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**Multimedia systems and equipment – Colour measurement and management –
Part 7-1: Colour printers – Reflective prints – RGB inputs**

**Systèmes et appareils multimédia – Mesure et gestion de la couleur –
Partie 7-1: Imprimantes couleur – Imprimés à réflexion – Entrées RVB**

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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Letters and symbols	9
5 Conditions	9
5.1 Environmental conditions	9
5.2 Sampling conditions	10
5.3 Measurement conditions.....	11
5.4 Method of calculation	12
6 Spectral characteristics	14
6.1 Attributes to be measured	14
6.2 Method of measurement.....	14
6.3 Presentation of the result	14
7 Basic colorimetric characteristics.....	15
7.1 Attribute to be measured	15
7.2 Method of measurement.....	15
7.3 Presentation of the results.....	15
8 Tone reproduction characteristics.....	16
8.1 Attribute to be measured	16
8.2 Method of measurement.....	16
8.3 Presentation of the results.....	17
9 Spatial non-uniformity characteristics	18
9.1 Attribute to be measured	18
9.2 Method of measurement.....	18
9.3 Presentation of the result	18
10 Temporal instability characteristics	19
10.1 Short-term instability	19
10.2 Long-term instability.....	20
11 Dependency on illuminant characteristics	23
Annex A (normative) Values in the colour test-chart file	26
Annex B (normative) Specification of the measurement positions in the spatial non-uniformity test-chart file and the reporting form	32
Annex C (normative) Specification for the measurement of short-term instability characteristics	37
Annex D (informative) Estimation of effect for backing material change	38
Annex E (informative) Layout of the colour test-chart file reproduced as a reflective print	39
Annex F (informative) Layout of the spatial non-uniformity test-chart file reproduced as a reflective print	40
Annex G (informative) Layout of the short-term instability test-chart file reproduced as a reflective print	41
Bibliography.....	42

Figure 1 – Spectral reflectance of the primary and secondary saturated colours, and white, grey and black	15
Figure 2 – Example plots for gamut of colours in the CIE 1976 $L^*a^*b^*$ colour space.....	16
Figure 3 – An example of reporting tone reproduction characteristics.....	17
Table 1 – Reference to Table A.1	14
Table 2 – Reference to Table A.3	17
Table 3 – Conditions for sampling and measurements	19
Table 4 – Specification of data in the colour test chart file and the form for reporting the result in the long-term instability measurement	22
Table 5 – Specification of colour patches	23
Table 6 – Specification of data in the colour test chart file and the form of reporting the result of dependency on illuminants measurement –	24
Table 7 – Specification of data in the colour test chart file and the form of reporting the result of dependency on illuminants measurement –	25
Table A.1 – Specification of the colour test chart file and the form for reporting – Primary colours.....	26
Table A.2 – Specification of the colour test-chart file and the form for reporting – 6-by-6-by-6 cubic data	26
Table A.3 – Specification of the colour test-chart file and the form for reporting – Data and form for gradation	30
Table B.1 – Form of reporting with measurement positions	32
Table C.1 – Short-term instability characteristics	37

IEC 61966-7-1:2006
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**MULTIMEDIA SYSTEMS AND EQUIPMENT –
COLOUR MEASUREMENT AND MANAGEMENT –**

Part 7-1: Colour printers – Reflective prints – RGB inputs

FOREWORD

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International Standard IEC 61966-7-1 has been prepared by Task Area 2: Colour measurement and management, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This second edition cancels and replaces the first edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition.

- a) In addition to the default illuminant, D50, D65, F11 and illuminant A were added as optional illuminants.
- b) The numbering of the colour patches in the test-chart file was changed for easy understanding of the measurement location.
- c) Two test-chart files: short-term instability test chart and spatial non-uniformity test chart were added.

This bilingual version (2012-08) corresponds to the monolingual English version, published in 2006-05.

The text of this standard is based on the following documents:

FDIS	Report on voting
100/1061FDIS	100/1082/RVD

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

The French version of this standard has not been voted upon.

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 (proposed work item)
- Part 2-1: Colour management – Default RGB colour space – sRGB
- Part 2-2: Colour management – Extended RGB colour space – scRGB
- Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYC (to be published)
- Part 2-5: Colour management – Optional RGB colour space – opRGB (under consideration)
- 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 (proposed work item)
- Part 8: Multimedia colour scanners
- Part 9: Digital cameras
- Part 10: Quality assessment – Colour image in network systems (proposed work item)
- Part 11: Quality assessment – Impaired video in network systems (proposed work item)

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

This part of IEC 61966 is applicable to characterization of colour printers that produce colour on opaque substrate corresponding to digital data files in which colour image information is expressed in a red–green–blue colour space. The characterization will be realized by objective measurements to be utilized for colour management in open systems. The measured and reported results are used to relate the equipment-dependent and undefined red–green–blue colour space to the default RGB colour space defined as the sRGB by IEC 61966-2-1. This standard is also applicable to assessment of colour image attributes on reflective prints reproduced from colour digital image files.

The recommended usage of the standard is for evaluation of the output of home and office RGB printers.

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MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 7-1: Colour printers – Reflective prints – RGB inputs

1 Scope

This part of IEC 61966 specifies a set of data in colour test chart files for measurements, sampling of successive prints, measurement conditions and forms of reporting the results so as to make possible the characterization of the colour printer and comparison of the results of measurements. The sets of data for measurements are in colour test chart files expressed in a red–green–blue colour space, to which corresponding colour images are reproduced on reflective substrate. The methods of measurement in this standard are designed to be applicable to reflective colour prints for consumer use. The reflective colour prints may be produced by non-impact colour printers, incorporating such technologies as ink-jet, sublimation transfer, thermal transfer, electro-photography and other similar technologies.

This standard does not specify limiting values for various attributes.

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*

ISO 216:1975, *Writing paper and certain classes of printed matter – Trimmed sizes – A and B series*

ISO/CIE 10526:1999, *CIE standard illuminants for colorimetry*

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

CIE 15, *Colorimetry*

3 Terms and definitions

For the purposes of this document, terms and definitions which relate to lighting in IEC 60050(845), as well as the following, apply.

3.1

colour printer

system composed of an application programme to handle colour digital image files, a driver for equipment that produces colour images on a substrate, and the equipment itself which accepts equipment specific data for each input channel and is able to process by such technologies as ink jet, sublimation transfer, thermal transfer, or electro-photography and other similar technologies

NOTE The colour printer includes a system whereby the equipment that reproduces prints is connected direct to another piece of equipment in which a set of colour digital image data is contained.

3.2

driver

software code which converts output data from an application programme to feed a series of digital signals to the equipment which produces reflective prints

3.3

application programme

any software which has access to the colour digital image file and output colour image information to the driver, and possibly renders the colour image on displays

3.4

consumable

any material necessary to run colour printers; for example, sheets of paper, toners, ink, fuser oil, etc.

3.5

half-tone screen

set of rules for two-dimensional pixel layouts to render a tone

3.6

image

visible two-dimensional representation of electronic signals intended to form a picture

3.7

substrate

opaque substance providing support for a medium

3.8

reflective print

colour image reproduced on a piece of substrate

3.9

gamut of colours

three-dimensional maximum range of reproducible colours expressed in the CIE 1976 $L^*a^*b^*$ colour space defined in CIE15

3.10

primary colours

colours used to define a colour space incorporated in the colour digital image file

NOTE Red, green and blue are the primary colours for this standard.

3.11

secondary colours

colours to be defined by a mixture of two primary colours except black

NOTE Cyan, magenta and yellow are the secondary colours for this standard.

3.12

saturated colours

primary colours and secondary colours intended to be reproduced corresponding to their maximum excitation of electronic signals

NOTE Saturation means the maximum excitation purity (chromaticity) limited by each specific system.

3.13

reproduced colours

colorimetric information measured from the reflective print, expressed in the CIE 1976 colour space defined in CIE 15

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3.14**tone reproduction**

relationship between data in the colour digital image file which are intended to reproduce the images of primary, secondary and achromatic colours and the CIE 1976 lightness values of reflective prints actually reproduced

3.15**characterization**

process of obtaining the spectral characteristics, basic colorimetric characteristics, tone reproduction characteristics, spatial non-uniformity characteristics, temporal instability characteristics or dependency on illuminant characteristics. In general, these characteristics relate the input RGB signal to some measured CIE colour values

3.16**electronic signal**

data prepared as a colour digital image file intended to form a picture

4 Letters and symbols

The letters and symbols consistently adopted in this part of IEC 61966 are summarized below.

N_s	Number of samples of reflective prints for measurements
N_u	Metric in colour difference ΔE_{ab}^* for spatial non-uniformity within a page
N_t	Metric in colour difference ΔE_{ab}^* for short-term instability among successive reflective prints
p	Printing speed of the colour printer
$S(\lambda)$	Spectral power distribution of the illuminant D50 as default, D65, F11 and illuminant A optional
$\rho(\lambda)$	Spectral reflectance of a printed image
D_R, D_G, D_B	Digital data in integers fed to colour printers
R, G, B	Data normalized by $2^N - 1$, where N is the number of bits per channel
$\tilde{L}^*, \tilde{a}^*, \tilde{b}^*$	Colour in CIE 1976 UCS in reference to printed colour white (see also equation (4))

NOTE Special attention should be given to the illuminant and illumination used. Future work is hoped for in this area for consumer situations.

5 Conditions**5.1 Environmental conditions**

Sampling and measurements shall be carried out within the environmental conditions specified by the manufacturer of the equipment that produces reflective prints, unless otherwise specified by this standard. The environmental conditions, at least the room temperature and the relative humidity, during sampling and measurement shall be reported, together with the presentation of the results of measurements.

NOTE Recommended environmental conditions are a temperature of $20\text{ °C} \pm 5\text{ °C}$, a relative humidity of $65\% \pm 10\%$ and atmospheric pressure from 86 kPa to 106 kPa, unless otherwise specified.

5.2 Sampling conditions

5.2.1 Substrate

The substrate shall be opaque as specified by the manufacturer of the equipment that produces reflective prints as either recommended or default. The substrate shall be exposed for at least one day in order to be accustomed to the environmental conditions.

5.2.2 Settings and operation

5.2.2.1 Half-tone screen

All sampling shall be carried out in the half-tone screen mode whenever applicable. This shall be as specified by the manufacturer of the equipment that produces reflective prints as either recommended or default. When multiple options such as half-tone screen for texts, graphics, and natural pictures are available, the choices shall be reported together with the presentation of the results of measurements.

If the half-tone screen is not applicable, this shall be reported together with the presentation of the results.

5.2.2.2 Resolution

All sampling shall be carried out with the resolution setting specified by the manufacturer of the equipment that produces reflective prints as either recommended or default. When multiple options such as resolution for texts, graphics, natural pictures are available, the choices shall be reported together with the presentation of the results of measurements.

5.2.2.3 Miscellaneous settings

Colour rendering, digital filtering and tone reproduction characteristics shall be set as specified by the manufacturer of the printing equipment that produces reflective prints as either recommended or default.

The application programme used should provide no extra colour processing or enhancement. Otherwise, a type of colour processing or enhancement shall be reported.

5.2.3 Number of samples

To minimize an error due to short-term variation and non-uniformity within a page, the number of samples of reflective prints N_s should be decided by equation (1), except for Clause 9, and 10.1 and 10.2.

$$N_s = \sqrt{N_u^2 + N_t^2} \quad (1)$$

where N_u is the metric in colour difference ΔE_{ab}^* for spatial non-uniformity within a page as defined in equation (7) and N_t is the metric in colour difference ΔE_{ab}^* for short-term instability among successive reflective prints as defined in equation (8).

The number of samples less than N_s shall be reported together with the presentation of the results of measurements.

NOTE For simplicity of the characterization procedure, $N_s = 1$ may be allowed.

5.2.4 Operation of colour printers

All sampling shall be carried out in line with the conditions specified in the operation manuals of the colour printer, unless otherwise specified in this standard.

5.2.5 Electric power source

All sampling shall be carried out with an a.c. power source with nominal voltage $\pm 10\%$ of stable frequency.

5.2.6 Consumables

All sampling shall be carried out with the consumables for the equipment that produces reflective prints as specified by the manufacturer of the equipment.

5.2.7 Other conditions

All sampling shall be carried out after the warm-up time specified by the manufacturer of the equipment that produces reflective prints, unless otherwise specified in this standard.

NOTE If the equipment that produces reflective prints has multiple paper trays, any paper tray can be used for sampling.

5.3 Measurement conditions

5.3.1 General

To minimize an error due to instability of the instruments for colorimetric measurement, the reflective prints shall be measured at least three times and the measured data shall be averaged. The number of average times less than three shall be reported together with the presentation of the results of measurements.

5.3.2 Spectrophotometric and colorimetric measurements

Reflective prints shall be measured successively without any time interval, unless otherwise specified.

For spectrophotometric measurement, spectral reflectance of the reflective prints shall be measured over the wavelengths at least from 400 nm to 700 nm every 10 nm for the reflective print illuminated by incandescent lamps and every 5 nm for the reflective print illuminated by fluorescent lamps.

NOTE 1 The measurement over the wavelengths from 380 nm to 780 nm is recommended.

NOTE 2 The spectral reflectance should be measured using a spectrophotometer with either $0^\circ/45^\circ$ or $45^\circ/0^\circ$ geometry as specified in ISO 5-4, in order to remove the specular component of the reflected light.

NOTE 3 With some media and colorants, fluorescence may affect the colorimetry measured.

For colorimetric measurement, the spectral radiance of the illumination shall be approximated to the illuminant D50, as default, defined in Table 1.1 of CIE 15.

The name of the manufacturer of the measuring instrument, the model number and the manufactured date shall be reported together with the measured results.

5.3.3 Backing material

White backing material, such as five pieces or more of the same substrate on which the colour image is printed, shall be used. When other backing materials are used, the specification of the material shall be reported together with the presentation of the results of measurements.

NOTE For estimation of the effect of backing material changes, refer to Annex D.

5.4 Method of calculation

5.4.1 Illuminants and colorimetric observers

The illuminant D50, as default, defined in Table 1.1 of CIE 15 and the CIE 1931 Standard Colorimetric Observer defined in ISO/CIE 10527 shall be used for calculation of the tristimulus values from the measured spectral data. D65, F11 and illuminant A can be used for the calculation as optional. If any other illuminants are used, this shall be reported.

NOTE For some measurements, optical reflective density may be used but it should be noted that the measured values depend on the instruments used for the measurement.

5.4.2 Tristimulus values

The tristimulus values X , Y and Z in the CIE 1931 XYZ colour space for object colours and illuminant colours shall be calculated by the summations of the products of the spectral power distribution $S(\lambda)$ of the illuminant D50 as default, D65, F11 and illuminant A as optional, the spectral reflectance $\rho(\lambda)$ of the printed image, and the colour matching functions $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, $\bar{z}(\lambda)$, in accordance with equation (2).

$$\begin{aligned} X &= \frac{1}{K} \int_{\text{vis}} S(\lambda) \rho(\lambda) \bar{x}(\lambda) d\lambda \\ Y &= \frac{1}{K} \int_{\text{vis}} S(\lambda) \rho(\lambda) \bar{y}(\lambda) d\lambda \\ Z &= \frac{1}{K} \int_{\text{vis}} S(\lambda) \rho(\lambda) \bar{z}(\lambda) d\lambda \end{aligned} \quad (2)$$

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where $K = \int_{\text{vis}} S(\lambda) \bar{y}(\lambda) d\lambda$.

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5.4.3 CIELAB colour space

The CIELAB values L^* , a^* and b^* in the CIE 1976 $L^*a^*b^*$ colour space shall be calculated as in equation (3) in accordance with CIE 15.

$$\begin{aligned} L^* &= 116 \left(\frac{Y}{Y_n} \right)^{\frac{1}{3}} - 16 \\ a^* &= 500 \left\{ \left(\frac{X}{X_n} \right)^{\frac{1}{3}} - \left(\frac{Y}{Y_n} \right)^{\frac{1}{3}} \right\} \\ b^* &= 200 \left\{ \left(\frac{Y}{Y_n} \right)^{\frac{1}{3}} - \left(\frac{Z}{Z_n} \right)^{\frac{1}{3}} \right\} \end{aligned} \quad (3)$$

where the tristimulus values X_n , Y_n and Z_n correspond to the default illuminant D50; $X_n = 96,42$, $Y_n = 100,00$ and $Z_n = 82,49$ to optional illuminant D65; $X_n = 95,04$, $Y_n = 100,00$ and $Z_n = 108,89$ to optional illuminant F11; $X_n = 100,95$, $Y_n = 100,00$ and $Z_n = 64,37$ to optional illuminant A; $X_n = 109,85$, $Y_n = 100,00$ and $Z_n = 35,58$.

Relative values to the colour white shall also be calculated when it is required in accordance with equation (4).

$$\begin{aligned}
 \tilde{L}^* &= 116 \left(\frac{Y}{Y_W} \right)^{\frac{1}{3}} - 16 \\
 \tilde{a}^* &= 500 \left\{ \left(\frac{X}{X_W} \right)^{\frac{1}{3}} - \left(\frac{Y}{Y_W} \right)^{\frac{1}{3}} \right\} \\
 \tilde{b}^* &= 200 \left\{ \left(\frac{Y}{Y_W} \right)^{\frac{1}{3}} - \left(\frac{Z}{Z_W} \right)^{\frac{1}{3}} \right\}
 \end{aligned} \tag{4}$$

where the tristimulus values X_W , Y_W and Z_W correspond to the printed colour white resulting from $D_R = D_G = D_B = 2^N - 1$ under the illuminant D50 as default, D65, F11 and illuminant A optional.

5.4.4 Averaging CIELAB values

The colorimetric values in the CIELAB colour space for reproduced colour chips obtained by multiple printing jobs shall be averaged over all the measured and calculated values as in equation (5).

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$$\begin{aligned}
 \bar{L}^* &= \frac{1}{N_s} \sum_{n=1}^{N_s} L_n^* \\
 \bar{a}^* &= \frac{1}{N_s} \sum_{n=1}^{N_s} a_n^* \\
 \bar{b}^* &= \frac{1}{N_s} \sum_{n=1}^{N_s} b_n^*
 \end{aligned} \tag{5}$$

<https://standards.iteh.ai/catalog/standards/sist/375af91c-cac5-44e9-b91c-03a25055373b/iec-61966-7-1-2006>

for Clauses 6, 7 and 8, where N_s is the number of printing jobs defined in equation (1); and

$$\begin{aligned}
 \bar{L}^* &= \frac{1}{M} \sum_{m=1}^M L_m^* \\
 \bar{a}^* &= \frac{1}{M} \sum_{m=1}^M a_m^* \\
 \bar{b}^* &= \frac{1}{M} \sum_{m=1}^M b_m^*
 \end{aligned} \tag{6}$$

for 10.1, where M is the number of printing jobs defined in 10.1.2. For simplicity, \bar{L}^* , \bar{a}^* and \bar{b}^* are written without the bars in the following clauses.