.1 Characteristics to be measured

The spectral characteristics of the light emitted from the electronic flash light source integrated in digital cameras for illuminating objects to be shot.

8.2 Measurement conditions

The arrangement of measuring equipment shall be as in Figure 1. Test chart 2 with grey chip 15 shall be inserted into the hole at the centre of test chart 1.

8.3 Method of measurement

a) The spectral reflectance characteristics, $W(\lambda)$, at the centre of grey chip 15 in test chart 2 shall be known.

b) The spectral distribution characteristics, $L_W(\lambda)$, of the reflected light at the centre of the grey chip illuminated by the built-in electronic flash shall be measured using the spectro-radiometer.

c) The spectral distribution characteristics of the built-in flash, $L_S(\lambda)$, shall be calculated using the following formula:

$$L_S(\lambda) = k \frac{L_W(\lambda)}{W(\lambda)} \quad (5)$$

where k is an arbitrary normalization factor for the maximum value of $L_S(\lambda)$ to be 100 %.

NOTE 1 The spectral distribution of the built-in flash may be directly measured using the spectro-radiometer in irradiance geometry.

NOTE 2 An auxiliary flash or a lamp other than built-in can be measured by the method specified in this clause.

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8.4 Presentation of results

a) The spectral characteristics of the built-in electronic flash, $L_S(\lambda)$, shall be reported in electronic form.

b) The characteristics, $L_S(\lambda)$, shall be plotted as the curve exemplified in Figure 8.

c) The correlated colour temperature, defined in 5.5 of CIE 15.2, for the built-in flash light shall also be calculated and reported in kelvins, together with the deviation Δ_{uv}.

NOTE For the actual procedure to calculate correlated colour temperatures, refer to [6].

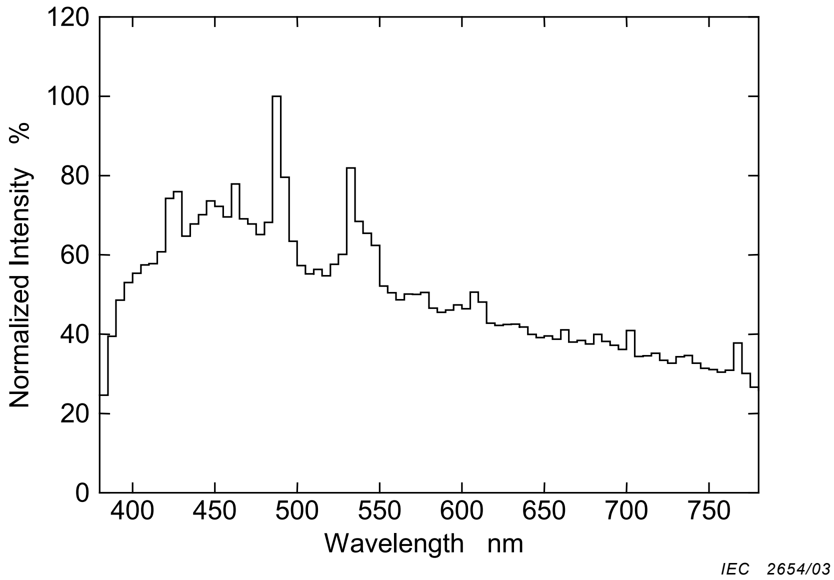

Figure 8 – Example of the spectral distribution characteristics of a built-in electronic flash

9 Spatial non-uniformity

9.1 Characteristics to be measured

The non-uniformity of the digital image data acquired by shooting an evenly illuminated white chart.

9.2 Measurement conditions

The arrangement of the equipment shall be as shown in Figure 9. The illumination shall be the same as that specified in 4.2.2 with the colour temperature conversion filter of –140 MK^{-1} to achieve an effective correlated colour temperature of 5 500 K.

9.3 Method of measurement

a) Test chart 3 in Figure 5 shall be shot by the digital camera under test.

b) The mean values, D_{R_j}, D_{G_j}, D_{B_j} of red – green – blue digital image data for $P_v/100 \times P_v/100$ picture elements peripheral to the position j specified in 5.4b) shall be recorded for j = 1 to 25, where P_v is the number of picture elements in the vertical direction.

NOTE If further precise measurement is required, the luminance in cd/m[2] at the centre of each point may be measured and the values obtained in b) can be compensated.

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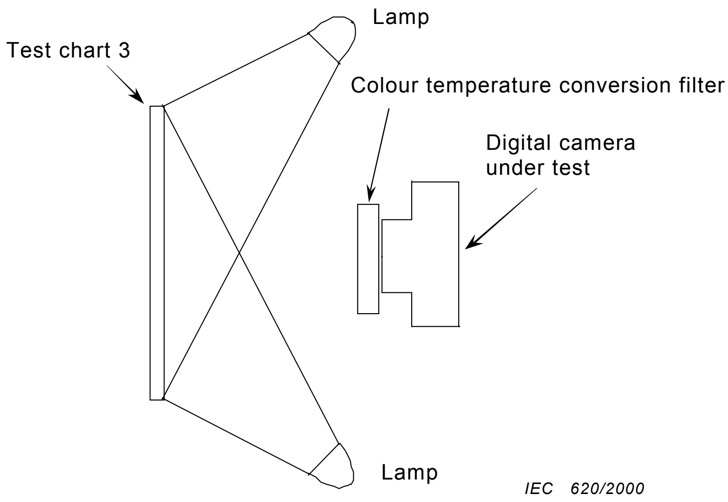

Figure 9 – Equipment arrangement for measurement of spatial non-uniformity

9.4 Presentation of results

a) The R, G, and B data shall be converted to the tristimulus values X, Y, and Z in accordance with 3.2 of IEC 61966-2-1.

b) As indices of non-uniformity, calculated results, $\Delta u'$, $\Delta v'$, $\Delta u'v'$, ΔL^* and ΔC^*_{ab} for i = 1 to 25 shall be reported as a table, as shown in Table 3.

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Table 3 – An example of reporting form for spatial non-uniformity

j	D_R (%)	D_G (%)	D_B (%)	$\Delta u' \times 10^3$	$\Delta v' \times 10^3$	$\Delta u'v' \times 10^3$	ΔL^*	ΔC^*_{ab}
1	52,2	47,8	46,3	1,95	-1,78	2,64	-5,41	2,10
2	55,9	52,4	49,4	0,91	-0,29	0,95	-2,80	0,71
3	56,6	53,6	50,3	0,42	-0,10	0,43	-2,17	0,32
4	55,6	52,6	49,4	0,46	-0,14	0,48	-2,75	0,37
5	51,1	47,9	45,6	0,86	-0,91	1,25	-5,55	1,06
6	55,3	51,6	49,0	1,10	-0,71	1,31	-3,23	1,04
7	57,6	55,0	51,2	0,04	0,33	0,33	-1,43	0,18
8	59,1	56,2	52,6	0,22	0,02	0,22	-0,70	0,14
9	57,7	55,3	51,6	-0,16	0,14	0,21	-1,28	0,16
10	54,1	51,2	47,8	0,47	0,23	0,53	-3,61	0,24
11	56,7	53,4	50,1	0,69	-0,03	0,70	-2,25	0,47
12	59,1	56,3	52,5	0,15	0,24	0,28	-0,67	0,15
13	60,2	57,5	53,8	0,00	0,00	0,00	0,00	0,00
14	59,2	56,5	52,8	0,05	0,09	0,10	-0,56	0,04
15	55,2	52,5	49,0	0,23	0,20	0,30	-2,86	0,10
16	56,6	53,3	50,2	0,68	-0,28	0,73	-2,30	0,57
17	58,4	55,7	52,1	0,07	0,03	0,08	-1,01	0,04
18	59,4	56,5	53,2	0,18	-0,36	0,40	-0,52	0,33
19	58,6	55,8	52,5	0,13	-0,32	0,35	-0,93	0,30
20	55,0	52,0	48,6	0,52	0,17	0,55	-3,12	0,29
21	55,4	50,9	49,1	1,80	-1,55	2,38	-3,51	1,90
22	56,8	53,6	50,4	0,58	-0,19	0,61	-2,14	0,47
23	57,1	54,0	50,9	0,46	-0,37	0,59	-1,92	0,50
24	56,5	53,4	50,5	0,48	-0,57	0,74	-2,26	0,63
25	53,2	49,4	47,3	1,30	-1,18	1,76	-4,53	1,43

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Annex A
(normative)

Letters and symbols

D_R	Compensated and normalized image data for the red channel
D_G	Compensated and normalized image data for the green channel
D_B	Compensated and normalized image data for the blue channel
E^R	Mean value corresponding to the step of grey steps for the tone-characteristic measurement of the red channel
E^G	Mean value corresponding to the step of grey steps for the tone-characteristic measurement of the green channel
E^B	Mean value corresponding to the step of grey steps for the tone-characteristic measurement of the blue channel
F^R	Mean value corresponding to the step of grey steps for the spectral responsivity characteristic measurement of the red channel
F^G	Mean value corresponding to the step of grey steps for the spectral responsivity characteristic measurement of the green channel
F^B	Mean value corresponding to the step of grey steps for the spectral responsivity characteristic measurement of the blue channel
$f_R(\ )$	Tone characteristics of the red channel
$f_G(\ )$	Tone characteristics of the green channel
$f_B(\ )$	Tone characteristics of the blue channel
h	Height of the test charts
w	Width of the test charts
L	Luminance of the test charts in cd/m^2
$L(\lambda_i)$	Light intensity at wavelength λ_i measured through the correlated colour temperature conversion filter
$L_S(\lambda_i)$	Spectral distribution of the built-in flash
P_v	Number of picture elements in the vertical direction of digital camera picture data
$R_C(\lambda)$	Spectral responsivity characteristics of the red channel of the digital camera
$G_C(\lambda)$	Spectral responsivity characteristics of the green channel of the digital camera
$B_C(\lambda)$	Spectral responsivity characteristics of the blue channel of the digital camera

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Annex B
(informative)

Procedure to calculate the inverse function

The normalized set of data, D_{R_i}, D_{G_i}, and D_{B_i} should be retrieved from Table 2.

A mean data of D_x is supposed where $D_i \le D_x \le D_{i+1}$. Figure 6 is approximated in a piecewise linear relationship as in

$$D_x = \frac{D_{i+1} - D_i}{L_{i+1} - L_i} L_x + \frac{D_i L_{i+1} - D_{i+1} L_i}{L_{i+1} - L_i} \qquad \text{(B.1)}$$

Thus, the corresponding radiance L_x in cd/m^2 to the data D_x will be obtained as a solution of equation B.1 as in

$$L_x = \frac{D_{i+1} L_{i+1} - D_x L_i}{D_{i+1} - D_i} \qquad \text{(B.2)}$$

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Annex C
(informative)

Example of the use of the reported results for colour management

C.1 Introduction

There will be multiple methods to perform external colour control of image data for characterization of digital cameras in use for an open system as a constituent part of colour information production and reproduction systems under colour management. This annex is in line with IEC TTA-3 [2] and describes a method to control colour reproduction based on the data reported as the results of performing the measuring methods specified in this standard. In other words, colour control methods based on equipment-dependent characteristics, being capable of conversion to the equipment-independent characteristics are described as examples.

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C.2 Colorimetric characteristics of the scRGB colour space

The ideal spectral characteristics of digital cameras $r_s(\lambda)$, $g_s(\lambda)$, and $b_s(\lambda)$ compliant to the scRGB colour space as defined in IEC 61966-2-2, is obtained by the following calculation based on CIE 1931 colour-matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$; chromaticity coordinate values in CIE 1931 chromaticity diagram for red – green – blue $(x_\mathrm{R}, y_\mathrm{R})$, $(x_\mathrm{G}, y_\mathrm{G})$, and $(x_\mathrm{B}, y_\mathrm{B})$; and the neutral colour (CIE D65) $(x_\mathrm{n}, y_\mathrm{n})$, all of which are defined in CIE 15.2.

Namely, based on equation 1 of IEC 61966-2-2, by expanding the relationship to spectral characteristics, the following more strict constraint is obtained.

$$\begin{pmatrix} r_s(\lambda) \\ g_s(\lambda) \\ b_s(\lambda) \end{pmatrix} = \begin{pmatrix} 3{,}240\,625 & -1{,}537\,208 & -0{,}498\,629 \\ -0{,}968\,931 & 1{,}875\,756 & 0{,}041\,518 \\ 0{,}055\,710 & -0{,}204\,021 & 1{,}056\,996 \end{pmatrix} \begin{pmatrix} \bar{x}(\lambda) \\ \bar{y}(\lambda) \\ \bar{z}(\lambda) \end{pmatrix} \tag{C.1}$$

C.3 Colour control for digital cameras

C.3.1 Matching tone characteristics to the scRGB

Let the measured and reported tone characteristics be $t(x)$ and the ideal target tone characteristics of scRGB specified in IEC 61966-2-2 be $scRGB(x)$, where x corresponds to a light input level normalized to [0,1]. A $t(x)$ differing from $scRGB(x)$ will be converted so that

$$A\tilde{t}(x)^p \approx scRGB(x) \tag{C.2}$$

where $\tilde{t}(x) = t(x) - t(0)$, and the parameters A and p are unknowns and will be determined by the method of the least squares.

Taking logarithm of equation C.2,

$$\sum_x (a + p\log\tilde{t}(x) - \log scRGB(x))^2 = f(a,p) \tag{C.3}$$

where $a = \log A$. From partial differentiations of equation C.3 by a and p, it permits the determination of the unknowns in order to minimize $f(a, p)$.

$$\begin{pmatrix} \sum_x \log \tilde{t}(x) & \sum_x \log^2 \tilde{t}(x) \\ n & \sum_x \log \tilde{t}(x) \end{pmatrix} \begin{pmatrix} a \\ p \end{pmatrix} = \begin{pmatrix} \sum_x \log \tilde{t}(x) \log scRGB(x) \\ \sum_x \log scRGB(x) \end{pmatrix} \quad \text{(C.4)}$$

where n is the number of sample data in the summation.

C.3.2 Colorimetric match to the scRGB

Let the spectral responsivity characteristics reported in 7.4 be $r_c(\lambda)$, $g_c(\lambda)$, and $b_c(\lambda)$. Here is an example to approximate these characteristics to the ones for the scRGB digital camera. Let an unknown linear conversion matrix be $\mathbf{C}$ as in

$$\mathbf{C} \begin{pmatrix} r_c(\lambda) \\ g_c(\lambda) \\ b_c(\lambda) \end{pmatrix} \approx \begin{pmatrix} m_r r_s(\lambda) \\ m_g g_s(\lambda) \\ m_b b_s(\lambda) \end{pmatrix} \quad \text{(C.5)}$$

where m_r, m_g and m_b are coefficients in which the white balancing control is considered. For a digital camera, and illumination of spectral distribution characteristics $L(\lambda)$, the coefficients should be calculated as follows.

$$\begin{aligned} m_r &= \int_\lambda g_s(\lambda) L(\lambda) d\lambda \Big/ \int_\lambda r_s(\lambda) L(\lambda) d\lambda \\ m_g &= 1 \\ m_b &= \int_\lambda g_s(\lambda) L(\lambda) d\lambda \Big/ \int_\lambda b_s(\lambda) L(\lambda) d\lambda \end{aligned} \quad \text{(C.6)}$$

Taking into account the spectral distribution characteristics $L(\lambda)$ of halogen lamps of 3 100 K with the correlated colour conversion filter, m_r, m_g and m_b are calculated as follows:

$$\begin{aligned} m_r &= 0{,}925\,5 \\ m_g &= 1{,}000\,0 \\ m_b &= 1{,}408\,7 \end{aligned} \quad \text{(C.7)}$$

The nine unknown coefficients of the matrix $\mathbf{C}$ will be determined by the method of least squares applied to equation C.5.

Let $r_c(\lambda_i) = r_{c_i}$, $g_c(\lambda_i) = g_{c_i}$, $b_c(\lambda_i) = b_{c_i}$; $r_s(\lambda_i) = r_{s_i}$, $g_s(\lambda_i) = g_{s_i}$, $b_s(\lambda_i) = b_{s_i}$ then the following simultaneous equation holds.

$$\begin{pmatrix} \sum_{i=1}^n r_{c_i}^2 & \sum_{i=1}^n g_{c_i} r_{c_i} & \sum_{i=1}^n b_{c_i} r_{c_i} \\ \sum_{i=1}^n r_{c_i} g_{c_i} & \sum_{i=1}^n g_{c_i}^2 & \sum_{i=1}^n b_{c_i} g_{c_i} \\ \sum_{i=1}^n r_{c_i} b_{c_i} & \sum_{i=1}^n g_{c_i} b_{c_i} & \sum_{i=1}^n b_{c_i}^2 \end{pmatrix} \mathbf{C} = \begin{pmatrix} \sum_{i=1}^n m_r r_{s_i} r_{c_i} & \sum_{i=1}^n m_r r_{s_i} g_{c_i} & \sum_{i=1}^n m_r r_{s_i} b_{c_i} \\ \sum_{i=1}^n m_g g_{s_i} r_{c_i} & \sum_{i=1}^n m_g g_{s_i} g_{c_i} & \sum_{i=1}^n m_g g_{s_i} b_{c_i} \\ \sum_{i=1}^n m_b b_{s_i} r_{c_i} & \sum_{i=1}^n m_b b_{s_i} g_{c_i} & \sum_{i=1}^n m_b b_{s_i} b_{c_i} \end{pmatrix} \quad \text{(C.8)}$$

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where n is the number of samples in wavelength.

The matrix $\mathbf{C}$ is a solution of the equation C.8.

The method applied to the report in 7.4 results the matrix $\mathbf{C}$ as in

$$\mathbf{C} = \begin{pmatrix} 0{,}9255 & -0{,}3120 & 0{,}0153 \\ 0{,}1004 & 0{,}7179 & -0{,}1538 \\ -0{,}0326 & -0{,}2393 & 0{,}9179 \end{pmatrix} \quad \text{(C.9)}$$

When colour control in equation C.5 is applied, the spectral responsivity characteristics in Figure C.1 will be obtained. For information, the ideal scRGB responses are shown in broken curves.

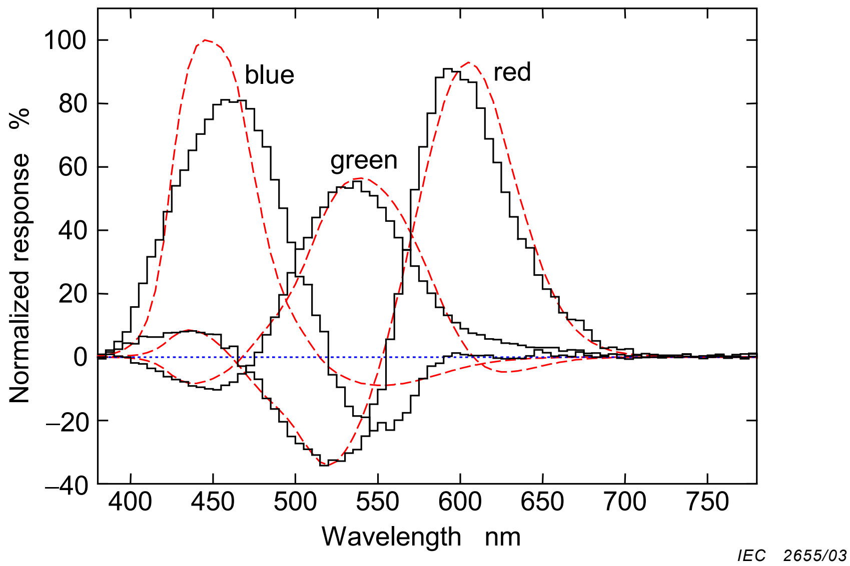

Figure C.1 – An example of spectral responsivity controlled to approximate the ideal scRGB characteristics superimposed as the broken curves

C.3.3 Transformation from image data of digital cameras to the data in scRGB colour space

Raw image data obtained from digital cameras will be transformed to the data in scRGB colour space by the following process in order to make the original data to be equipment independent.

a) The original image data from a digital camera should be linearized by taking into account the tone characteristics $t(x)$ of the digital camera under characterization. Namely, the inverse relation of the tone characteristics should be applied to the data to obtain linearized set of data D'_R, D'_G .and D'_B as in equation C.10.

$$\mathbf{C}\begin{pmatrix} t_R^{-1}(D_R) \\ t_G^{-1}(D_G) \\ t_B^{-1}(D_B) \end{pmatrix} = \begin{pmatrix} D'_R \\ D'_G \\ D'_B \end{pmatrix} \quad \text{(C.10)}$$

b) The linearized set of data D'_R, D'_G .and D'_B should be normalized in accordance with 4.2 of IEC 61966-2-2 finally to obtain R_{scRGB}, G_{scRGB} and B_{scRGB}.

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Annex D
(normative)

Method to compensate spectral responsivity characteristics at the neutral point

To compensate the neutral point shift due to possible errors caused by the measurement system, the following procedure shall be applied to decide the coefficients p_R, p_G and p_B, where $L_8(\lambda_i)$ is the spectral distribution characteristics of grey chip 8.

$$\begin{aligned}\sum_{i=1}^{81} p_R R'(\lambda_i) L_8(\lambda_i) &= \sum_{i=1}^{81} p_G G'(\lambda_i) L_8(\lambda_i) \\ \sum_{i=1}^{81} p_B B'(\lambda_i) L_8(\lambda_i) &= \sum_{i=1}^{81} p_G G'(\lambda_i) L_8(\lambda_i)\end{aligned} \quad \text{(D.1)}$$

With constraint $p_G = 1$, the unknown coefficients p_R and p_B will be obtained as solutions of equation D.1 as in

$$\begin{aligned}p_R &= \sum_{i=1}^{81} G'(\lambda_i) L_8(\lambda_i) \Big/ \sum_{i=1}^{81} R'(\lambda_i) L_8(\lambda_i) \\ p_B &= \sum_{i=1}^{81} G'(\lambda_i) L_8(\lambda_i) \Big/ \sum_{i=1}^{81} B'(\lambda_i) L_8(\lambda_i)\end{aligned} \quad \text{(D.2)}$$

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Annex E
(informative)

Automated extraction of data from the test chart image

E.1 Introduction

The optical viewfinder of a digital camera is designed to restrict the user's field of view to only a portion of the image actually captured by the image sensor. This helps to ensure that the digital camera actually captures every scene detail that was originally composed by the user as illustrated in Figure E.1.

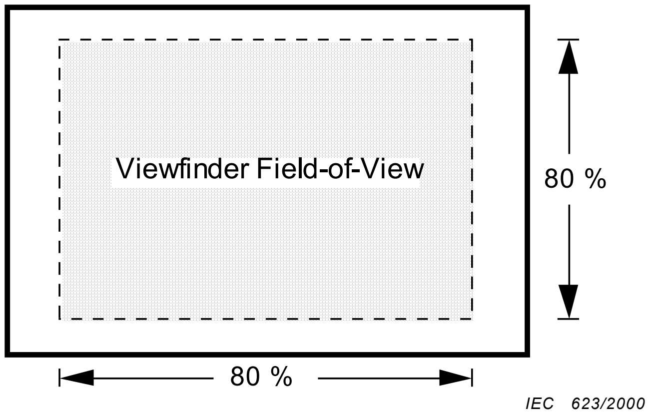

Figure E.1 – Example to compare a typical optical viewfinder area and the corresponding image sensible area (outer rectangle)

Due to manufacturing tolerances and parallax errors, other differences occur between what the user sees in the viewfinder of the digital camera and the captured image. These differences are to be apparent as a shift in the vertical and/or horizontal directions or a rotation in the image. The parallax error can only be zero at a single object distance. Often, this distance is chosen to be the point of best focus or hyper-focal distance of the lens. The addition of horizontal and vertical shift markers to a test chart is recommended to support automated extraction of data from the test chart image. These can be provided in the existing test chart by simply extending the current markers as shown in Figure E.2.

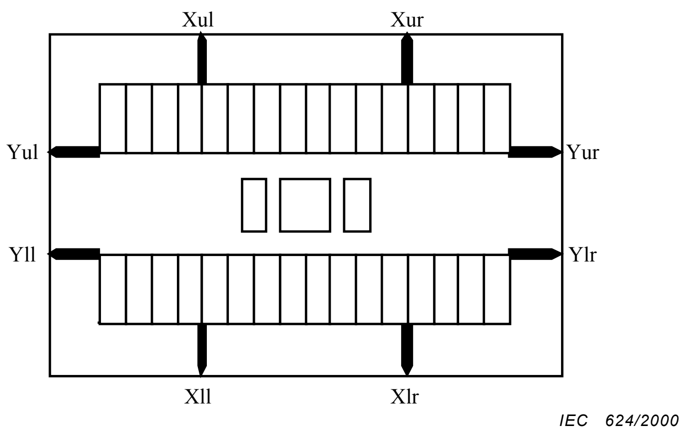

Figure E.2 – Test chart with extended orientation markers

The notations in the following information should be taken from Figure E.2.

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E.2 Horizontal image shift

Horizontal image shift, S_H, can be determined by calculating the difference between the average of the centres of the upper left (X_{ul}) and lower right (X_{lr}) orientation markers and the ideal horizontal image centre (X_c) according to equations E.1 and E.2. The upper right (X_{ur}) and lower left (X_{ll}) orientation markers can also be used.

$$S_H = \frac{1}{2}\left(X_{ul} + X_{lr} - X_c\right) \quad \text{(pixels)} \tag{E.1}$$

Normalized horizontal image shift, s_h, will be

$$s_h = \frac{1}{P_w} S_H \times 100 \quad (\%) \tag{E.2}$$

where P_w is the image width in pixels.

E.3 Vertical image shift

Similarly, vertical image shift, S_V, can be determined by calculating the difference between the average of the centres of the upper left (Y_{ul}) and lower right (Y_{lr}) orientation markers and the ideal vertical image centre (Y_c) according to equations E.3 and E.4. The lower left (Y_{ll}) and upper right (Y_{ur}) orientation markers can also be used.

$$S_V = \frac{1}{2}\left(Y_{ul} + Y_{lr} - Y_c\right) \quad \text{(pixels)} \tag{E.3}$$

Normalized vertical image shift, s_v, will be

$$s_v = \frac{1}{P_h} S_V \times 100 \quad (\%) \tag{E.4}$$

where P_h is the image height in pixels.

E.4 Image rotation

Image rotation, $\Re$, can be determined from a knowledge of the location of the centres of the upper left (Y_{ul}) and upper right (Y_{ur}) orientation markers and the horizontal distance (ΔX, in pixels) between which these centres were measured by the software according to equation E.5.

$$\Re = \tan^{-1}\left(\frac{Y_{ul} - Y_{ur}}{\Delta X}\right) \tag{E.5}$$

E.5 Image magnification

No formulae are offered for calculating image magnification. However, this parameter can easily be determined by calculating the distance (in pixels) between either set of vertical orientation.

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Bibliography

[1] SUGIURA H., KUNO T., MATOBA N. and IKEDA H. "A measurement method for spectral responsivity of digital cameras with tone characteristics compensation per pixel", *Proceedings of SPIE*, Vol. 3650, p. 128–137 (January, 1999)

[2] IEC TTA-3:1997, IKEDA H., ABE M., and HIGAKI Y. "Equipment independent colour reproduction systems", IEC Technical Trend Assessment, No.3, IEC Geneva (1997)

[3] JIS Z 8724:1996, *Methods of measurement for light source colour*

[4] IKEDA H., ABE M., HIGAKI Y., KOBAYASHI T. and NAKAMICHI M. "Automated Evaluation of Colour Reproduction for Colour Video Cameras", *IEE Conference Publication* No.335, p.31–38 (June, 1991)

[5] IKEDA H. "Colorimetric parameters in television systems", *Journal of the Institute of Television Engineers of Japan*, Vol.43, No.6, p. 620–622 (June, 1989)

[6] ROBERTSON A.R. "Computation of correlated color temperature and distribution temperature," *J. Opt. Soc. Amer.*, Vol. 58, No. 11, p. 1528–1535 (November, 1968).

[7] CIE 63:1984, *The spectroradiometric measurement of light sources*

[8] CIE 105:1993, *Spectroradiometry of pulsed optical radiation sources*

[9] CIE15.2:1986, *Colorimetry*

[10] IEC 61966-2-2:2003, *Multimedia systems and equipment – Colour measurement and management – Part 2-2: Colour management – Extended RGB colour space – scRGB*

[11] IEC 61966-8:2001, *Multimedia systems and equipment – Colour measurement and management – Part 8: Multimedia colour scanners*

[12] ISO 14524:1999, *Photography – Electronic still-picture cameras – Methods for measuring opto-electronic conversion functions (OECFs)*

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