

Prints and transparencies produced from electronic sources — Assessment of image quality

The European Standard EN 61610 : 1996 has the status of a
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Committees responsible for this British Standard

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Audio Engineering Society
British Broadcasting Corporation
British Educational Suppliers' Association
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British Telecommunications plc
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Federation of the Electronics Industry
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Institute of Sound and Communication Engineers
Institution of Electrical Engineers
International Association of Broadcasting Manufacturers
Professional Lighting and Sound Association
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National foreword

This British Standard has been prepared by Subcommittee EPL/100/3 and is the English language version of EN 61610 : 1996 *Prints and transparencies produced from electronic sources — Assessment of image quality*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 1610 : 1995, published by the International Electrotechnical Commission (IEC).

Cross-references

Publication referred to	Corresponding British Standard
ISO 5-1 : 1984	BS 1384 <i>Photographic density measurements</i> Part 1 : 1985 <i>Guide for terms, symbols and notations</i>
ISO 5-2 : 1991	Part 2 : 1993 <i>Specification for geometric conditions for transmission density</i> BS ISO 5 <i>Photography. Density measurements</i>
ISO 5-3 : 1984	BS ISO 5-3 : 1995 <i>Spectral conditions</i>
ISO 5-4 : 1983	BS ISO 5-4 : 1995 <i>Geometric conditions for reflection density</i>

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Descriptors: Electronic equipment, reproduction: Documents, printing, colour printing, printed forms, printers, images, colours, measurements method, characteristics, testing conditions

English version

Prints and transparencies produced from electronic sources Assessment of image quality

(IEC 1610 : 1995)

Images imprimées et transparents obtenus à
partir de sources électroniques
Evaluation de la qualité de l'image
(CEI 1610 : 1995)

Beurteilung der Bildqualität von durch
elektronischen Quellen erzeugten reflektierenden
und transparenten Reproduktionen
(IEC 1610 : 1995)

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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.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 84/399/FDIS, future edition 1 of IEC 1610, prepared by IEC TC 84, Equipment and systems in the field of audio, video and audiovisual engineering, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61610 on 1995-11-28.

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 (dop) 1996-09-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1996-09-01

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

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PRINTS AND TRANSPARENCIES PRODUCED FROM ELECTRONIC SOURCES – ASSESSMENT OF IMAGE QUALITY

1 Scope

This International Standard applies to the assessment of image attributes on prints and transparencies produced from electronic sources. Assessment of the equipment itself which produces prints and transparencies is outside the scope.

This standard specifies test signals, measurement conditions and forms of reporting the results so as to make possible the comparison of the results of measurements. The methods of measurement are designed to make possible the assessment of the image quality of prints and transparencies produced from electronic sources. The electronic sources are either analogue or digital signals of defined format, whose corresponding images are reproduced on either a transparent or a non-transparent medium.

The methods of measurement in this standard are designed to be applicable to a wide quality range of colour prints and transparencies. This range runs from a small piece of image for consumer use to a large and precise image for professional use. The prints and transparencies may be produced either by colour video printers with analogue inputs for consumer use, by professional colour image printers with digital inputs or by any other electronic means.

This standard does not specify limiting values for various parameters.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(845): 1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting*

ISO 5-1: 1984, *Photography – Density measurements – Part 1: Terms, symbols and notations*

ISO 5-2: 1991, *Photography – Density measurements – Part 2: Geometric conditions for transmission density*

ISO 5-3: 1984, *Photography – Density measurements – Part 3: Spectral conditions*

ISO 5-4: 1983, *Photography – Density measurements – Part 4: Geometric conditions for reflection density*

ISO/CIE¹ 10526: 1991, *CIE standard for colorimetric illuminants*

¹⁾ CIE stands for the International Commission on Illumination.

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

CIE 15.1: 1972, *Special metamerism index: Change in illuminant*

CIE 15.2: 1986, *Colorimetry*

CIE Technical Report 80: 1989, *Special metamerism index: Change in observer*

ITU-R¹⁾ Recommendation BT 471-1: 1990, *Nomenclature and description of colour bar signals*

3 Terms and definitions

For the purpose of this International Standard, the following definitions apply.

3.1 image: Visible, two-dimensional representation of electronic signals intended to form a picture.

3.2 electronic source: Apparatus which supplies electronic signals of analogue or digital form carrying colorimetric information to be used as input to equipment that produces coloured images.

3.3 medium: Substance within which the equipment produces an image.

3.4 substrate: Substance providing support for a medium.

3.5 test signal: Output of an electronic source to enable the performance of the image-making equipment to be assessed.

3.6 print: Reproduced image formed on an opaque substrate.

3.7 transparency: Reproduced image formed on a transparent substrate.

3.8 image quality: Objective quality of an image.

3.9 integrated density: Logarithm to base ten of the reciprocal of definite integral of the spectral product of the CIE standard luminous efficiency function with the spectral reflectance or spectral transmittance.

NOTE – The notations for integrated densities are modified from those specified in ISO 5-1 for the sake of avoiding confusion.

3.10 gamut of colours: Three-dimensional maximum range of reproducible colours expressed in CIE 1976 $L^*a^*b^*$ colour space defined in CIE 15.2.

3.11 primary colours: Colours produced by signals from the electronic source, which when formed by the additive process are red, green and blue, or by the subtractive process are yellow, cyan and magenta.

3.12 secondary colours: Colours produced by a mixture of two primary colours.

3.13 saturated colours: Reproduced primary colours and secondary colours.

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

¹⁾ Formerly CCIR Recommendation.

3.14 colour bars: Test signal which carries colorimetric information on black, white and saturated colours.

3.15 reproduced colours: Colorimetric information measured from the reproduced image expressed in CIE 1976 $L^*a^*b^*$ colour space which is defined in CIE 15.2.

3.16 tone reproduction: Colorimetric relation between a test signal which is intended to produce an achromatic image and the image actually produced.

4 Conditions

4.1 *Environmental conditions*

All measurements shall be carried out within the environmental conditions as specified by the manufacturer of the equipment which produces prints and transparencies, unless otherwise specified by this standard.

The environmental conditions during measurement, at least the room temperature and the relative humidity, shall be reported together with the presentation of the results of measurements.

4.2 *Conditions of measurement*

Any adjustable parameters shall be set to the manufacturer's recommended or defaults values. An adequate warm-up time shall be allowed.

The test images shall be produced by applying the test signals to the equipment following the manufacturer's specification. The medium on which the images are produced shall be the one specified by the manufacturer of the equipment.

The measurements of image quality of prints and transparencies shall be carried out by measuring the optical characteristics of reflectance or transmittance, respectively. Optical spectral density and integrated density may be used for specific measurements in this standard.

Each test signal of known characteristics shall be generated to produce the image which is specified in this standard. The image shall be measured without any time interval, unless otherwise specified. Spectral radiation or spectral reflectance should be measured over the wavelengths from 360 nm to 780 nm, but shall be measured at least from 400 nm to 700 nm in 10 nm, and 5 nm steps for incandescent lamps and fluorescent lamps, respectively.

If the input signal to equipment which produces prints or transparencies is expressed in a set of digital codes whose colorimetric coordinate values for four colours (white, red, green and blue) in the CIE 1931 xy chromaticity diagram defined in CIE 15.2 are different from those corresponding to the standard colours for conventional television systems [1]*, these values shall be specified by the manufacturer of the equipment for the four colours: white, red, green, and blue. These coordinate values shall be used to translate the actual input information to corresponding tristimulus values by the method given in [2] to obtain the conversion coefficients.

* Numbers in square brackets refer to annex B, Bibliography.

NOTES

1 The spectral reflectance should be measured using a spectrophotometer with either 0/5 or 45/0 geometry as stated in ISO 5-4.

2 Reflectance (optical) density is defined as logarithm to base ten of the reciprocal of the reflectance [IEV 845-04-65]. The IEV also states that the reflectance is composed of regular reflectance and diffuse reflectance, and that the results of measurements of these reflectances depend on the instruments and the measuring techniques used [IEV 845-04-62]. The same applies for transmittance (optical) density [IEV 845-04-66, IEV 845-04-59, IEV 845-04-63].

4.3 Conditions of calculation

4.3.1 Illuminants and colorimetric observers

The CIE standard illuminant *C* or *D₆₅* defined in ISO/CIE 10526 and the CIE 1931 standard colorimetric observer defined for a view angle of 2° in ISO/CIE 10527 should be used for calculation of the tristimulus values. If any another illuminant is used, it shall be reported. For some measurements, optical transmittance density and reflective density may be used, but it should be noted that the measured values depend on the instruments used for the measurement.

4.3.2 Tristimulus values

The tristimulus values for object colours and illuminant colours shall be calculated by the summations of the products of the spectral radiation, $S(\lambda)$, of the standard illuminant, the spectral transmittance or reflectance, $\rho(\lambda)$, and the colour matching functions, $x(\lambda)$, $y(\lambda)$, $z(\lambda)$ as defined by the following formulae:

$$X = \frac{1}{K} \int_{\text{vis}} S(\lambda) \rho(\lambda) \bar{x}(\lambda) d\lambda$$

$$Y = \frac{1}{K} \int_{\text{vis}} S(\lambda) \rho(\lambda) \bar{y}(\lambda) d\lambda$$

$$Z = \frac{1}{K} \int_{\text{vis}} S(\lambda) \rho(\lambda) \bar{z}(\lambda) d\lambda$$

where

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

$\bar{x}(\lambda)$, $\bar{y}(\lambda)$ and $\bar{z}(\lambda)$ are the functions specified as the CIE 1931 standard colorimetric observer for a view angle of 2° (see ISO/CIE 10527).

4.3.3 Relation between input values and tristimulus values

When the input signal is a standard analogue or digital video signal, the appropriate colorimetric specification should be used to transform corresponding tristimulus values. The conversions from *R*, *G*, *B* to the tristimulus values shall be made by the following equations according to the video standard used.

For standard NTSC system with standard illuminant *C*

$$X = 0,60674 R + 0,17353 G + 0,20025 B$$

$$Y = 0,29884 R + 0,58673 G + 0,11443 B$$

$$Z = 0,00000 R + 0,06611 G + 1,11566 B$$

For standard PAL/SECAM systems with standard illuminant *D₆₅*

$$X = 0,43066 R + 0,34155 G + 0,17819 B$$

$$Y = 0,22206 R + 0,70666 G + 0,07128 B$$

$$Z = 0,02019 R + 0,12956 G + 0,93848 B$$

For any standard HDTV system

The equations should be decided in accordance with the chromaticity coordinate values for the input primary colours, and for the reference white, in accordance with the method described in [2].

5 Methods of measurements

5.1 Gamut of colours

5.1.1 Characteristics to be determined

The maximum reproducible colour range in terms of the psychometric lightness and chromaticity.

5.1.2 Measurement procedure

a) The test signals containing input saturated colours shall be generated as specified by this standard. The signals shall correspond to the colours white, yellow, cyan, green, magenta, red, blue, and black as prints and transparencies.

The level of each input signal shall be in accordance with table 1.

Table 1 – Input signal specification

Colours	Input signals %		
	<i>R</i>	<i>G</i>	<i>B</i>
1 White	100	100	100
2 Yellow	100	100	0
3 Cyan	0	100	100
4 Green	0	100	0
5 Magenta	100	0	100
6 Red	100	0	0
7 Blue	0	0	100
8 Black	0	0	0

If the equipment accepts standard video signals, the standard colour bar generator to produce colour bars (a) 100/0/100/0 (see ITU-R Recommendation BT 471-1) may be used.

b) The spectral density $d(\lambda)$, or spectral reflectance or spectral transmittance $\rho(\lambda)$, for object colours of the prints or illuminant colours of transparencies, corresponding to the test signals, shall be measured for wavelengths from 400 nm to 700 nm in 10 nm steps.

If spectral density is adopted for the measurement, it shall be converted to spectral reflectance or transmittance by the following formula:

$$\rho(\lambda) = 10^{-d(\lambda)}$$

c) The tristimulus values, *X*, *Y*, *Z* shall be calculated for each colour (see 4.3.2).

5.1.3 Presentation of results

The measured spectral characteristics for the eight colours, including white and black, shall be plotted as the curves (see figure 1). The calculated tristimulus values shall be converted to values in the CIE 1976 colour space, $L^*a^*b^*$ as defined in CIE 15.2 for eight colours. They shall be reported as a table (see table 2), together with the kind of the standard illuminant used for calculation. The results shall also be presented as graphs, as shown in figure 2.

$$L^* = 116,0 Y'^{1/3} - 16,0$$

$$a^* = 500,0(X' - Y')$$

$$b^* = 200,0(Y' - Z')$$

where

$$X' = \left(\frac{X}{X_n}\right)^{\frac{1}{3}} \quad \text{for} \quad \frac{X}{X_n} \geq 0,008856$$

$$Y' = \left(\frac{Y}{Y_n}\right)^{\frac{1}{3}} \quad \text{for} \quad \frac{Y}{Y_n} \geq 0,008856$$

$$Z' = \left(\frac{Z}{Z_n}\right)^{\frac{1}{3}} \quad \text{for} \quad \frac{Z}{Z_n} \geq 0,008856$$

and

$$X' = 7,787 \frac{X}{X_n} + \frac{16,0}{116,0} \quad \text{for} \quad \frac{X}{X_n} \leq 0,008856$$

$$Y' = 7,787 \frac{Y}{Y_n} + \frac{16,0}{116,0} \quad \text{for} \quad \frac{Y}{Y_n} \leq 0,008856$$

$$Z' = 7,787 \frac{Z}{Z_n} + \frac{16,0}{116,0} \quad \text{for} \quad \frac{Z}{Z_n} \leq 0,008856$$

and where X_n , Y_n , Z_n are the tristimulus values for the illuminant of the colorimetric system adopted for the input signal.

For the NTSC system:

$$X_n = 0,98054$$

$$Y_n = 1,00000$$

$$Z_n = 1,18181$$

For the PAL/SECAM system:

$$X_n = 0,95041$$

$$Y_n = 1,00000$$

$$Z_n = 1,08825$$

For the systems other than the above, taking into account the specific illuminant, $S(\lambda)$:

$$X_n = \frac{\int_{\text{vis}} S(\lambda) \bar{x}(\lambda) d\lambda}{\int_{\text{vis}} S(\lambda) \bar{y}(\lambda) d\lambda}$$

$$Y_n = 1,00000$$

$$Z_n = \frac{\int_{\text{vis}} S(\lambda) \bar{z}(\lambda) d\lambda}{\int_{\text{vis}} S(\lambda) \bar{y}(\lambda) d\lambda}$$