BRITISH STANDARD

BS EN 61966-8:2001
IEC 61966-8:2001

# Multimedia systems and equipment — Colour measurement and management —

## Part 8: Multimedia colour scanners

The European Standard EN 61966-8:2001 has the status of a British Standard

ICS 33.160.60; 35.180

# National foreword

This British Standard is the official English language version of EN 61966-8:2001. It is identical with IEC 61966-8:2001.

The UK participation in its preparation was entrusted to Technical Committee EPL/100, Audio, video and multimedia systems and equipment, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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EUROPEAN STANDARD **EN 61966-8**

NORME EUROPÉENNE

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English version

# Multimedia systems and equipment - Colour measurement and management Part 8: Multimedia colour scanners
(IEC 61966-8:2001)

Systèmes et appareils multimédia -
Mesure et gestion de la couleur
Partie 8: Numériseurs couleur
(CEI 61966-8:2001)

Multimediasysteme und -geräte -
Farbmessung und Farbmanagement
Teil 8: Multimedia-Farbscanner
(IEC 61966-8:2001)

This European Standard was approved by CENELEC on 2001-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**



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## Foreword

The text of document 100/192/FDIS, future edition 1 of IEC 61966-8, prepared by IEC TC 100, Audio, video and multimedia systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61966-8 on 2001-04-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (don) 2002-01-01

– latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2004-04-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annexes A, B and ZA are normative and annex C is informative.
Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 61966-8:2001 was approved by CENELEC as a European Standard without any modification.

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# INTRODUCTION

This introduction is intended to distinguish the field of application of ISO 12641 and IEC 61966-8.

In order to standardize the calibration procedure for input scanners used in the printing and prepress industry, ISO 12641 was published in 1997. This part of IEC 61966 targets colour scanners for multimedia applications by providing characterization data necessary for colour management in open multimedia systems. It characterizes any multimedia colour scanners for consumer use, typically being connected to personal computers so as to capture colour images and display the colour information, either locally or distributed worldwide.

In such applications, colour management is important. Any red – green – blue data should have their colorimetric attributes clearly specified. The characterization data reported from this part of IEC 61966 will be used for the calculation of equipment specific colorimetric characterization so that colour management in open systems can be conducted.

The capture of colour information in a prepress input scanner usually assumes that the source is a positive film (transparent) original. The second most common type of original is positive photographic printing paper (reflective). Recently, prepress input scanners can support various types of reflective originals in addition to printing paper and can also capture an image directly from a negative film, although this is not yet very common. Due to these circumstances, ISO 12641 was established for prepress digital data exchange corresponding to transparent and reflective originals. However, a standard colour target for transparent film negative originals has not yet been established.

Spectral sensitivity characteristics of prepress scanners are not derived from the calculation based on a special colour system or the spectral distribution of printing ink; but are base signals relatively close to the three primary colours (red, green, blue) acquired for calibration purposes. The characteristics of the prepress input scanners are guaranteed by the experience of the operator or the sophistication of the colour processing application so that subtle variations among the colours appear in the printed result. In fact, printing and prepress scanners have many settings that are made available to professional users, and the operator can control the input scanner characteristics in a non-linear fashion to suit their objectives. In older input scanners, these controls were part of the stand-alone scanner system itself. For the scanners of the printing industry, these controls are typically part of the colour processing application software which processes the signals after capture and transfers them to the general purpose computer (workstation or server). In other words, a highly experienced and skilled operator can adjust the settings to freely change scanner characteristics such as tone and colour separation as he desires. Furthermore, scanner characteristics can be changed to correct and compensate for the characteristics of the original image target, such as colour fogging, as well as absorb them, and the operator can even change scanner colour separation conditions (typically cyan, yellow, magenta and black) in anticipation of the later printing process so as to obtain the most feasible printed result. As such, on the site of the prepress scanner, good colour separation (reproduction) is and has been dependent on the skill of the operator.

All prepress input scanners show variation in colour sensitivity characteristics depending on types, manufacturers, manufactured time and condition. Prepress input scanners tend to show less variation than other general-purpose multimedia colour scanners because of their usage in critical colour capturing in a closed system in comparison with the worldwide open system such as the Internet. There has never been an attempt to standardize the colour characteristics of prepress input scanners put on the market by different manufacturers.

However, it is demanded that the printing process should produce essentially the same results from the same original regardless of the input scanner used. This demand has been accomplished by the skill of the operator. For this reason, the process of scanning, including colour processing for the raw data, should involve the human operator, and the total system be considered as one system. In this human-machine interaction system, the characteristics can be understood as unified or standardized.

Under these circumstances, and in consideration of the actual work process, ISO/TC 130 (Graphic technology) has established a method using a colour target as stipulated in ISO 12641 for prepress input scanner calibration that includes functions capable of handling colour changes accompanying local distortions in colour regions. These targets for both positive reflective material (photographic printing paper) and positive transmission material (photographic film) are implemented by the photographic manufacturers on their specific materials of their particular products.

Multimedia colour scanners for general use which are much less expensive in comparison with prepress input scanners, are available for small office/home office personal computers. Targets for scanning are not specified as in prepress input scanners. Images of natural objects such as the petals of violets, green plants or human skin will be most important. As many of the users of multimedia colour scanners are not colour experts, it is preferable to have an automatic system requiring minimal adjustment. The manufacturers of this type of colour scanner do not provide colorimetric specifications of the red – green – blue data obtained from their scanner on one hand. On the other hand, the data obtained from the multimedia colour scanner are easily compressible and compatible to the World Wide Web and anonymous users will use the colour information in colour reproduction without having available the specific features of the original generator.

Prepress scanners have been used for many years in the printing and prepress industry and an environment has already been created in which only prepress scanners meeting certain critical criteria are selected. This being the case, there is no need for a new evaluation of prepress input scanner performance. In such an environment, however, the maintenance of input scanner quality is important and it is necessary and sufficient to calibrate a scanner using the appropriate target. The internationally standardized target in ISO 12641 exists for this purpose.

However, open multimedia systems and composing equipment creates a new environment different from the conventional printing industry, and the colour scanners used for multimedia systems have not undergone a similar evaluation process in related industries. In the multimedia environment, it is assumed that multimedia colour scanners will be used for a variety of purposes. This means that the initially assumed environment will vary and the functions required for individual multimedia colour scanners will also vary. In other words, the multimedia colour scanners supplied to the market and bought by general users might be designed for different purposes and will not all assure the same quality and characteristics. This will not be the case if multimedia colour scanner specifications are unified in the future; however, there is currently no movement in this direction.

Therefore, it would be a great advantage to the general user, if he could evaluate the characteristics of the multimedia colour scanner he is about to buy and judge whether it suits his purpose. In other words, knowing the colour reproduction characteristics of each scanner before making a decision, would allow the user to select a multimedia colour scanner having characteristics suited to his purpose.

While there is hope that scanners used in a multimedia environment will undergo critical evaluation in the market over time, the ability to quantitatively evaluate the colour reproduction of such multimedia colour scanners would be of direct benefit to the critical issue of colour management that we now face.

The purpose of IEC 61966-8 is to provide a method for evaluating the colour reproduction of multimedia colour scanners used in a multimedia environment and allows the specification of their colour reproduction characteristics from spectral transmission functions, which can be used for colour management. In an environment such as multimedia that has not yet matured and is constantly developing, the most critical consideration is determining whether or not a multimedia colour scanner is suited to the intended purpose. For this reason, IEC 61966-8 must be viewed separately from strict standards (such as ISO 12641) applicable to the equipment once characteristics have reached a certain level. As such, IEC 61966-8 is presented as a critical, though interim tool, during the undetermined period of evolution of these types of scanners.

Colour control within the equipment is out of the scope of this part. This is because the output data of a multimedia colour scanner depend on the spectral characteristics of the colour pigments or colour inks of the original and a large variety of originals with different pigments or inks has to be considered in office and multimedia applications, for example, photographic colour pigments, offset printing colours, ink jet colours, painting art colours, etc. The output data of the multimedia colour scanner are the result of the spectral reflection of a colour of a document under the in-built light source and the respective selection by the spectral sensitivity curves of the three sensor channels of the multimedia colour scanner. Since the spectral sensitivity curves of multimedia colour scanners do not fit a linear combination of the colour matching functions in ISO/CIE 10527, metameric colours scanned from different colour originals will result in different output data.

Due to this fact, colour control and management requires the restriction to certain classes of colour inks of the originals to be scanned. The multimedia colour scanner characterization of this standard therefore focuses on the characterization of spectral transfer functions of the three channels as multiband sensitivities and achromatic tone characteristics. This enables the user of the standard to optimize colour management for his own class of originals. An example for the use of the spectral characterization defined in this standard to specify sRGB values according to IEC 61966-2-1 is given in annex C.

# MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

## Part 8: Multimedia colour scanners

### 1 Scope and object

This part 8 of IEC 61966 is applicable to the characterization and assessment of multimedia colour scanners used in computer systems, multimedia and similar applications.

The methods of measurement standardized in this part are designed to make possible the characterization and objective performance assessment of multimedia colour scanners which can capture colour images and output colour information such as red, green and blue data from reflective originals. The measured results are intended to be used for the purpose of colour management in multimedia systems. Measurement conditions, possible methods of measurement and characterization are defined to make colour management possible.

Colour control within the equipment is out of the scope of this part. For calibration of prepress input scanners, ISO 12641 will be applied.

### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61966. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61966 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(845)/CIE 17.4:1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting – International Lighting Vocabulary* (IEC/CIE joint publication)

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

CIE 15.2:1986, *Colorimetry*

ISO 5-4:1995, *Photography – Density measurements – Part 4: Geometric conditions for reflection density*

ISO 9241-8:1997, *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 8: Requirements for displayed colours*

ISO 12641:1997, *Graphic technology – Prepress digital data exchange – Colour targets for input scanners calibration*

ISO 13655:1996, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*

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

## 3 Terms and definitions

For the purpose of this part of IEC 61966, the definitions given in IEC 60050(845)/CIE 17.4 and the following apply.

**3.1**
**illuminant E**
illuminant of constant spectral power distribution $S_n = 1$ where $S_n$ represents the relative radiant power in the $n$-th interval per 10 nm bandwidth

**3.2**
**input scanner**
equipment capable of converting the light reflected by a photographic paper into electronic signals, where the electronic signals are arranged to have an organized relationship to the spatial areas of the paper evaluated

**3.3**
**multimedia colour scanner**
electrotechnical equipment with a light source illuminating a scanning area where an original is placed, which provides means to sense colour signals from the light reflected from specified picture elements within the scanning area in digital form as output data

**3.4**
**driver software**
computational function to control the multimedia colour scanner from internal parameters and parameters specified by the user such as scaling of scan, spatial resolution, etc. comprising a colour control function to convert the colour signals of the multimedia colour scanner into approximate components of a defined colour space such as the sRGB colour space in IEC 61966-2-1 or an equipment independent colour space such as the CIE 1931 XYZ colour space or the CIELAB colour space in CIE 15.2

**3.5**
**light flux**
incident radiant power valued by physical spectral responsivities

**3.6**
**scanning area**
dimension of the area to be scanned, given in square centimetres or the number of resolved picture elements along the vertical and the horizontal directions from which digital image data are made readily available at the output

**3.7**
**spatial resolution**
number of picture elements used to describe a region of an image of fixed spatial size

**3.8**
**scaling of scan**
magnification or reduction of pieces of the scanning area and corresponding image data

**3.9**
**target**
image composed of grey patches or colour patches for use in the measurement for characterization of multimedia colour scanners

**3.10**
**original**
reflective material, for example, a sheet of paper, a photograph, a hardcopy, etc. to be scanned to obtain corresponding red, green and blue data

## 4 Letters and symbols

The notations consistently adopted in this part of IEC 61966 are summarized below.

$\Phi_R$: normalized light flux reflected from the target and captured by the red channel. See also 3.5 for the definition of light flux

$\Phi_G$: normalized light flux reflected from the target and captured by the green channel. See also 3.5 for the definition of light flux

$\Phi_B$: normalized light flux reflected from the target and captured by the blue channel. See also 3.5 for the definition of light flux

$D_R$: integer data obtained from the red channel of the multimedia colour scanner averaged for more than 10 × 10 picture elements corresponding to the centre of a patch of the target

$D_G$: integer data obtained from the green channel of the multimedia colour scanner averaged for more than 10 × 10 picture elements corresponding to the centre of a patch of the target

$D_B$: integer data obtained from the blue channel of the multimedia colour scanner averaged for more than 10 × 10 picture elements corresponding to the centre of a patch of the target

$d_R$: normalized $D_R$ by $2^N - 1$

$d_G$: normalized $D_G$ by $2^N - 1$

$d_B$: normalized $D_B$ by $2^N - 1$

$N$: the number of bits per channel

$Y$: luminance factor. One of the tristimulus values in the CIE 1931 XYZ colour space with the reference illuminant E

$\lambda_n$: the $n$-th wavelength at the centre of 10 nm wavelength band

$S_n$: spectral power of a built-in light source at the centre wavelength $\lambda_n$

$p_{R_n}$: physical spectral sensitivities at the centre wavelength $\lambda_n$ of the red channel

$p_{G_n}$: physical spectral sensitivities at the centre wavelength $\lambda_n$ of the green channel

$p_{B_n}$: physical spectral sensitivities at the centre wavelength $\lambda_n$ of the blue channel

$s_{R_n}$: effective spectral sensitivities at the centre wavelength $\lambda_n$ as response of light flux being captured by the red channel; it is a linear combination of $p_{R_n}$, $p_{G_n}$ and $p_{B_n}$

$s_{G_n}$: effective spectral sensitivities at the centre wavelength $\lambda_n$ as response of light flux being captured by the green channel; it is a linear combination of $p_{R_n}$, $p_{G_n}$ and $p_{B_n}$

$s_{B_n}$: effective spectral sensitivities at the centre wavelength $\lambda_n$ as response of light flux being captured by the blue channel; it is a linear combination of $p_{R_n}$, $p_{G_n}$ and $p_{B_n}$

$r_{k_n}$: spectral reflectance of the $k$-th colour patch at the centre wavelength $\lambda_n$

$K$: the number of usable colour patches

# 5 Conditions

## 5.1 General conditions

Unless otherwise specified, automatic functions shall be disabled to prevent the multimedia colour scanner from responding automatically to the target and from establishing scanning conditions. This condition shall not be changed during the period of the test.

The scaling of scan shall be set to unity. Resolution of scanning shall be set to the maximum spatial resolution. The multimedia colour scanner shall be powered on 1 h before the measurement, except for the measurement in clause 12.

Environmental conditions such as temperature and relative humidity shall be reported together with the results of measurement. If additional environmental conditions are described in the manufacturer's specifications, these should be taken into account.

Unless otherwise stated in this standard, conditions of measurement shall be set to the conditions recommended by the manufacturer as default conditions.

### 5.2 Output digital image data

Red – green – blue digital image data, $D_{\mathrm{R}}$, $D_{\mathrm{G}}$, $D_{\mathrm{B}}$, corresponding to the target shall be used as basic data for reporting and further processing of the data. If direct output from the multimedia colour scanner is not available, red – green – blue data shall be calculated using the driver software provided or specified by the manufacturer of the equipment being characterized.

When a general-purpose software is used for handling the raw data, its name and version number shall be reported together with the results of measurements.

## 6 Measurement equipment and target of scan

### 6.1 Spectrophotometer

A spectrophotometer with the following specifications shall be used for the measurements.

a) Wavelength range and interval: minimum range between 400 nm and 700 nm at 10 nm intervals, measurements beyond the minimum range are permissible.

b) Geometry: 45°/0° or 0°/45° per ISO 5-4.

The guidance in ISO 13655 shall be taken into account as appropriate.

### 6.2 Spectroradiometer

A one-shot spectroradiometer, which picks up spectral data in parallel at a certain time, with the following specifications shall be used for the measurement of spectral distribution of the built-in light source in clause 7.

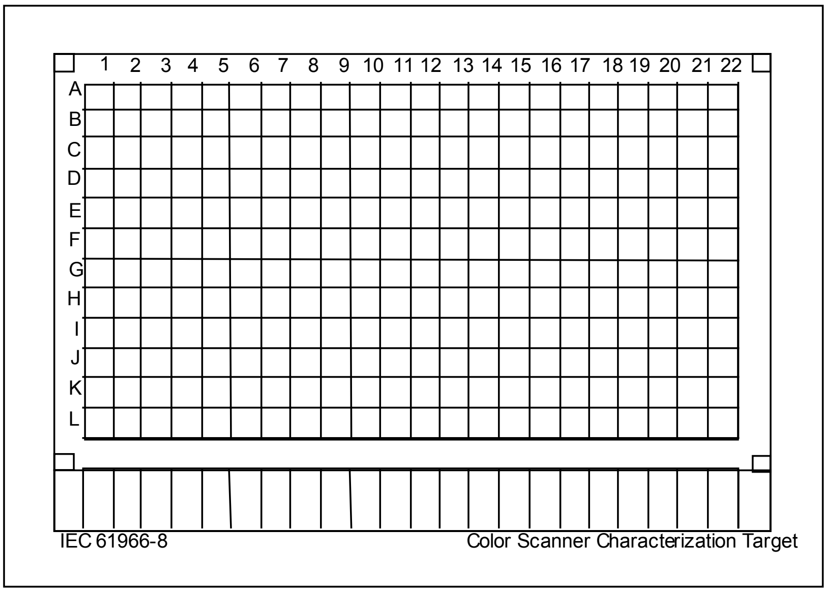
a) Wavelength range and interval: minimum range between 400 nm and 700 nm at 10 nm intervals, measurements beyond the minimum range are permissible.
b) Built-in calibrated spectral reference table.
c) Mobile sensor head to be placed on the scanning area.

### 6.3 Specification of the target

A special reflective target shall be used for the measurements in clauses 8 and 10. The layout of the target is shown in figure 1. The basic format is 12,7 cm × 17,8 cm in accordance with the ISO 12641. There are 12 rows and 22 columns of colour patches with the size of 6,5 mm × 6,5 mm. The patches at the addresses A1 to L22 are filled with selected printing colours of high saturation and strong variation of their spectral reflection.

An achromatic neutral scale lying along the bottom of the target has lightness values according to ISO 12641. The patch located to the left of step one of the grey scale (column zero) has the highest lightness value. The patch to the right of the 24th step (column 23) of the grey scale is of the lowest lightness value.

NOTE It is most important for the application in this standard that the neutral grey scale is printed from a single black colourant to assure that the spectral reflectances of the patches of the grey scale from light to dark just differ by a luminance factor.




IEC 124/01

**Figure 1 – Specification of the target for characterization of multimedia colour scanners**

Calibrated targets are the targets with measured spectral reflection of each patch on the basis of a calibrated spectrophotometer as specified in 6.1. The luminance factor $Y$ of each patch of the grey scale shall be calculated in reference to the illuminant E. The tristimulus values of each colour patch at addresses from A1 to L22 and the grey scale patches in the CIE 1931 XYZ colour space or the values in the CIELAB colour space calculated in reference to the illuminant E shall be given together with the actual target being used for characterization.

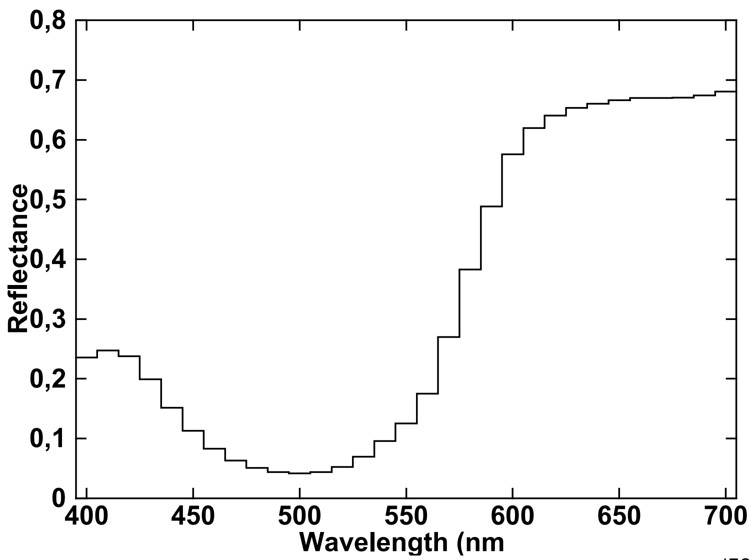
NOTE The illuminant E is the simplest illuminant which provides equally bright spectral radiant power as defined in 3.1. Under the assumption that the grey scale is neutral as specified, it does not matter which illuminant is used. In the algorithm incorporated in IEC 61966-8, the $Y$ values are used as relative factors just describing the relative response of the red, green and blue channels for the patches of the grey scale.

The multiband spectral reflection shall be specified according to the example of table 1 and its graphical representation of figure 2 at 10 nm intervals from 400 nm to 700 nm. The white reference of the spectrophotometer, normally barium sulfate or equivalent, shall be used for normalization.

**Table 1 – Example of a reporting form of a spectral table**

| $n$ | $\lambda_n$ (nm) | $r_n$ | $n$ | $\lambda_n$ (nm) | $r_n$ |
|---|---|---|---|---|---|
| 1 | 400 | 0,2358 | 17 | 560 | 0,1748 |
| 2 | 410 | 0,2474 | 18 | 570 | 0,2700 |
| 3 | 420 | 0,2377 | 19 | 580 | 0,3827 |
| 4 | 430 | 0,1993 | 20 | 590 | 0,4881 |
| 5 | 440 | 0,1517 | 21 | 600 | 0,5756 |
| 6 | 450 | 0,1129 | 22 | 610 | 0,6194 |
| 7 | 460 | 0,0827 | 23 | 620 | 0,6402 |
| 8 | 470 | 0,0629 | 24 | 630 | 0,6533 |
| 9 | 480 | 0,0507 | 25 | 640 | 0,6605 |
| 10 | 490 | 0,0437 | 26 | 650 | 0,6662 |
| 11 | 500 | 0,0419 | 27 | 660 | 0,6697 |
| 12 | 510 | 0,0441 | 28 | 670 | 0,6700 |
| 13 | 520 | 0,0526 | 29 | 680 | 0,6704 |
| 14 | 530 | 0,0697 | 30 | 690 | 0,6742 |
| 15 | 540 | 0,0957 | 31 | 700 | 0,6807 |
| 16 | 550 | 0,1253 | | | |

Spectral values are understood to represent the spectral energy in the 10 nm interval around the centre wavelengths.




IEC 125/01

**Figure 2 – Example of graphical representation of multiband spectral reflection of a colour patch**

# 7 Spectral power distribution of the built-in light source

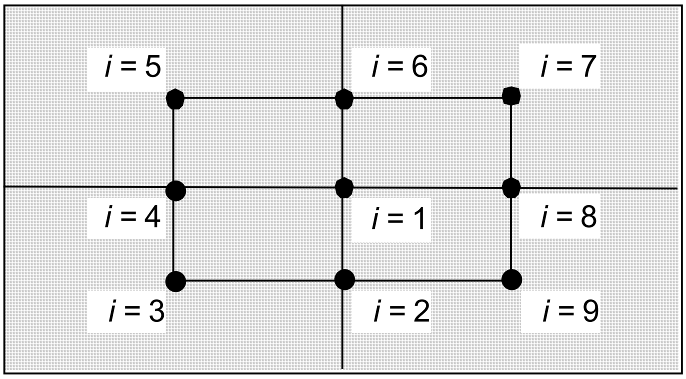
## 7.1 Characteristics to be measured

Spectral power distribution $S(\lambda_n) = S_n$ of the built-in light source normalized by $S_{16}$ for the wavelength $\lambda_n$ for the wavelength range from 400 nm to 700 nm at 10 nm intervals denoted by $n$ being from 1 for the interval centred at 400 nm to $n = 31$ for the interval centred at 700 nm with reference to the illuminant E.

NOTE If it is not possible to measure the spectral power distribution of the built-in light source(s) of the multimedia colour scanner, the following measurement as in clause 7 may be skipped. In this case, the spectral characteristics of the unknown light source should be reported as in table 2 and figure 3 and should be set to unity, which will be used as in clause 10.

## 7.2 Measurement conditions

The spectroradiometer shall be used for the measurement with the sensor head placed at the centre of the scanning area (the position $i = 1$), the sensitive area of the head parallel to the scanning area, and the eight positions from $i = 2$ to $i = 9$ half way out of the centre of the scanning area according to figure 3.




IEC 126/01

**Figure 3 – Scanning area and the points of measurement**

If the points of measurement are not accessible due to mechanical reasons, deviated points of measurement shall be reported.

## 7.3 Presentation of results

a) The average values $S_n$ of the measured values $S_{n_i}$ of the nine locations,

$$S_n = \frac{1}{9}\sum_{i=1}^{9} S_{n_i}$$

shall be calculated and reported as in table 2 together with wavelength $\lambda_n$.

**Table 2 – Example of multiband spectral characteristics of the light source**

| $n$ | $\lambda_n$ (nm) | $S_n$ | $n$ | $\lambda_n$ (nm) | $S_n$ |
|---|---|---|---|---|---|
| 1 | 400 | 0,006 | 17 | 560 | 0,134 |
| 2 | 410 | 0,025 | 18 | 570 | 0,033 |
| 3 | 420 | 0,089 | 19 | 580 | 0,081 |
| 4 | 430 | 0,211 | 20 | 590 | 0,334 |
| 5 | 440 | 0,367 | 21 | 600 | 0,311 |
| 6 | 450 | 0,459 | 22 | 610 | 0,144 |
| 7 | 460 | 0,475 | 23 | 620 | 0,209 |
| 8 | 470 | 0,415 | 24 | 630 | 0,392 |
| 9 | 480 | 0,324 | 25 | 640 | 0,063 |
| 10 | 490 | 0,532 | 26 | 650 | 0,049 |
| 11 | 500 | 0,372 | 27 | 660 | 0,038 |
| 12 | 510 | 0,316 | 28 | 670 | 0,036 |
| 13 | 520 | 0,365 | 29 | 680 | 0,050 |
| 14 | 530 | 0,242 | 30 | 690 | 0,016 |
| 15 | 540 | 0,317 | 31 | 700 | 0,025 |
| 16 | 550 | 1,000 | | | |

b) The average values $S_n$ shall also be graphically presented as exemplified in figure 3, where the horizontal axis is the wavelength in nanometres and the vertical axis denotes the normalized spectral values.

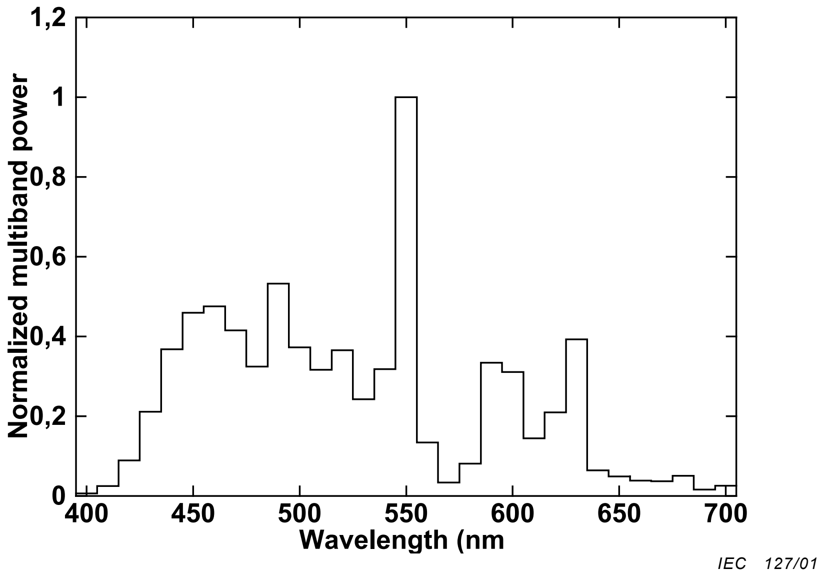



**Figure 4 – Example of the normalized spectral power distribution of the built-in light source**

## 8 Tone characteristics

### 8.1 Characteristics to be measured

Relationship between the normalized light flux, $\Phi_{R_i}$, $\Phi_{G_i}$ and $\Phi_{B_i}$, reflected from the grey patches of the grey scale of the target and captured by the red, green and blue channels and output digital image data of the red, green and blue channels normalized to their maximimum values as follows for $N$-bit quantization per channel; $d_{R_i}(\Phi_{R_i})$, $d_{G_i}(\Phi_{R_i})$ and $d_{B_i}(\Phi_{B_i})$.

$$d_{R_i} = D_{R_i} / (2^N - 1)$$
$$d_{G_i} = D_{G_i} / (2^N - 1)$$
$$d_{B_i} = D_{B_i} / (2^N - 1)$$

The grey patches are denoted by the column number $i = 0$ to $i = 23$ from left to right in the target shown in figure 1.

### 8.2 Measurement conditions

a) The target shall be placed over the surface at the centre of the scanning area.

b) A non-linear function applied to the output digital image data by the driver software should be set to unity wherever possible.

c) The red, green and blue data of the channels of the multimedia colour scanner should be set to 0,96 of the maximum data value for the mean measurements of the patch of the grey scale with the highest reflectance wherever adjustable (245 in 8-bit quantization for each channel). If it is not adjustable, a respective remark shall be made in the report of the measurement.

### 8.3 Method of measurement

a) The multiband spectral reflectance of each grey patch shall be measured using the spectrophotometer. One of the tristimulus values $Y$ in the CIE 1931 XYZ colour space for illuminant E shall be calculated from the spectral reflectances and normalized to get $Y_i$ so that the value of $Y_0 = 1{,}0$.

NOTE For these measurements, the normalized $Y_i$ values are used to represent the normalized light flux $\Phi$ captured by the red – green – blue channels with respective spectral sensitivities. This assumes constant multiband spectral distribution of the grey patches of the target, and $\Phi_{R_i} \propto Y_i$, $\Phi_{G_i} \propto Y_i$ and $\Phi_{B_i} \propto Y_i$.

b) The red, green and blue data of the channels of the multimedia colour scanner for more than 10 × 10 picture elements corresponding to the centre of the grey patches shall be averaged to obtain $D_{R_i}$, $D_{G_i}$ and $D_{B_i}$ for the grey patch $i$.

c) The scan shall be repeated 10 times for each of the grey patches and the red, green and blue data of the channels shall be averaged.

d) The measured and averaged data shall be normalized as in 8.1 and shall be recorded.

### 8.4 Calculation of results

A set of coefficients $(r_0, r_1, r_2, r_3, r_4)$ of the 4th order polynomial for the red channel, coefficients $(g_0, g_1, g_2, g_3, g_4)$ for the green channel and coefficients $(b_0, b_1, b_2, b_3, b_4)$ for the blue channel shall be calculated according to the method of the least squares as follows.

$$\left(r_0, r_1, r_2, r_3, r_4\right)^t = \mathbf{M}^{-1}\left(\sum_{i=0}^{M-1} d_{R_i}, \sum_{i=0}^{M-1} d_{R_i} Y_i, \sum_{i=0}^{M-1} d_{R_i} Y_i^2, \sum_{i=0}^{M-1} d_{R_i} Y_i^3, \sum_{i=0}^{M-1} d_{R_i} Y_i^4\right)^t \quad (1)$$

$$\left(g_0, g_1, g_2, g_3, g_4\right)^t = \mathbf{M}^{-1}\left(\sum_{i=0}^{M-1} d_{G_i}, \sum_{i=0}^{M-1} d_{G_i} Y_i, \sum_{i=0}^{M-1} d_{G_i} Y_i^2, \sum_{i=0}^{M-1} d_{G_i} Y_i^3, \sum_{i=0}^{M-1} d_{G_i} Y_i^4\right)^t \quad (2)$$

$$\left(b_0, b_1, b_2, b_3, b_4\right)^t = \mathbf{M}^{-1}\left(\sum_{i=0}^{M-1} d_{B_i}, \sum_{i=0}^{M-1} d_{B_i} Y_i, \sum_{i=0}^{M-1} d_{B_i} Y_i^2, \sum_{i=0}^{M-1} d_{B_i} Y_i^3, \sum_{i=0}^{M-1} d_{B_i} Y_i^4\right)^t \quad (3)$$

where values $d_{R_i}$, $d_{G_i}$ and $d_{B_i}$ correspond to the values $D_{R_i}$, $D_{G_i}$ and $D_{B_i}$ normalized by $2^N - 1$, respectively , and $M$ is the number of grey patches used in calculation.

The common matrix $\mathbf{M}$ is a 5 × 5 matrix with elements $m_{ij}$ defined as in equation (4).

$$m_{ij} = \sum_{k=0}^{M-1} Y_k^{(i-1)+(j-1)} \quad (4)$$

.

**8.5 Presentation of results**

a) The calculated coefficients shall be reported as shown in table 3.

**Table 3 – Example of a reporting form of the polynomial coefficients of the red, green and blue channels**

| Index ( $i$ ) | Red channel ( $r_i$ ) | Green channel ( $g_i$ ) | Blue channel ( $b_i$ ) |
|---|---|---|---|
| 0 | 0,010 753 | 0,012 568 | 0,017 003 |
| 1 | 0,973 467 | 1,035 753 | 0,954 590 |
| 2 | 0,894 595 | 0,310 046 | 1,045 692 |
| 3 | –1,560 279 | –0,121 839 | –2,004 106 |
| 4 | 1,217 356 | 0,136 919 | 1,453 908 |

b) The results of the polynomial characterization shall be reported in mathematical form with scaling factors applied as follows:

$$\begin{aligned} d_R(\Phi_R) &= r_0 + r_1\Phi_R + r_2\Phi_R^2 + r_3\Phi_R^3 + r_4\Phi_R^4 \\ d_G(\Phi_G) &= g_0 + g_1\Phi_G + g_2\Phi_G^2 + g_3\Phi_G^3 + g_4\Phi_G^4 \\ d_B(\Phi_B) &= b_0 + b_1\Phi_B + b_2\Phi_B^2 + b_3\Phi_B^3 + b_4\Phi_B^4 \end{aligned} \quad (5)$$

Data $\Phi_R$, $\Phi_G$ and $\Phi_B$ denote the normalized light flux captured by the red, green and blue channels. These responses are given by the light reflected from the scanned grey chips, picked up by the channels and weighted with the respective spectral channel sensitivities.

c) Graphical representations as shown in figure 4 shall also be reported, where the horizontal axis is the normalized light flux $\Phi_R$, $\Phi_G$ and $\Phi_B$, and the vertical axis is the evaluated values $d_R$, $d_G$ and $d_B$ of the polynomials in equation (5) with measured and normalized values as points.

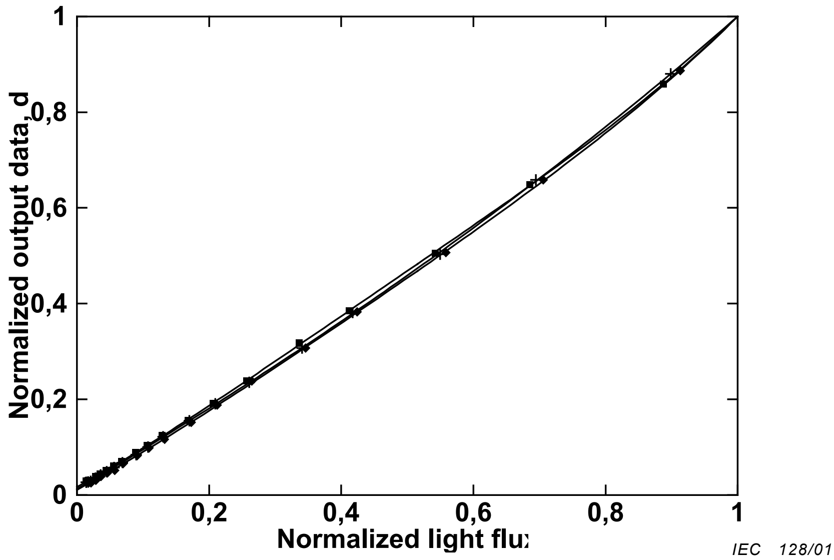



**Figure 5 – Example of reporting form of tone characteristics, light flux $\Phi$ vs. output data**

## 9 Inverse tone characteristics

### 9.1 Characteristics to be calculated

Relationship between the normalized output data $d_R$, $d_G$ and $d_B$ and normalized light flux $\Phi_R(d_R)$, $\Phi_G(d_G)$ and $\Phi_B(d_B)$ captured by the red, green and blue channels.

### 9.2 Method of calculation

A set of coefficients $(r_0^*, r_1^*, r_2^*, r_3^*, r_4^*)$ for the red channel, coefficients $(g_0^*, g_1^*, g_2^*, g_3^*, g_4^*)$ for the green channel and coefficients $(b_0^*, b_1^*, b_2^*, b_3^*, b_4^*)$ for the blue channel of polynomials of degree four shall be calculated according to the method of the least squares as follows:

$$\left(r_0^*, r_1^*, f_2^*, r_3^*, r_4^*\right)^t = \mathbf{T}_R^{-1}\left(\sum_{i=0}^{M-1} Y_i, \sum_{i=0}^{M-1} Y_i d_{R_i}, \sum_{i=0}^{M-1} Y_i d_{R_i}^2, \sum_{i=0}^{M-1} Y_i d_{R_i}^3, \sum_{i=0}^{M-1} Y_i d_{R_i}^4\right)^t \quad (6)$$

$$\left(g_0^*, g_1^*, g_2^*, g_3^*, g_4^*\right)^t = \mathbf{T}_G^{-1}\left(\sum_{i=0}^{M-1} Y_i, \sum_{i=0}^{M-1} Y_i d_{G_i}, \sum_{i=0}^{M-1} Y_i d_{G_i}^2, \sum_{i=0}^{M-1} Y_i d_{G_i}^3, \sum_{i=0}^{M-1} Y_i d_{G_i}^4\right)^t \quad (7)$$

$$\left(b_0^*, b_1^*, b_2^*, b_3^*, b_4^*\right)^t = \mathbf{T}_B^{-1}\left(\sum_{i=0}^{M-1} Y_i, \sum_{i=0}^{M-1} Y_i d_{B_i}, \sum_{i=0}^{M-1} Y_i d_{B_i}^2, \sum_{i=0}^{M-1} Y_i d_{B_i}^3, \sum_{i=0}^{M-1} Y_i d_{B_i}^4\right)^t \quad (8)$$

where $Y_i$ is considered to be the channel stimulus and $d_{R_i}$, $d_{G_i}$ and $d_{B_i}$ are the normalized output data from the red, green and blue channels recorded in 8.3 d), and $M$ is the number of data used for calculation.

$\mathbf{T}_R$, $\mathbf{T}_G$ and $\mathbf{T}_B$ are 5 × 5 matrices with elements $t_{R_{ij}}$, $t_{G_{ij}}$ and $t_{B_{ij}}$ of the form:

$$t_{R_{ij}} = \sum_{k=0}^{M-1} d_{R_k}^{(i-1)+(j-1)}$$
$$t_{G_{ij}} = \sum_{k=0}^{M-1} d_{G_k}^{(i-1)+(j-1)}$$
$$t_{B_{ij}} = \sum_{k=0}^{M-1} d_{B_k}^{(i-1)+(j-1)} \quad (9)$$

### 9.3 Presentation of results

The calculated coefficients shall be reported as shown in table 4 and in polynomial form:

$$\Phi_R(d_R) = r_0^* + r_1^* d_R + r_2^* d_R^2 + r_3^* d_R^3 + r_4^* d_R^4$$
$$\Phi_G(d_G) = g_0^* + g_1^* d_G + g_2^* d_G^2 + g_3^* d_G^3 + g_4^* d_G^4$$
$$\Phi_B(d_B) = b_0^* + b_1^* d_B + b_2^* d_B^2 + b_3^* d_B^3 + b_4^* d_B^4 \quad (10)$$

where data $d_R$, $d_G$ and $d_B$ are the normalized output data produced by the normalized light flux $\Phi_R$, $\Phi_G$ and $\Phi_B$, considered to be captured by the red, green and blue channels, respectively. The results represent the polynomial transformation from normalized output data to captured light flux of the red, green and blue channels.

**Table 4 – Example of reporting form of the polynomial coefficients of the red, green and blue channels**

| Index ( $i$ ) | Red channel ( $r_i^*$ ) | Green channel ( $g_i^*$ ) | Blue channel ( $b_i^*$ ) |
|---|---|---|---|
| 0 | | | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

## 10 Spectral responsivity characteristics

### 10.1 Characteristics to be measured

Effective spectral sensitivities $s_{R_n}$, $s_{G_n}$ and $s_{B_n}$ as multiband of wavelength response of light flux captured by red, green and blue channels and overall spectral characteristics of multimedia colour scanners.

NOTE The algorithm in clause 10 will automatically calculate the overall responsivity of the multimedia colour scanner taking into account the spectral power distribution of the built-in light source, yet, an effect of strong spikes of the actual built-in light source will not be reproduced in the results when it is not measured and reported as in clause 7. The algorithm reproduces responsivities with limited non-smoothness and averaged spikes.

### 10.2 Measurement conditions

a) The scanning target shall be placed over the centre of the scanning area.

b) A non-linear adjustment, if there is any, applied to the output digital image data by the driver software shall be the same as in the measurement in clause 8.

c) The red, green and blue data of the channels of the multimedia colour scanner shall be set to 0,96 of the maximum value (245 at 8-bit quantization for each channel) for the measurement of the patch of the grey scale with maximum reflectance (white reference).

### 10.3 Method of measurement

a) Spectral characteristics, $r_{ij}(\lambda_n) = r_{ij_n}$, of each colour patch composing the target with row numbers $i = 1...12$ corresponding to rows A to L and column number $j = 1...22$ (see figure 1) shall be measured by the spectrophotometer over the wavelength range from 400 nm to 700 nm in 10 nm steps denoted by $n = 1...31$.

b) Red – green – blue output data of more than 10 × 10 picture elements corresponding to the centre of the colour patches shall be averaged to obtain the output values $D_{\mathrm{R}_{ij}}$, $D_{\mathrm{G}_{ij}}$ and $D_{\mathrm{B}_{ij}}$, respectively.

c) Only colour patches that provide the output data $D_{\mathrm{R}_{ij}}$, $D_{\mathrm{G}_{ij}}$ and $D_{\mathrm{B}_{ij}}$ between 2 % and 96 % of the maximum value (i.e. between 5 and 245 in 8-bit quantization for each channel) shall be used and the other data shall be excluded. The remaining data are denoted as $D_{\mathrm{R}_k}$, $D_{\mathrm{G}_k}$ and $D_{\mathrm{B}_k}$, where $k = 1...K$ and $K \leq 264$.

NOTE There will be 88 different colours of large chroma values in rows E, F, G, H in the target. A similar set of colours are available with reduced lightness of the bright colours and the dark colours of small chroma values in rows A, B, C, D (10 % reduction) and rows I, J, K, L (20 % reduction). If too many output data corresponding to colours of the target are excluded, the spectral responsivity characterization of the multimedia colour scanner in this clause will not work.

d) Normalized light flux values $\Phi_{\mathrm{R}_k}$, $\Phi_{\mathrm{G}_k}$, $\Phi_{\mathrm{B}_k}$ shall be calculated from the normalized output $d_{\mathrm{R}_k}$, $d_{\mathrm{G}_k}$ and $d_{\mathrm{B}_k}$ using the polynomials corresponding to the inverse tone characteristics expressed in equation (10).

e) The multiband spectral responsivity characteristics of the multimedia colour scanner $s_{\mathrm{R}_n}$, $s_{\mathrm{G}_n}$ and $s_{\mathrm{B}_n}$ for the red, green and blue channels shall be estimated as a solution of the minimum error algorithm shown in annex A, using all of the multiband spectral reflectance characteristics of the colour patches $r_k(\lambda_n) = r_{k_n}$, the multiband spectral power distribution $S(\lambda_n) = S_n$ of the built-in light source reported in 7.3, and the averaged and normalized red, green and blue output data $d_{\mathrm{R}_k}$, $d_{\mathrm{G}_k}$ and $d_{\mathrm{B}_k}$ for the $k$-th colour patch. If the multiband spectral power distribution is not available from 7.3, $S_n = 1$ shall be used.

NOTE The estimation algorithm for the minimum error algorithm is based on the linear programming using the simplex algorithm. See detailed description shown in annex A and available software in the bibliography.

### 10.4 Presentation of results

a) Multiband integrated responsitivity characteristics $s_{\mathrm{R}_n}$, $s_{\mathrm{G}_n}$ and $s_{\mathrm{B}_n}$ shall be reported as in table 5 together with step $n$ and centre wavelength $\lambda_n$.

**Table 5 – Example of a reporting form of the multiband responsitivity characteristics**

| $n$ | $\lambda_n$ | $s_{R_n}$ | $s_{G_n}$ | $s_{B_n}$ |
|---|---|---|---|---|
| 1 | 400 | –0,002 971 | 0,010 477 | 0,146 219 |
| 2 | 410 | –0,002 512 | 0,006 859 | 0,136 913 |
| 3 | 420 | –0,002 052 | 0,003 241 | 0,127 606 |
| 4 | 430 | –0,001 593 | –0,000 378 | 0,118 300 |
| 5 | 440 | –0,001 133 | –0,003 996 | 0,108 994 |
| 6 | 450 | –0,000 516 | –0,002 730 | 0,096 202 |
| 7 | 460 | 0,000 260 | 0,003 422 | 0,079 917 |
| 8 | 470 | 0,000 952 | 0,013 436 | 0,062 620 |
| 9 | 480 | 0,001 316 | 0,026 288 | 0,046 794 |
| 10 | 490 | 0,001 353 | 0,041 977 | 0,032 439 |
| 11 | 500 | 0,001 062 | 0,060 504 | 0,019 553 |
| 12 | 510 | –0,001 193 | 0,080 104 | 0,008 976 |
| 13 | 520 | –0,003 607 | 0,094 817 | 0,001 892 |
| 14 | 530 | –0,004 480 | 0,103 493 | –0,001 775 |
| 15 | 540 | –0,002 112 | 0,104 982 | –0,002 097 |
| 16 | 550 | 0,003 498 | 0,099 285 | 0,000 925 |
| 17 | 560 | 0,012 686 | 0,087 826 | 0,003 839 |
| 18 | 570 | 0,025 601 | 0,071 230 | 0,005 133 |
| 19 | 580 | 0,040 398 | 0,054 249 | 0,004 498 |
| 20 | 590 | 0,055 245 | 0,038 145 | 0,003 618 |
| 21 | 600 | 0,066 608 | 0,028 202 | 0,001 875 |
| 22 | 610 | 0,076 271 | 0,019 410 | 0,000 207 |
| 23 | 620 | 0,083 991 | 0,010 743 | 0,001 095 |
| 24 | 630 | 0,089 376 | 0,003 800 | 0,003 577 |
| 25 | 640 | 0,091 276 | 0,003 020 | 0,005 196 |
| 26 | 650 | 0,091 477 | 0,003 389 | 0,006 890 |
| 27 | 660 | 0,089 978 | 0,004 908 | 0,008 658 |
| 28 | 670 | 0,086 779 | 0,007 578 | 0,010 501 |
| 29 | 680 | 0,083 580 | 0,010 247 | 0,012 344 |
| 30 | 690 | 0,080 381 | 0,012 917 | 0,014 186 |
| 31 | 700 | 0,077 183 | 0,015 586 | 0,016 029 |

b) The responsitivity characteristics shall also be plotted as steps, as shown in figure 5 as an example for the red channel with bands centred at wavelengths 400 nm to 700 nm at 10 nm intervals.

c)

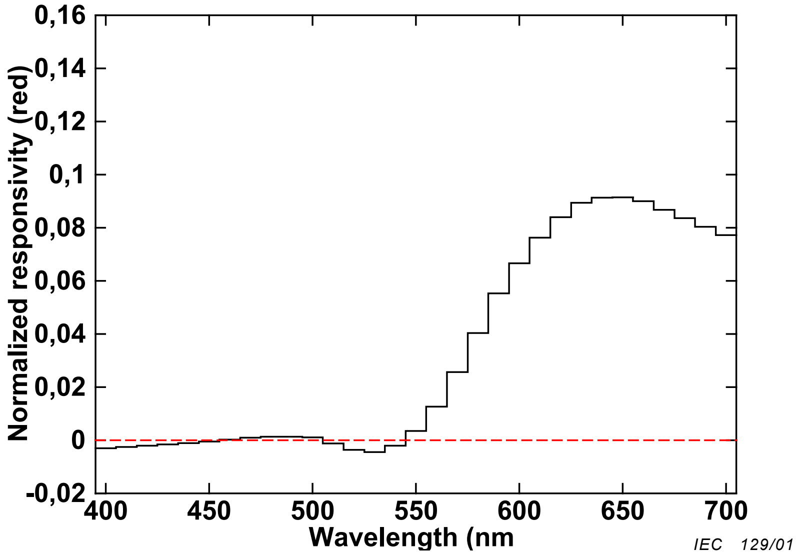



Figure 6a - Red channel

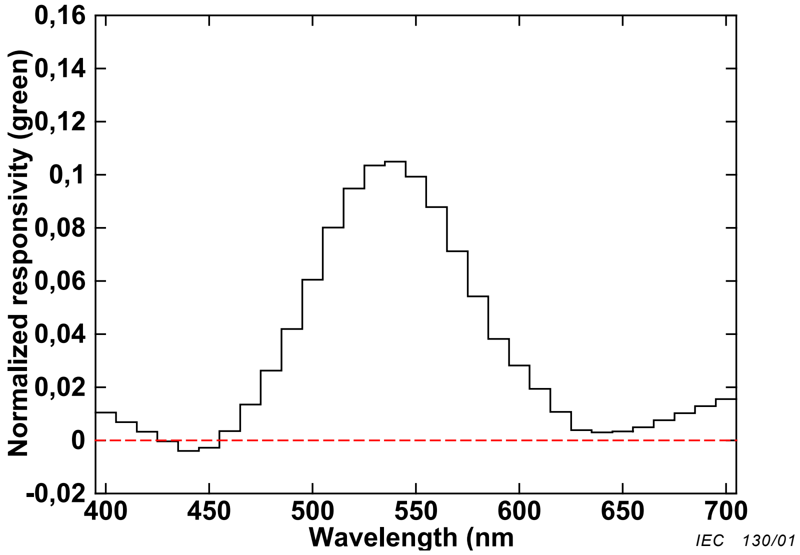



Figure 6b - Green channel

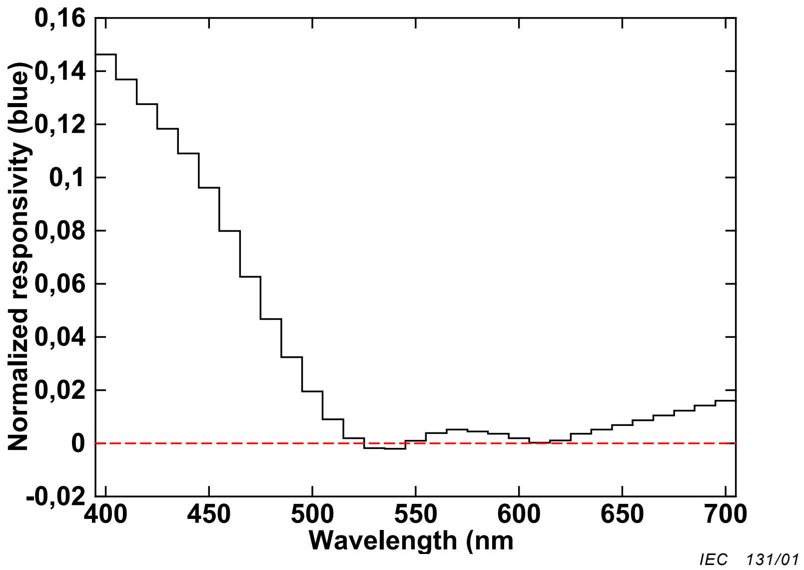



Figure 6c - Blue channel

**Figure 6 – An example of multiband spectral responsivity, $s_R$, $s_G$ and $s_B$**

d) Multiband overall responsivity characteristics $S_n s_{R_n}$, $S_n s_{G_n}$ and $S_n s_{B_n}$ shall also be reported as in figure 6 taking into account the multiband spectral power distribution of the built-in light source reported in 7.3.

NOTE If the multiband spectral power distribution of the built-in light source is not measured and reported as in 7.3, this item is not applicable.

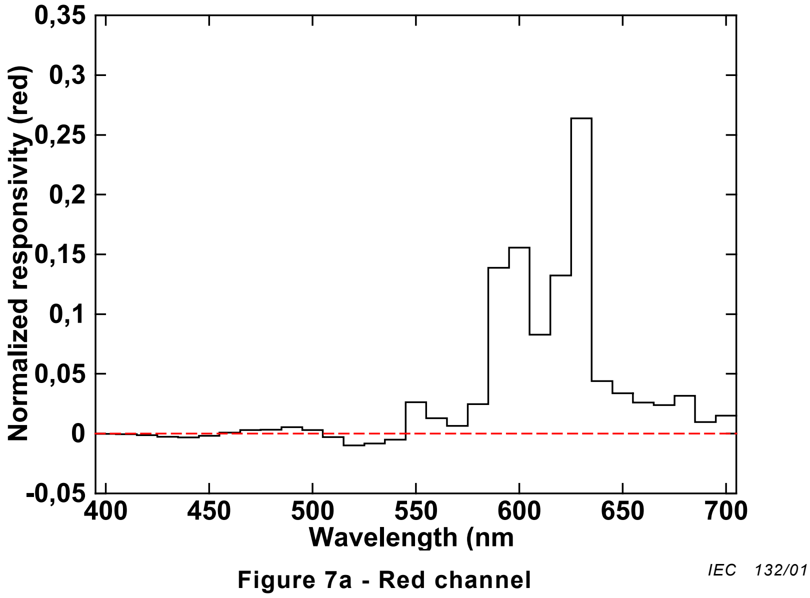



**Figure 7a - Red channel**

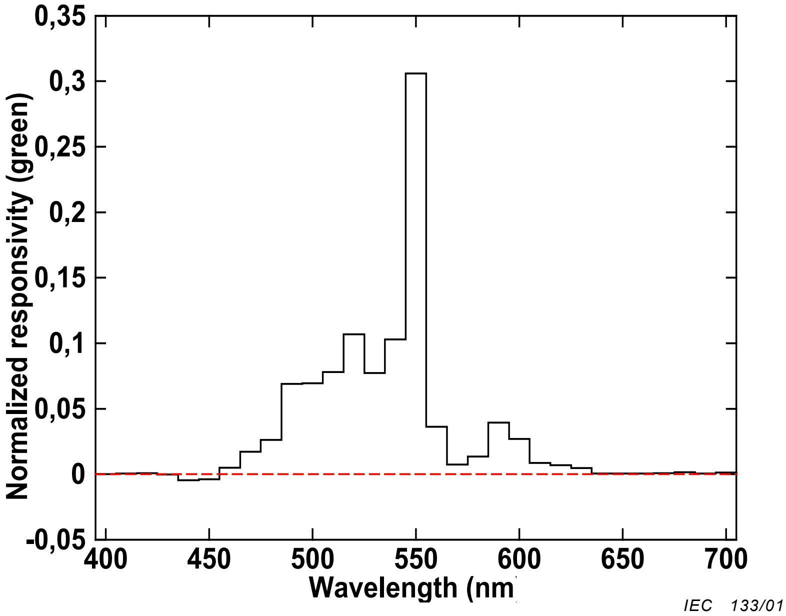



**Figure 7b - Green channel**

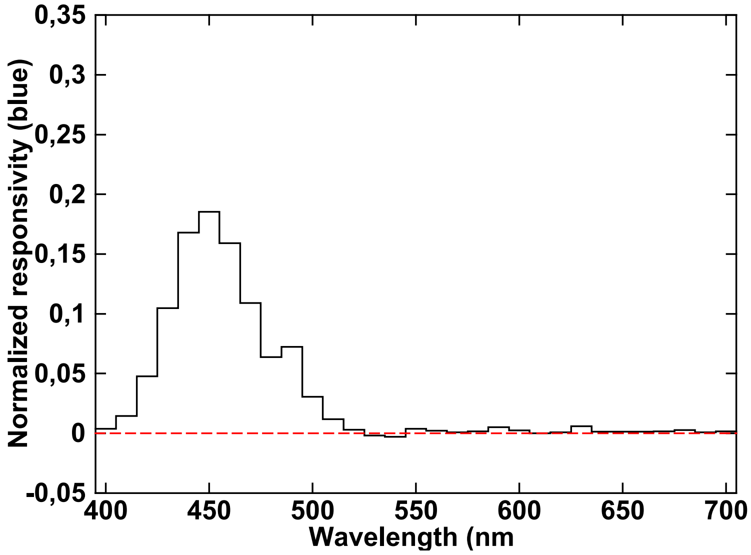



Figure 7c - Blue channel

**Figure 7 – Example of a reporting form of the overall multiband spectral responsitivity, $S_n s_{R_n}$, $S_n s_{G_n}$ and $S_n s_{B_n}$**

## 11 Spatial non-uniformity

### 11.1 Characteristics to be measured

Dependency on scanning position in terms of colour reproduction.

### 11.2 Measurement conditions

a) A grey sheet of paper with reflectance between 60 % and 80 % shall be used for the measurements as the target.

NOTE It is recommended that uniformity of greyness should be $\Delta E^*_{ab} \leq 0{,}5$ between the centre of the paper (point 13) and any of the 24 other points across the paper.

b) The target shall be placed over the surface at the centre of the scanning area so that no space or air gap exists between them as far as possible.

### 11.3 Method of measurement

a) The uniform grey target shall be scanned and the mean values of more than 10 × 10 picture elements shall be calculated and recorded for peripherals at 25 points indicated in figure 7, where $h$ and $w$ are height and width, respectively, of the whole scanning area.

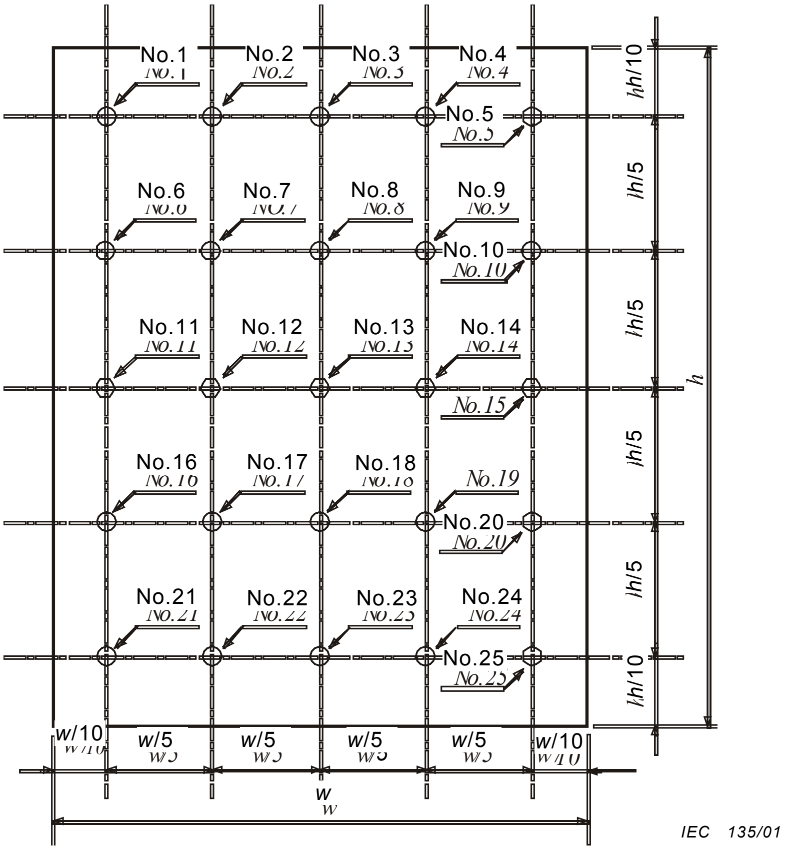



**Figure 8 – Measurement points for spatial non-uniformity**

NOTE If a single sheet of the uniform scanning target does not cover the whole scanning area, the same target may be moved and replaced to acquire the necessary data for the whole area.

b) Output data $D_{\mathrm{R}_i}$, $D_{\mathrm{G}_i}$ and $D_{\mathrm{B}_i}$ corresponding to the position $i$ shall be used if the specification of an RGB colorimetric specification of the equipment under measurement is not provided by the manufacturer and mean square deviations from the centre point ($i = 13$) shall be calculated for each component.

c) Alternately, the tristimulus values $X_i$, $Y_i$, $Z_i$ defined in CIE 15.2 shall be calculated based on the RGB specification of the multimedia colour scanner provided by the manufacturer. In that case, the following colour differences in CIE 1976 UCS and CIE 1976 $L^*a^*b^*$ colour space shall be calculated with a reference to the data $X_{13}$, $Y_{13}$, $Z_{13}$, which correspond to the centre of the scanning area.

$$\Delta u'_i = u'_i - u'_{13}$$
$$\Delta v'_i = v'_i - v'_{13}$$
$$\Delta u'v'_i = \sqrt{\Delta u'^2_i + \Delta v'^2_i}$$
$$\Delta L^*_i = L^*_i - L^*_{13}$$
$$\Delta C^*_{ab_i} = \sqrt{a^{*2}_i + b^{*2}_i} - \sqrt{a^{*\,2}_{13} + b^{*\,2}_{13}}$$

where $u'$, $v'$ and $L^*$, $a^*$, $b^*$ are defined by CIE 15.2 as in

$$u'_i = \frac{4X_i}{X_i + 15Y_i + 3Z_i}$$

$$v'_i = \frac{9Y_i}{X_i + 15Y_i + 3Z_i}$$

$$L^*_i = 116\left(\frac{Y_i}{Y_{13}}\right)^{\frac{1}{3}} - 16$$

$$a^*_i = 500\left\{\left(\frac{X_i}{X_{13}}\right)^{\frac{1}{3}} - \left(\frac{Y_i}{Y_{13}}\right)^{\frac{1}{3}}\right\}$$

$$b^*_i = 200\left\{\left(\frac{Y_i}{Y_{13}}\right)^{\frac{1}{3}} - \left(\frac{Z_i}{Z_{13}}\right)^{\frac{1}{3}}\right\}$$

NOTE These equations are valid for $\frac{X_i}{X_{13}} \geq 0{,}008\ 856$, $\frac{Y_i}{Y_{13}} \geq 0{,}008\ 856$ and $\frac{Z_i}{Z_{13}} \geq 0{,}008\ 856$.

### 11.4 Presentation of results

The original data $D_R$, $D_G$ and $D_B$ and the respective mean square deviations or the calculated results, $\Delta u'$, $\Delta v'$, $\Delta u'v'$, $\Delta L^*$ and $\Delta C^*_{ab}$ for $1 \leq i \leq 25$ shall be reported as indices of non-uniformity, together with the reflectance of the uniform grey target, as shown in table 6. For interpretation and requirement for the values of $\Delta u'v'$, ISO 9241-8 shall be referred to.

**Table 6 – Reporting form for the measurement of spatial non-uniformity**

| $i$ | $D_R$ | $D_G$ | $D_B$ | $\Delta u'$ | $\Delta v'$ | $\Delta u'v'$ | $\Delta L^*$ | $\Delta C^*_{ab}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 246,63 | 247,81 | 247,44 | –0,00048 | –0,00071 | 0,00086 | 0,84 | 0,62 |
| 2 | 242,19 | 242,63 | 241,81 | –0,00014 | –0,00036 | 0,00039 | –0,92 | 0,30 |
| 3 | 243,19 | 242,88 | 241,50 | 0,00023 | 0,00006 | 0,00023 | –0,79 | 0,18 |
| 4 | 243,19 | 243,75 | 242,00 | –0,00015 | 0,00020 | 0,00025 | –0,56 | 0,23 |
| 5 | 247,88 | 246,75 | 245,88 | 0,00056 | –0,00019 | 0,00059 | 0,63 | 0,53 |
| 6 | 248,06 | 249,31 | 248,88 | –0,00051 | –0,00068 | 0,00085 | 1,35 | 0,60 |
| 7 | 238,75 | 239,25 | 238,75 | –0,00018 | –0,00056 | 0,00059 | –2,09 | 0,46 |
| 8 | 244,63 | 244,19 | 242,13 | 0,00031 | 0,00049 | 0,00058 | –0,34 | 0,41 |
| 9 | 242,94 | 243,50 | 242,19 | –0,00017 | –0,00007 | 0,00018 | –0,63 | 0,13 |
| 10 | 248,50 | 248,75 | 246,75 | 0,00000 | 0,00036 | 0,00036 | 1,19 | 0,32 |
| 11 | 250,44 | 251,06 | 250,75 | –0,00024 | –0,00070 | 0,00074 | 2,01 | 0,56 |
| 12 | 244,63 | 245,44 | 245,44 | –0,00034 | –0,00091 | 0,00097 | 0,05 | 0,73 |
| 13 | 245,06 | 245,25 | 243,88 | 0,00000 | 0,00000 | 0,00000 | 0,00 | 0,00 |
| 14 | 246,63 | 248,00 | 246,50 | –0,00052 | –0,00004 | 0,00052 | 0,86 | 0,42 |
| 15 | 250,13 | 250,88 | 249,13 | –0,00023 | 0,00016 | 0,00028 | 1,90 | 0,28 |
| 16 | 251,44 | 252,25 | 252,06 | –0,00032 | –0,00079 | 0,00085 | 2,41 | 0,64 |
| 17 | 246,31 | 246,81 | 246,00 | –0,00016 | –0,00038 | 0,00041 | 0,53 | 0,31 |
| 18 | 248,38 | 247,44 | 246,06 | 0,00050 | 0,00010 | 0,00051 | 0,84 | 0,40 |
| 19 | 245,19 | 246,00 | 244,88 | –0,00029 | –0,00021 | 0,00036 | 0,22 | 0,25 |
| 20 | 250,25 | 250,63 | 249,50 | –0,00009 | –0,00018 | 0,00021 | 1,86 | 0,15 |
| 21 | 251,25 | 251,63 | 251,44 | –0,00013 | –0,00075 | 0,00076 | 2,23 | 0,61 |
| 22 | 246,19 | 246,00 | 245,63 | 0,00012 | –0,00058 | 0,00059 | 0,31 | 0,53 |
| 23 | 247,13 | 247,31 | 246,50 | –0,00002 | –0,00035 | 0,00035 | 0,73 | 0,29 |
| 24 | 246,19 | 247,00 | 246,06 | –0,00030 | –0,00033 | 0,00044 | 0,57 | 0,31 |
| 25 | 251,13 | 252,06 | 249,75 | –0,00029 | 0,00047 | 0,00055 | 2,28 | 0,55 |

## 12 Mid-term instability

### 12.1 Characteristics to be measured

The instability of output data upon turning on the multimedia colour scanner.

### 12.2 Measurement conditions

a) The multimedia colour scanner under measurment shall be powered down for more than 2 h before beginning any measurement.

b) The scaling of scan shall be set to unity. Resolution of scanning shall be set to the maximum spatial resolution.

c) A uniform grey sheet of paper as in 11.2 shall be used as the target for the measurement.

d) The target shall be placed in the centre of the scanning area in intimate contact with the scanning field of the multimedia colour scanner.

e)

### 12.3 Method of measurement

a) The target shall be placed over the scanning area.

b) The multimedia colour scanner shall be powered on.

c) The small target area at about the centre of the scanning area shall be scanned after 1 min, and successively scanned once per minute for 120 min.

d) The output data corresponding to more than 10 × 10 picture elements for each red, green and blue channel, respectively, shall be averaged and recorded as $D_R$, $D_G$ and $D_B$.

### 12.4 Presentation of results

The measured data, $D_R$, $D_G$ and $D_B$ shall be normalized by the average value, respectively, and reported as shown in figure 8.

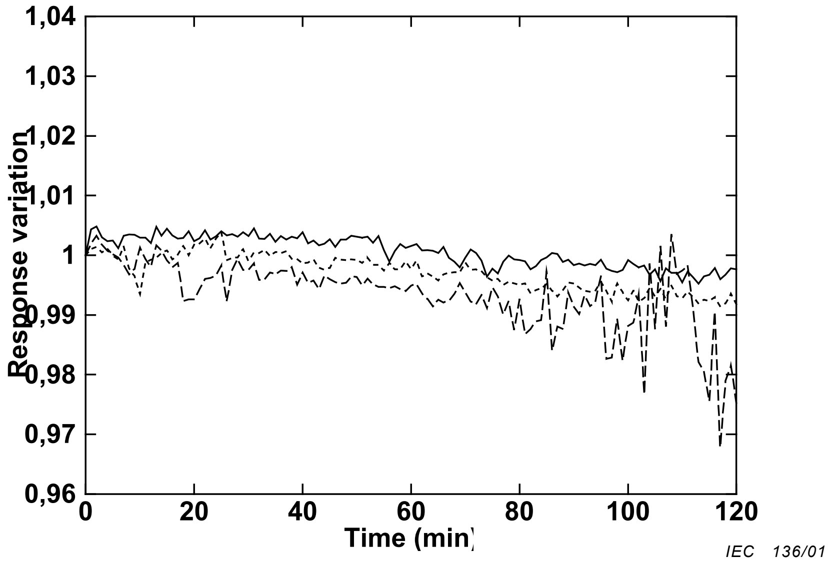



**Figure 9 – Example of a report of mid-term instability**

## 13 Large area spatial crosstalk

### 13.1 Characteristics to be measured

Dependency of the output digital data of a colour patch on reflectance of surrounding areas.

### 13.2 Measurement conditions

a) A target with 15 square test patches as specified in figure 9 shall be used for the measurements. The target shall be printed on a sheet of non-fluorescent paper. The test patches shall be uniform grey with reflectance between 20 % and 40 %. The colour differences $\Delta E^*_{ab}$ among the 15 test patches shall be $\Delta E^*_{ab} \leq 0,5$. The white areas of the target are the surface reflectances of the paper, and the dark areas are of black at the maximum density of a printing system. The size of the target shall be magnified or reduced to fit to a scanning field of the multimedia colour scanner under examination.

b) The target shall be placed over the surface at the centre of the scanning area so that no space or air gap exists between them as far as possible.

c)

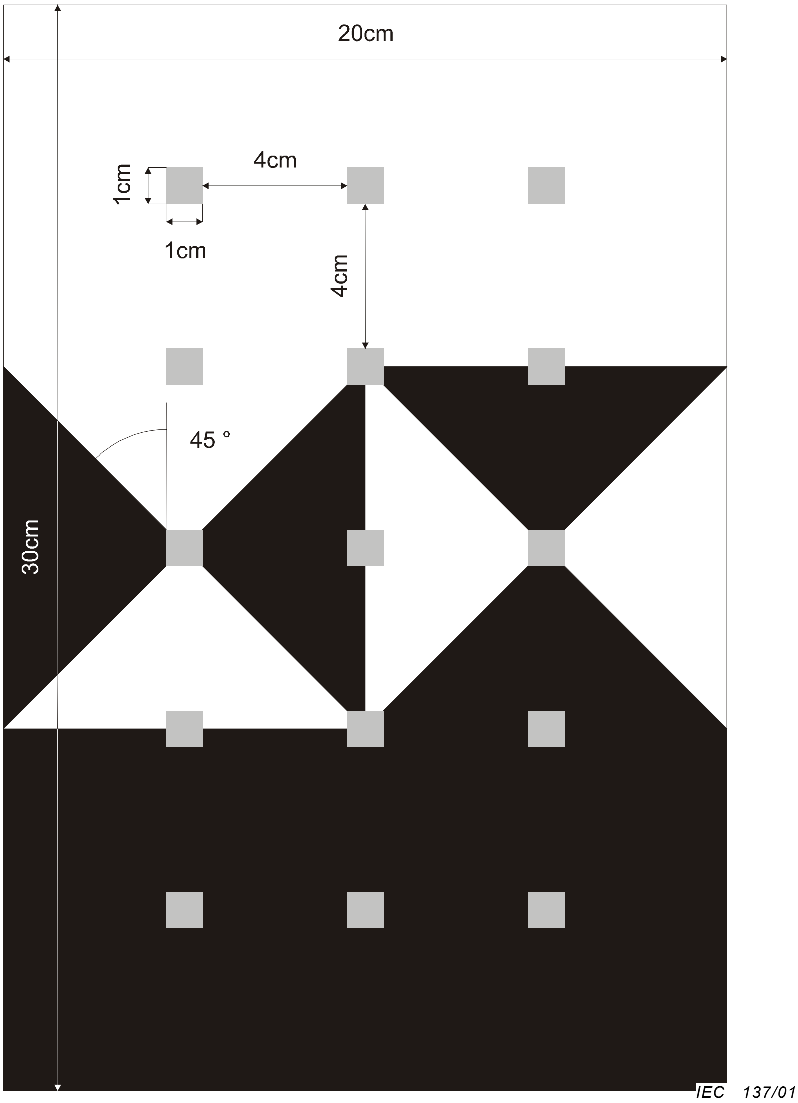



**Figure 10 – Target for the measurement of spatial crosstalk**

## 13.3 Method of measurement

a) The target shall be scanned three times in one direction and scanned three times in the opposite direction after rotating the target by 180°. The mean values of more than $10 \times 10$ picture elements in the centre of each of the 15 colour patches specified in figure 8 shall be recorded as output data $D_{\mathrm{R}_p}$, $D_{\mathrm{G}_p}$ and $D_{\mathrm{B}_p}$ for $1 \leq p \leq 15$.

b) The output data of the grey patches shall be averaged to determine the mean data values $\langle D_{\mathrm{R}} \rangle = \frac{1}{15} \sum_{p=1}^{15} D_{\mathrm{R}_p}$, $\langle D_{\mathrm{G}} \rangle = \frac{1}{15} \sum_{p=1}^{15} D_{\mathrm{G}_p}$ and $\langle D_{\mathrm{B}} \rangle = \frac{1}{15} \sum_{p=1}^{15} D_{\mathrm{B}_p}$.

c) The maximum data $D_{\mathrm{R}_{\max}}$, $D_{\mathrm{G}_{\max}}$ and $D_{\mathrm{B}_{\max}}$, the minimum data $D_{\mathrm{R}_{\min}}$, $D_{\mathrm{G}_{\min}}$ and $D_{\mathrm{B}_{\min}}$ and the relative differences between these values in the red, green and blue channels shall be calculated as percentage points as in $\frac{\Delta D_{\mathrm{R}}}{\langle D_{\mathrm{R}} \rangle} \times 100$, $\frac{\Delta D_{\mathrm{R}}}{\langle D_{\mathrm{R}} \rangle} \times 100$ and $\frac{\Delta D_{\mathrm{R}}}{\langle D_{\mathrm{R}} \rangle} \times 100$.

d)

e) The relative root mean standard deviations resulting from all the patches shall be calculated as percentage points as in $100\sqrt{\frac{1}{15}\sum_{p=1}^{15}\left(\frac{D_{R_p}}{\langle D_R\rangle}\right)^2 - 1}$, $100\sqrt{\frac{1}{15}\sum_{p=1}^{15}\left(\frac{D_{G_p}}{\langle D_G\rangle}\right)^2 - 1}$ and $100\sqrt{\frac{1}{15}\sum_{p=1}^{15}\left(\frac{D_{B_p}}{\langle D_B\rangle}\right)^2 - 1}$.

NOTE Detailed analysis of the large area crosstalk shows that the effect on a colour patch under test is approximately proportional to the reflectance of that colour patch.

### 13.4 Presentation of results

a) The original data $D_{R_p}$, $D_{G_p}$ and $D_{B_p}$ shall be reported as exemplified in table 7.

**Table 7 – Reporting form for the measurement of spatial crosstalk**

| $p$ | $D_R$ | $D_G$ | $D_B$ |
|---|---|---|---|
| 1 | 186,33 | 189,04 | 203,71 |
| 2 | 186,68 | 189,64 | 205,22 |
| 3 | 186,40 | 189,36 | 204,25 |
| 4 | 187,80 | 190,19 | 205,42 |
| 5 | 181,02 | 183,18 | 199,02 |
| 6 | 179,05 | 181,02 | 196,37 |
| 7 | 176,69 | 178,90 | 192,52 |
| 8 | 178,97 | 181,57 | 196,00 |
| 9 | 183,58 | 188,23 | 202,21 |
| 10 | 178,64 | 182,17 | 195,56 |
| 11 | 173,79 | 177,47 | 191,26 |
| 12 | 171,21 | 174,91 | 188,45 |
| 13 | 166,27 | 168,18 | 181,27 |
| 14 | 167,44 | 169,38 | 183,61 |
| 15 | 169,77 | 173,03 | 187,49 |

b) The average data, the crosstalk given by the relative differences between maximum and minimum data in percentage points and the relative root mean standard deviations given in percentage points shall be reported as exemplified in table 8.

**Table 8 – Reporting form of average data and maximum crosstalk given by relative maximum differences and relative standard deviations of data in red, green and blue channels (8 bits per channel)**

| | **Red channel** | **Green channel** | **Blue channel** |
|---|---|---|---|
| Average data | 178,26 | 181,1 | 195,5 |
| Relative maximum differences (%) | 12,1 | 12,1 | 12,4 |
| Relative standard deviations (%) | 4,1 | 4,1 | 4,1 |

NOTE The accuracy of spectral characterization of the multimedia colour scanner according to clauses 8 and 9 will be limited by spatial crosstalk with worst case values as estimated above.

# Annex A
(normative)

# Estimation of multiband of wavelength sensitivities

## A.1 Quantities to be estimated

Effective spectral sensitivities of multimedia colour scanners, $s_{R_n}$, $s_{G_n}$ and $s_{B_n}$ at the centre wavelength $\lambda_n$, as multiband of wavelength responses of the red, green and blue channels; and built-in 3 × 3 channel-coupling matrix $\mathbf{C}$, with elements $c_{ij}$ for $i$-th row and $j$-th column, determining the relation between the effective spectral sensitivities and the physical sensitivities $p_{R_n}$, $p_{G_n}$ and $p_{B_n}$ $s_{B_n}$ at the centre wavelength $\lambda_n$ of the red, green and blue channels as in equation (A.1).

$$\begin{pmatrix} p_{R_n} \\ p_{G_n} \\ p_{B_n} \end{pmatrix} = \mathbf{C} \begin{pmatrix} s_{R_n} \\ s_{G_n} \\ s_{B_n} \end{pmatrix} \quad \text{(A.1)}$$

NOTE If there is no built-in coupling matrix between the channels, the physical and the effective spectral sensitivities are identical and the matrix $\mathbf{C}$ will be the identity matrix.

## A.2 Input to the algorithm

a) Effective multiband spectral stimuli $r_k^*(\lambda_n) = r_{k_n}^*$ defined in equation (A.2) of the test patches of the target ($k = 1...K$) over the wavelength range from 400 nm to 700 nm in 10 nm steps denoted $n = 1...31$. The effective multiband spectral reflectance is calculated from the multiband spectral reflectance $r_k(\lambda_n) = r_{k_n}$ of the test patches and the spectral power distribution $S(\lambda_n) = S_n$ of the built-in light source, reported in 7.3, according to equation (A.2).

$$r_{k_n}^* = S_n r_{k_n} \quad \text{(A.2)}$$

If the spectral power distribution of the built-in light source of the multimedia colour scanner is not reported in 7.3, $S_n$ for all $n$ shall be set to unity.

NOTE The algorithm of this standard will automatically calculate the overall responsivity of the multimedia colour scanner including the power distribution of the light source, yet, strong spikes of the actual light source will not be reproduced in the results in this case. The algorithm of this standard reproduces responsivities with limited non-smoothness and averaged spikes.

b) Normalized light flux at the input of the red, green and blue channels, $\Phi_{R_k}$, $\Phi_{G_k}$ and $\Phi_{B_k}$, inversely calculated from the normalized output data $d_{R_k}$, $d_{G_k}$ and $d_{B_k}$, according to equation (10).

c) Diagonal elements of the channel-coupling matrix $\mathbf{C}$, $c_{ij} = 1$ for $i = j$.

d) Weight factors $w_N$, $w_{N_{max}}$, $w_P$, and $w_{P_{max}}$ denoting the weight of the corresponding internal parameters of the objective function defined in equation (A.4) for an optimum estimation of the multiband spectral sensitivities.

e)

NOTE For small noise levels of the multimedia colour scanner, the weighting factors $w_{\mathrm{N}} = \frac{1}{3K}$; $w_{\mathrm{N_{max}}} = 10$; $w_{\mathrm{P}} = 0{,}023$ and $w_{\mathrm{P_{max}}} = 2$ should be used. For higher noise levels, the weight factors $w_{\mathrm{P}}$ and $w_{\mathrm{P_{max}}}$ should slightly be increased.

## A.3 Output to the algorithm

a) Estimated physical sensitivities $p_{\mathrm{R}_n}$, $p_{\mathrm{G}_n}$ and $p_{\mathrm{B}_n}$ of the red, green and blue channels, where $p_{\mathrm{R}_n} \geq 0$, $p_{\mathrm{G}_n} \geq 0$ and $p_{\mathrm{B}_n} \geq 0$ for $n = 1...31$.

b) Estimated off-diagonal elements of the channel-coupling matrix $\mathbf{C}$, $c_{ij}$ for $i \neq j$, where $-1 \leq c_{ij} \leq 1$.

c) Estimated spectral sensitivities $s_{\mathrm{R_n}}$, $s_{\mathrm{G_n}}$ and $s_{\mathrm{B_n}}$ calculated from equation (B.1).

## A.4 Internal variables of the algorithm

The estimation algorithm requires a number of internal variables and parameters to be defined.

a) Absolute values of the model errors for the $k$-th test patch defined for the red, green and blue channel by:

$$\begin{aligned} N_{\mathrm{R}_k} &= \left| \sum_{n=1}^{31} p_{\mathrm{R}_n} r^*_{k_n} - (c_{11}\Phi_{\mathrm{R}_k} + c_{12}\Phi_{\mathrm{G}_k} + c_{13}\Phi_{\mathrm{B}_k}) \right| \\ N_{\mathrm{G}_k} &= \left| \sum_{n=1}^{31} p_{\mathrm{G}_n} r^*_{k_n} - (c_{21}\Phi_{\mathrm{R}_k} + c_{22}\Phi_{\mathrm{G}_k} + c_{23}\Phi_{\mathrm{B}_k}) \right| \\ N_{\mathrm{B}_k} &= \left| \sum_{n=1}^{31} p_{\mathrm{B}_n} r^*_{k_n} - (c_{31}\Phi_{\mathrm{R}_k} + c_{32}\Phi_{\mathrm{G}_k} + c_{33}\Phi_{\mathrm{B}_k}) \right| \end{aligned} \quad (A.3)$$

b) Maximum values of the absolute values defined by equation (A.3): $N_{\mathrm{R_{max}}} = \max(N_{\mathrm{R}_k})$, $N_{\mathrm{G_{max}}} = \max(N_{\mathrm{G}_k})$ and $N_{\mathrm{B_{max}}} = \max(N_{\mathrm{B}_k})$.

c) Non-smoothness measures defined by equation (A.4) for multiband of wavelength $n = 2...30$.

$$\begin{aligned} P_{\mathrm{R}_n} &= \left| p_{\mathrm{R}_{n-1}} - 2p_{\mathrm{R}_n} + p_{\mathrm{R}_{n+1}} \right| \\ P_{\mathrm{G}_n} &= \left| p_{\mathrm{G}_{n-1}} - 2p_{\mathrm{G}_n} + p_{\mathrm{G}_{n+1}} \right| \\ P_{\mathrm{B}_n} &= \left| p_{\mathrm{B}_{n-1}} - 2p_{\mathrm{B}_n} + p_{\mathrm{B}_{n+1}} \right| \end{aligned} \quad (A.4)$$

NOTE Small values of the non-smoothness measure mean smooth function.

d) Maximum values of the non-smoothness measures defined by equation (A.4): $P_{\mathrm{R_{max}}} = \max(P_{\mathrm{R}_n})$, $P_{\mathrm{G_{max}}} = \max(P_{\mathrm{G}_n})$ and $P_{\mathrm{B_{max}}} = \max(P_{\mathrm{B}n})$.

## A.5 Estimation algorithm

The physical spectral sensitivities of the multimedia colour scanners are estimated by using the simplex algorithm to solve the linear programming system described by equation (A.5).

$$\min\begin{pmatrix} w_{N_{\max}}\left(N_{R_{\max}} + N_{G_{\max}} + N_{B_{\max}}\right) + w_N \sum_{k=1}^{K}\left(N_{R_k} + N_{G_k} + N_{B_k}\right) \\ + w_{P_{\max}}\left(P_{R_{\max}} + P_{G_{\max}} + P_{B_{\max}}\right) + w_P \sum_{n=2}^{30}\left(P_{R_k} + P_{G_k} + P_{B_k}\right) \end{pmatrix} \quad \text{(A.5)}$$

where the ranges of the values are $p_{R_n} \geq 0$, $p_{G_n} \geq 0$ and $p_{B_n} \geq 0$ for $n = 1...31$; $-1 \leq c_{ij} \leq 1$ for $i \neq j$ and $1 \leq i, j \leq 3$.

The absolute values in equations (A.3) and (A.4) cannot be used to solve the linear programming system. However, if $x = |a|$ is required and $x$ is a variable to be minimized, it is possible to use $x \geq a$ and $x \geq -a$ instead to fulfil the requirement. The following constraints are formulated accordingly:

a) Constraints for the definitions of the model errors $N_k$ for $k = 1...K$.

$$N_{R_k} \geq \sum_{n=1}^{31} r_{k_n}^{*} p_{R_n} - (\Phi_{R_k} + c_{12}\Phi_{G_k} + c_{13}\Phi_{B_k})$$

$$N_{R_k} \geq -\sum_{n=1}^{31} r_{k_n}^{*} p_{R_n} + (\Phi_{R_k} + c_{12}\Phi_{G_k} + c_{13}\Phi_{B_k})$$

$$N_{G_k} \geq \sum_{n=1}^{31} r_{k_n}^{*} p_{G_n} - (c_{21}\Phi_{R_k} + \Phi_{G_k} + c_{23}\Phi_{B_k})$$

$$N_{G_k} \geq -\sum_{n=1}^{31} r_{k_n}^{*} p_{G_n} + (c_{21}\Phi_{R_k} + \Phi_{G_k} + c_{23}\Phi_{B_k})$$

$$N_{B_k} \geq \sum_{n=1}^{31} r_{k_n}^{*} p_{B_n} - (c_{31}\Phi_{R_k} + c_{32}\Phi_{G_k} + \Phi_{B_k})$$

$$N_{B_k} \geq -\sum_{n=1}^{31} r_{k_n}^{*} p_{B_n} + (c_{31}\Phi_{R_k} + c_{32}\Phi_{G_k} + \Phi_{B_k})$$

$$N_{R_{\max}} \geq N_{R_k}$$

$$N_{G_{\max}} \geq N_{G_k}$$

$$N_{B_{\max}} \geq N_{B_k}$$

b) Constraints for the definitions of non-smoothness terms for $n = 2...30$.

$$P_{R_n} \geq p_{R_{n-1}} - 2p_{R_n} + p_{R n+1}$$

$$P_{R_n} \geq -p_{R_{n-1}} + 2p_{R_n} - p_{R n+1}$$

$$P_{G_n} \geq p_{G_{n-1}} - 2p_{G_n} + p_{G n+1}$$

$$P_{G_n} \geq -p_{G_{n-1}} + 2p_{G_n} - p_{G n+1}$$

$$P_{B_n} \geq p_{B_{n-1}} - 2p_{B_n} + p_{B n+1}$$

$$P_{B_n} \geq -p_{B_{n-1}} + 2p_{B_n} - p_{B n+1}$$

$$P_{R_{\max}} \geq P_{R_k}$$

$$P_{G_{\max}} \geq P_{G_k}$$

$$P_{B_{\max}} \geq P_{B_k}$$

The solution of this linear programming system is to be obtained using the SIMPLEX algorithm [2],[3].

NOTE Differences between the available software packages concern the speed of computation but not the results.

# Annex B
(normative)

## Scanner model output data from estimated multiband sensitivities

Scanner model output data $D_{\mathrm{R}}$, $D_{\mathrm{G}}$ and $D_{\mathrm{B}}$ of the red, green and blue channels for an arbitrary colour patch with given multiband spectral reflection $r(\lambda_n) = r_n$ for $n = 1...31$ are calculated from the estimated multiband sensitivities in 10.4 and the multiband spectral power distribution $S(\lambda_n) = S_n$ of the built-in light source according to the following algorithm.

a) The normalized light flux values $\Phi_{\mathrm{R}}$, $\Phi_{\mathrm{G}}$, $\Phi_{\mathrm{B}}$ of the red, green and blue channel are calculated from the spectral reflection $r(\lambda_n) = r_n$ for $n = 1...31$ of the colour patch, the multiband spectral power distribution $S(\lambda_n) = S_n$, the effective multiband responsivities, $s_{\mathrm{R}_n}$, $s_{\mathrm{G}_n}$ and $s_{\mathrm{B}_n}$, normalized to the respective values of the white reference colour with spectral reflection $r_{\mathrm{W}}(\lambda_n) = r_{\mathrm{W}_n}$ for $n = 1...31$ as follows:

$$\Phi_R = \frac{1}{\sum_{n=1}^{31} S_n r_{W_n} s_{R_n}} \sum_{n=1}^{31} S_n r_n s_{R_n}$$

$$\Phi_G = \frac{1}{\sum_{n=1}^{31} S_n r_{W_n} s_{G_n}} \sum_{n=1}^{31} S_n r_n s_{G_n} \quad \text{(B.1)}$$

$$\Phi_B = \frac{1}{\sum_{n=1}^{31} S_n r_{W_n} s_{B_n}} \sum_{n=1}^{31} S_n r_n s_{B_n}$$

b) The normalized channel output data $d_{\mathrm{R}}$, $d_{\mathrm{G}}$ and $d_{\mathrm{B}}$ are calculated from equation (B.2):

$$d_{\mathrm{R}} = r_0 + r_1\Phi_{\mathrm{R}} + r_2\Phi_{\mathrm{R}}^2 + r_3\Phi_{\mathrm{R}}^3 + r_4\Phi_{\mathrm{R}}^4$$

$$d_{\mathrm{G}} = g_0 + g_1\Phi_{\mathrm{G}} + g_2\Phi_{\mathrm{G}}^2 + g_3\Phi_{\mathrm{G}}^3 + g_4\Phi_{\mathrm{G}}^4 \quad \text{(B.2)}$$

$$d_{\mathrm{B}} = b_0 + b_1\Phi_{\mathrm{B}} + b_2\Phi_{\mathrm{B}}^2 + b_3\Phi_{\mathrm{B}}^3 + b_4\Phi_{\mathrm{B}}^4$$

c) The digital output data $D_{\mathrm{R}}$, $D_{\mathrm{G}}$ and $D_{\mathrm{B}}$ are calculated from equation (B.3):

$$D_{\mathrm{R}} = d_{\mathrm{R}} D_{\mathrm{R_W}}$$

$$D_{\mathrm{G}} = d_{\mathrm{G}} D_{\mathrm{G_W}} \quad \text{(B.3)}$$

$$D_{\mathrm{B}} = d_{\mathrm{B}} D_{\mathrm{B_W}}$$

where $D_{\mathrm{R_W}}$, $D_{\mathrm{R_W}}$ and $D_{\mathrm{R_W}}$ are the digital output model values for the white reference (for example 255 for 8-bit quantization).

# Annex C
(informative)

# Examples for the application of the spectral characteristics

## C.1 Calculation of the ICC profiles

a) Measure the spectral reflectances $r_{k_n}$ of the test patches of the test chart.

b) Use the spectral reflectances $r_{k_n}$ to calculate the tristumulus values in CIE 1931 XYZ colour space for each patch.

c) Use the spectral power distribution $S_n$ of the built-in light source to calculate the spectral stimuli $r^*_{k_n} = S_n r_{k_n}$.

d) Calculate the normalized light flux at the input of the red, green and blue channels, $\Phi_{\mathrm{R}_k}$, $\Phi_{\mathrm{G}_k}$ and $\Phi_{\mathrm{B}_k}$ according to equation (10).

e) Calculate normalized output data $d_{\mathrm{R}_k}$, $d_{\mathrm{G}_k}$ and $d_{\mathrm{B}_k}$ according to equation (5). Use this to calculate digital output data $D_{\mathrm{R}_k}$, $D_{\mathrm{G}_k}$ and $D_{\mathrm{B}_k}$.

Use digital output $D_{\mathrm{R}_k}$, $D_{\mathrm{G}_k}$ and $D_{\mathrm{B}_k}$ and the calculated tristimulus values in CIE 1931 XYZ colour space to generate the ICC profile 5].

## C.2 Calculation of an optimized conversion for sRGB colour space

a) Measure the spectral reflectances $r_{k_n}$ of the test patches of the test chart containing a white patch and at least two more colours.

b) Use the spectral reflectances $r_{k_n}$ to calculate values in the sRGB colour space, $R_k$, $G_k$ and $B_k$, for each patch.

c) Use the spectral power distribution $S_n$ of the built-in light source reported in 7.3 to calculate the spectral stimuli $r^*_{k_n} = S_n r_{k_n}$.

d) Use the effective multiband spectral sensitivities of the multimedia colour scanner $s_{\mathrm{R}_n}$, $s_{\mathrm{G}_n}$ and $s_{\mathrm{B}_n}$ to calculate the normalized light flux at the input of the red, green and blue channels, $\Phi_{\mathrm{R}_k}$, $\Phi_{\mathrm{G}_k}$ and $\Phi_{\mathrm{B}_k}$.

e) Calculate normalized output data $d_{\mathrm{R}_k}$, $d_{\mathrm{G}_k}$ and $d_{\mathrm{B}_k}$ according to equation (5). Use this to calculate digital output data $D_{\mathrm{R}_k}$, $D_{\mathrm{G}_k}$ and $D_{\mathrm{B}_k}$.

f) Calculate a 3 × 3 matrix $\mathbf{M}$ that maps the white patch to the white point of the sRGB colour space defined in IEC 61966-2-1 and minimizes the colour errors for the remaining colours.

$$\begin{pmatrix} R_k \\ G_k \\ B_k \end{pmatrix} = \mathbf{M} \begin{pmatrix} D_{\mathrm{R}_k} \\ D_{\mathrm{G}_k} \\ D_{\mathrm{B}_k} \end{pmatrix} \qquad \text{for the achromatic patchs}$$

$$\begin{pmatrix} R_k \\ G_k \\ B_k \end{pmatrix} \approx \mathbf{M} \begin{pmatrix} D_{\mathrm{R}_k} \\ D_{\mathrm{G}_k} \\ D_{\mathrm{B}_k} \end{pmatrix} \qquad \text{for the remaining patchs}$$

# Bibliography

[1] IEC TTA-3: 1997, Hiroaki Ikeda, Masato Abe, and Yasuhiko Higaki: "Equipment independent colour reproduction systems", IEC Technical Trend Assessment, No .3, IEC, Geneva.

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[3] SCHRIJUV, Alexander, "Theory of linear and integer programming", J. Wiley and Sons, 1996.

[4] ISO/IEC 14473: 1999 (E), *Information technology – Office equipment – Minimum information to be specified for image scanners*.

[5] ICC specification ICC.1: 1989-09, File format for color profiles: Document ICC.1A: 1999-04, Amendment 2 to Spec. ICC.1: 1989-09.

[6] Complete software package for linear programming, for example, LPAKO at ftp://orly1.snu.ac.kr/pub/sal_sw/lpako/.

# Annex ZA
(normative)

## Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

| Publication | Year | Title | EN/HD | Year |
|---|---|---|---|---|
| IEC 60050-845 | 1987 | International Electrotechnical Vocabulary (IEV) Chapter 845: Lighting | - | - |
| IEC 61966-2-1 | 1999 | Multimedia systems and equipment - Colour measurement and management Part 2-1: Colour management - Default RGB colour space - sRGB | EN 61966-2-1 | 2000 |
| CIE 15.2 | 1986 | Colorimetry | - | - |
| ISO 5-4 | 1995 | Photography - Density measurements Part 4: Geometric conditions for reflection density | - | - |
| ISO 9241-8 | 1997 | Ergonomic requirements for office work with visual display terminals (VDTs) Part 8: Requirements for displayed colours | EN ISO 9241-8 | 1997 |
| ISO 12641 | 1997 | Graphic technology - Prepress digital data exchange - Colour targets for input scanners calibration | - | - |
| ISO 13655 | 1996 | Graphic technology - Spectral measurement and colorimetric computation for graphic arts images | - | - |
| ISO/CIE 10527 | 1991 | CIE standard colorimetric observers | - | - |

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