INTERNATIONAL STANDARD

ISO 12646

Second edition
2008-06-01

Graphic technology — Displays for colour proofing — Characteristics and viewing conditions

Technologie graphique — Affichages pour la réalisation d'épreuves en couleur — Caractéristiques et conditions d'examen visuel

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Reference number
ISO 12646:2008(E)

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Contents

Page

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12646 was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

This second edition cancels and replaces the first edition (ISO 12646:2004), which has been extensively revised to include the particular requirements of flat panel displays.

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Introduction

The ability to match colour images displayed on colour monitors to the images produced when the same digital file is rendered by proofing and printing systems (commonly referred to as “soft” proofing) is increasingly expected in graphic arts. Obtaining such a match is not simple and to be fully accurate requires careful control of many aspects of the process. The primary purpose of this International Standard is to make recommendations with respect to the soft proof viewing conditions. If these are controlled, it is then possible for users to exchange meaningful calibration (3.1.1) and characterization (3.1.2) data such that a consistent and, possibly, accurate colour match to the hard copy proof is achieved. In the case of visual display devices, the RGB device values are related to CIE tristimulus values.

The appearance of a colour image on a colour display is influenced by many physical factors other than controlled ambient viewing conditions. Among the most important of these are uniformity, convergence, size and resolution (in order to permit rendition of the proof at close to its normal size and with the finest detail visible on the hard copy at normal viewing distances), variation of electro-optical properties with viewing direction, freedom from flicker and glare (specular reflections with distinct images), the opto-electronic calibration of the display and the settings of its display driver software. So, to be acceptable as a proofing system which provides a reasonable level of image quality, the display must also exhibit these properties at an acceptable quality. This International Standard is based on the use of the flat panel display (FPD) and cathode ray tube display (CRT) technologies. It specifies the requirements for factors such as uniformity, convergence, refresh rate, size and spatial resolution. However, since these parameters are subject to improvement as display technology changes, this International Standard only defines minimum requirements for these parameters. It is assumed that displays used for this purpose will always conform to accepted industry “standards” for computer-aided design (CAD), and generally provide quality levels considered acceptable for this purpose, where they offer an improvement over the specifications herein.

Note that, even for displays of the highest quality, the appearance of the displayed image will be limited by the accuracy of the colour transformation used for converting the digital file from its encoded colour space to that required for display purposes. This International Standard provides no formal specifications for these transformations, although the issues are discussed in an informative annex (Annex A), together with recommendations for achieving an acceptable colour transformation.

This International Standard only considers the setting up of colour displays as “soft” proofing devices. It primarily focuses on applications where the displayed image will be directly compared to a hard copy. However, in some practical situations, the image on the screen is evaluated in the absence of a hard copy. In this International Standard examples of two practical use cases are described. The first concerns the comparison of a soft proof with a hard copy proof; the second concerns the viewing of displayed images independently of any hard copy image. For the viewing of displayed images independently of any hard copy image, less restrictive requirements are sufficient, and they are stated separately in this International Standard. This viewing is therefore concerned with modifying the “hard” and “soft” controls of the display to enable it to simulate a proof. In this sense, it can be looked on as a “slave” device. However, it is in the interests of a CAD user, where the colour display in a real sense “originates” from the image, to set up the display in a similar way. This will enable simpler optimization of the colour transformation to the selected hard copy system used for rendering the image, in order to produce an accurate reproduction, if this is an important requirement. However, it is possible to undertake image processing to modify the image when rendered to make it look like the displayed image (colour gamuts permitting) whatever the opto-electronic calibration of the display. This is briefly discussed in Annex A.

Users of this International Standard will also benefit from CIE Publication 122[14]. Those unfamiliar with the judgement of displays may also find it helpful to read IEC 61223-2-5[9] which contains much useful detailed information about evaluation and testing of image display devices.

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Graphic technology — Displays for colour proofing — Characteristics and viewing conditions

1 Scope

This International Standard specifies the minimum requirements for the characteristics of displays to be used for soft proofing of colour images. Included are requirements for uniformity, convergence, refresh rate, display diagonal size, spatial resolution and glare of the screen surface. The dependence of colorimetric properties on the electrical drive signals and viewing direction, especially for flat panel displays, is also specified.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3664, *Graphic technology and photography — Viewing conditions*

ISO 13655:—[1)], *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*

ISO 15790, *Graphic technology and photography — Certified reference materials for reflection and transmission metrology — Documentation and procedures for use, including determination of combined standard uncertainty*

CIE Publication 15, *Colorimetry*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
calibration
operation of establishing that the measured values agree with the values specified by a standard or a characterization process

3.1.2
characterization
process of relating device-dependent colour values to device-independent colour values

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1) To be published. (Revision of ISO 13655:1996)

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3.1.3
convergence
ability of the three electron beams (R, G and B) to come together at a single spot on the surface of the CRT (see 3.2)

NOTE Not applicable to FPDs (see 3.2).

3.1.4
DVD
design viewing direction
direction for which specific electro-optical characteristics of the display have been optimized

NOTE Examples of important electro-optical characteristics are maximum luminance and maximum contrast.

3.1.5
gamma
γ
best-fit parameter which relates the monitor normalized output luminance to a normalized input digital value presented to the monitor system including its hardware and software components as given in Equation (1):

$$L = S^{\gamma} \tag{1}$$

where

L is the normalized output luminance;

S is the normalized input digital value

NOTE This definition is traditionally used in graphic technology for work with CRTs (see 3.2). It ignores offset and gain and thus differs from that in CIE Publication 122[14]. See also target gamma (3.1.12).

3.1.6
hard copy proofing system
system for simulating a printed image using a printing device which may be different from that used for production

3.1.7
OFF-state
condition in which the display is switched off

3.1.8
ON-state
condition in which the display is switched on

NOTE This definition is important for light-valve-like displays, which might emit a significant light intensity even when displaying the darkest image (R = G = B = 0) in the ON-state.

3.1.9
opto-electronic transfer function
relationship between the input values provided to, and the luminance values produced by, a display device

3.1.10
refresh rate
frequency with which the image on the screen is redrawn

NOTE The refresh rate is expressed in Hertz (Hz).

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3.1.11
RGB
additive process colour model where the channels are called Red, Green and Blue

[ISO 15930-7:2008, definition 3.29]

3.1.12
target gamma
gamma value specified by the vendor either as a single number characterizing the total range or piecewise as a look-up table for inputs from 0 to 2^n-1 (n-bit)

NOTE The target gamma characterizes the intended input-output relation. The target gammas of all channels are assumed to be identical.

3.1.13
tracking
channel balance
process of ensuring (by adjustment of the amplifiers) that the relationship between the three channels of a display is balanced, so that for all levels equal values in each channel produce a neutral sensation

3.1.14
viewing cone
VC
conical space, originating at the display surface, that includes all viewing directions with a specified angle of inclination θ

3.1.15
surround
area adjacent to the border of an image, which, upon viewing the image, may affect the local state of adaptation of the eye

3.2 Abbreviated terms

CRT cathode ray tube display

FPD flat panel display

LCD liquid crystal display

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4 Requirements

4.1 Resolution

The display resolution shall be sufficient for displaying an image of 1 280 pixels × 1 024 pixels without interpolation. When a test image with dimensions as defined in 5.2 is displayed by a CRT, all specified lines shall be visible at a normal viewing distance (defined as 0,5 m for the purposes of this International Standard).

To avoid issues associated with interpolation, it is important to operate all displays at their intrinsic native resolution.

4.2 Size

The display shall be capable of displaying an image having a diagonal measurement of at least 43 cm and a height of at least 22 cm.

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4.3 Refresh rate (CRTs only)

The refresh rate, non-interlaced, shall be at least 80 Hz.

4.4 Uniformity of luminance

The display should be visually uniform when displaying flat white, grey and black images. When measured as described in 5.3, all luminance values should be within 5 % of the luminance of the centre and shall be within 10 % of it. There should also be no areas of significant visual non-uniformity between the points marked in Figure 2.

For the entire display, measured at least at the positions stated in 5.3, the chromaticity of every neutral image (defined by equal digital values for R, G, and B) shall be within a radius of 0,01 (in u', v' as defined in ISO 13655) from the chromaticity values measured at the centre of the display.

NOTE 1 The uniformity of chromaticity is specified in 4.8.

NOTE 2 The uniformity tolerance of a radius of 0,01 (in u', v') of CIE 1976[12] corresponds to an average CIELAB difference of 1,7 at a CIE L^* value of 5 and a difference of 8,7 at a CIE L^* value of 95.

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4.5 Geometric accuracy (CRTs only)

When displaying the grid pattern specified in 5.4, the display should essentially be free of distortion. The length of adjacent lines of the grid pattern shall be within 2 mm of each other and no line length shall deviate by more than 2,5 mm from the mean length.

4.6 Convergence (CRTs only)

When displaying the grid pattern specified in 5.4, all lines shall appear wholly free of colour fringing within the central region (defined as the area within half the linear diagonal distance). A small amount of fringing may be accepted outside of this area but is not recommended.

4.7 Ambient illumination, surroundings and environment

4.7.1 General

The luminance of the black level (R = G = B = 0) in the ON-state, measured with a spectroradiometer or a colorimeter in a dark room, as specified in 5.6, shall not be greater than 200 % of the black level reading in the OFF-state.

The reflective properties of the display surface in the OFF-state shall be judged visually in a darkroom using a point source. The reflection of the point source off the screen should appear hazy and should smoothly decrease as one turns away from the direction of specular reflection.

No strongly coloured surfaces (including clothing) should be present in the immediate environment surrounding the monitor.

NOTE Display reflective properties can also be determined as specified in ISO 13406-2 for “unwanted reflections”.

4.7.2 Comparison of monitor and hard copy images

For the comparison of monitor and hard copy images, the following applies.

a) It is necessary that the level of ambient illumination is sufficiently low. The luminance of a perfectly reflecting diffuser, placed at the position of the faceplate of the monitor, with the monitor switched off (OFF-state), shall not be greater than 1/4 of the monitor white point luminance (R = G = B = 255) and should not be greater than 1/8 of the monitor white point luminance. These limits also apply when

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measuring in any other plane which might affect the state of adaptation of the observer. The colour temperature of the ambient light, such as room light, should be within ±200 K of the colour temperature of the illumination used in the viewing booth.

b) The luminance of the area surrounding the monitor shall not exceed 1/10 of the luminance of the monitor showing a white screen (R = G = B = 255). The measurement shall be performed as specified in 5.6.

c) The conditions within the viewing booth shall conform to viewing condition P2 of ISO 3664.

d) No light from the viewing booth shall fall directly on the monitor.

e) Extraneous light, whether from light sources or reflected by objects, shall be baffled from view and from illuminating the print or other image being compared.

4.7.3 Viewing of single images

When viewing single images, the following applies.

a) The luminance of the area surrounding the monitor should not exceed 20 %, or preferably even 3 %, of the luminance of the white point of the monitor. The measurement shall be performed as specified in 5.6.

b) It is necessary that the level of ambient illumination is sufficiently low. The luminance of a perfectly reflecting diffuser, placed at the position of the faceplate of the monitor, with the monitor switched off (OFF-state), shall not be greater than 1/4 of the monitor white point luminance (R = G = B = 255) and should not be greater than 1/8 of the monitor white point luminance. These limits also apply when measuring in any other plane which might affect the state of adaptation of the observer.

   NOTE By keeping the level of ambient illumination significantly lower than the luminance level of the monitor white point, the full contrast range of the monitor is ensured not to be significantly reduced by the effects of veiling glare. This also enables the observer to adapt reasonably to the monitor. Given the luminance levels currently available with monitors whose white point is set to D65, it is necessary that the level of ambient illumination be less, and preferably much less, than 1/4 of the monitor's white luminance.

c) Extraneous light, whether from light sources or reflected by objects, shall be baffled from view.

4.8 Chromaticity, luminance of the white and black points, and tracking (channel balance)

4.8.1 General

The black point of the display shall have a luminance that is less than 1 % of the maximum luminance (i.e. a luminance ratio of at least 100 to 1).

The luminance of the white displayed on the monitor shall be at least 80 cd/m^2 but preferably 160 cd/m^2.

NOTE 1 In cases where the gradation of the white point cannot be adjusted by hardware means, and the white is therefore achieved by altering look-up tables in the driver software, one of the channels ought to be set to the maximum digital value.

NOTE 2 The display ought to be set at luminance levels lower than or equal to those recommended by the manufacturer.

4.8.2 Comparison of monitor and hard copy images

At the centre of the white image defined in 5.3, the chromaticity of the display should be set to that of D50; namely u' = 0,209 2, v' = 0,488 1 (as specified in CIE Publication 15). The chromaticity obtained, for the white point chosen by the software application vendor, shall be within a circle of radius 0,005 from this point.

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The luminance of the monitor should be as high as necessary to visually match an unprinted sheet of white paper located close to the monitor having an illuminance of 500 lx, as specified in ISO 3664 for viewing condition P2. If that is not possible, the luminance shall be at least 80 cd/m^2 but preferably 160 cd/m^2.

The conditions within the viewing booth shall conform to viewing condition P2 of ISO 3664.

4.8.3 Viewing of single images

At the centre of the white image defined in 5.3, the chromaticity of the display should be set to that of D50; namely $u' = 0{,}209\,2$, $v' = 0{,}488\,1$ (as defined in CIE Publication 15) but it may be set to that of a higher colour temperature such as D65.

NOTE When viewed under the conditions specified in 4.8.1 to 4.8.2, the CRT monitor itself will provide the primary adapting stimulus to the eye. The chromaticity of the white of the monitor is not very important in this situation, although many users prefer that it be close to that of D65. There is some evidence that, at the low luminance levels obtained with monitors, a chromaticity close to that of D65 provides a better evocation of white. Furthermore, such a chromaticity permits a higher level of luminance to be achieved with current display technology.

4.9 Gamma

The value of the target gamma of the display should be chosen, by the vendor, to fall into the range of 1,8 to 2,4. The luminance measurement shall be performed as specified in 5.6.

The luminance shall be measured for at least 10 neutral colours (R = G = B), approximately equally spaced in lightness, having a luminance greater than 1 % of the maximum luminance. The deviation between the normalized measured luminance and the normalized target luminance shall not exceed 10 % of the normalized target luminance in every case.

NOTE 1 Some standards (such as IEC 61966-2-1 [11]) suggest that, since the term gamma has been used in various ways, it is preferable not to use it at all to avoid possible ambiguity. Those requiring further information on the subject are referred to CIE Publication 122 [14] and to the paper by Anderson *et al* [16]. The paper by Anderson *et al* [16] includes explanation of some of the terms that have been in common use (including system gamma, monitor gamma and encoding gamma) and how they relate to the definition in CIE Publication 122 [14].

NOTE 2 Tone reproductions such as defined by CIE L^* lightness are considered to lie within the specified gamma range of 1,8 to 2,4 defined in this International Standard.

4.10 Colorimetric accuracy and grey balance

For at least 10 neutral colours (R = G = B), approximately equally spaced in lightness, having a luminance greater than 1 % of the maximum luminance, the tristimulus values shall be measured. For each neutral colour, the colour difference, ΔE_{c}, between these measured values and the CIELAB values (utilizing the white point chosen in 4.8.2 or 4.8.3), which are intended to be displayed by the software characterizing the display, shall be calculated in accordance with Equation (2):

$$\Delta E_{\mathrm{c}} = \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2} \qquad (2)$$

where

Δa^* is the difference for the CIELAB (red-green opponent) co-ordinate;

Δb^* is the difference for the CIELAB (yellow-blue) co-ordinate.

The deviation shall not exceed 3 and preferably not 2.

A reference RGB data file comprising at least five equally spaced code values for each channel (e.g. R = 0, 63, 127, 191 and 255, using 8-bit coding) and all combinations among the other channels, having a luminance greater than 1 % of the maximum luminance, shall be displayed and measured at the centre of the display.

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The measured tristimulus values shall be transformed to CIELAB values using the white point chosen by the software application vendor. The average of the CIE 1976 [12] colour differences between these values and the CIELAB values intended to be displayed by the software characterizing the display [e.g. an ICC[2]) monitor profile] shall not exceed 5 and preferably not 2. The maximum colour difference shall not exceed 10 and preferably not 4.

NOTE For high quality print work, a deviation of $\Delta E_c < 1$ is advisable.

4.11 Directional variation of luminance and chroma (FPDs only)

The angles defined in 5.6.2.1 shall be measured in the viewing cone. The quantities listed in 5.6.2.1 shall be evaluated at least for the drive states R = G = B = 255 and R = G = B = 127 (8-bit data) and should be evaluated for the 10 neutral colours defined in 4.10.

The CIE Y luminance at each measured angle shall be compared with the luminance at the DVD. The maximum luminance deviation should not exceed 10 % and shall not exceed 30 %.

In the contrast inversion test, for a given RGB drive state, and for all points on the display, the luminance at angles off the DVD shall not exceed the luminance at the DVD.

The colour difference, ΔE_c, defined in 4.10, shall not exceed 10 and preferably not 2,5.

5 Test methods

5.1 Preparation and instrument set-up

Prior to any measurement, the display shall be switched on and allowed to warm up for a period of at least 30 min (a warm-up period of 2 h is recommended) at approximately 85 % of the maximum luminance, at the chromaticity of the D50 white point.

All measurements shall be carried out on the calibrated and characterized display. The information (e.g. calibration process, software used, ICC profiles) necessary to describe and repeat the measurements shall be reported with the data.

If not otherwise required, all measurements shall be carried out at the DVD and in contact with the faceplate. They shall be in accordance with 5.6. If no design viewing condition is stated by the vendor, the normal to the display surface shall be used instead.

5.2 Resolution (CRTs only)

A test image, consisting of a number of fields, each composed of white and black lines of varying frequency, as shown in Figure 1 a), shall be displayed in various positions and orientations as shown in Figure 1 b). The lines and spaces are equal in width for each field, and range from 0,5 mm to 0,2 mm in intervals of 0,05 mm.

When viewed normally, and at a typical viewing distance (approximately 0,5 m), the lines labelled "D" shall be clearly distinguishable, and those labelled "F" should be clearly distinguishable, for all images within the central region of the display. (The central region is defined as that within half the diagonal distance.) Any images outside of this region may have a resolution which is poorer by 0,05 mm.

It is assumed that the observer making this assessment has reasonable vision (though possibly aided by spectacles). No additional magnifier should be used.

2) ICC: International Color Consortium.

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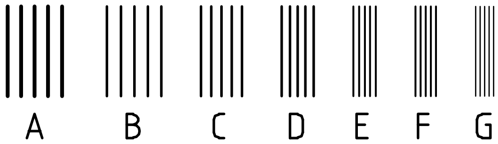
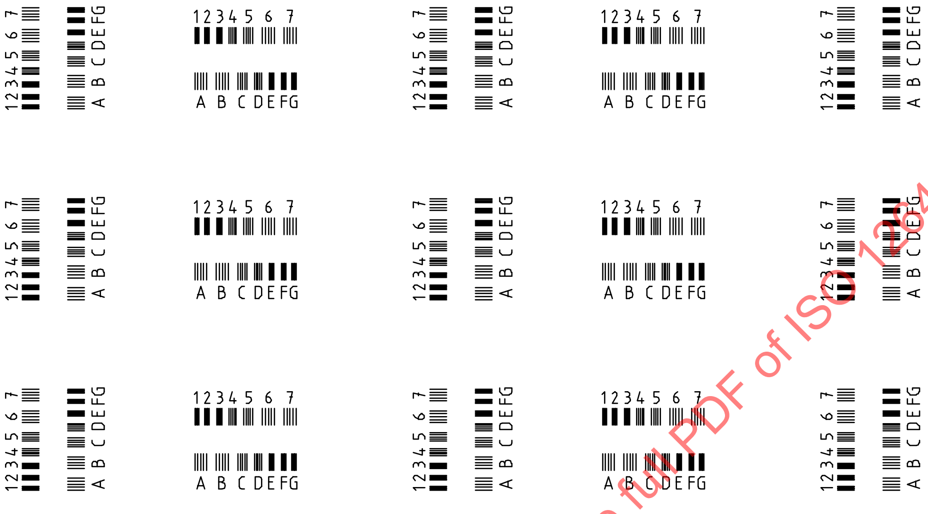


a) Resolution target



b) Layout of resolution targets

Key

A line and spacing width 0,50 mm
B line and spacing width 0,45 mm
C line and spacing width 0,40 mm
D line and spacing width 0,35 mm
E line and spacing width 0,30 mm
F line and spacing width 0,25 mm
G line and spacing width 0,20 mm

Figure 1 — Resolution test image

5.3 Uniformity

The uniformity shall be determined for white, grey and black images that each fill the screen. The white image shall consist of the maximum value in each of the Red, Green and Blue channels (255 for 8 bit). The grey image should consist of approximately half of the maximum value in each channel (127 for 8 bit), and the black should consist of approximately a quarter of the maximum value in each channel (63 for 8 bit) but shall be greater than 10 % of the maximum digital code value (26 for 8 bit).

For each level, at least 9 points of the image area of the screen shall be measured; see Figure 2.

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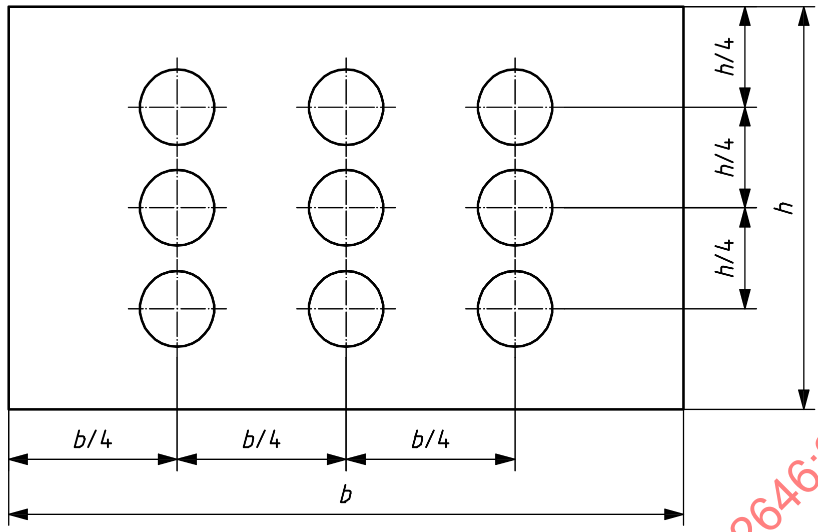

Key

h height of display

b width of display

Figure 2 — Positions for measurement of uniformity

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5.4 Geometric accuracy (CRTs only)

Geometric accuracy shall be evaluated using the test pattern shown in Figure 3 (derived from that shown in IEC 61223-2-5[9]). This pattern shall be displayed as black on white. It shall have at least 11 lines, and no more than 17 lines (preferably an odd number), in both horizontal and vertical orientations, and the lines shall be 2 display pixels wide. All lines shall be of the same length. The pattern shall have an identifiable outer boundary to ensure accurate positioning of the pattern on the display and shall contain the circle inscribed within the boundary to aid the visual assessment. The pattern should be assessed according to the following procedure derived from that given in IEC 61223-2-5.

a) Visually assess the boundary pattern to ensure it is all present.

b) Visually assess the circle for distortion, which should be negligible.

c) Measure the lengths of the lines.

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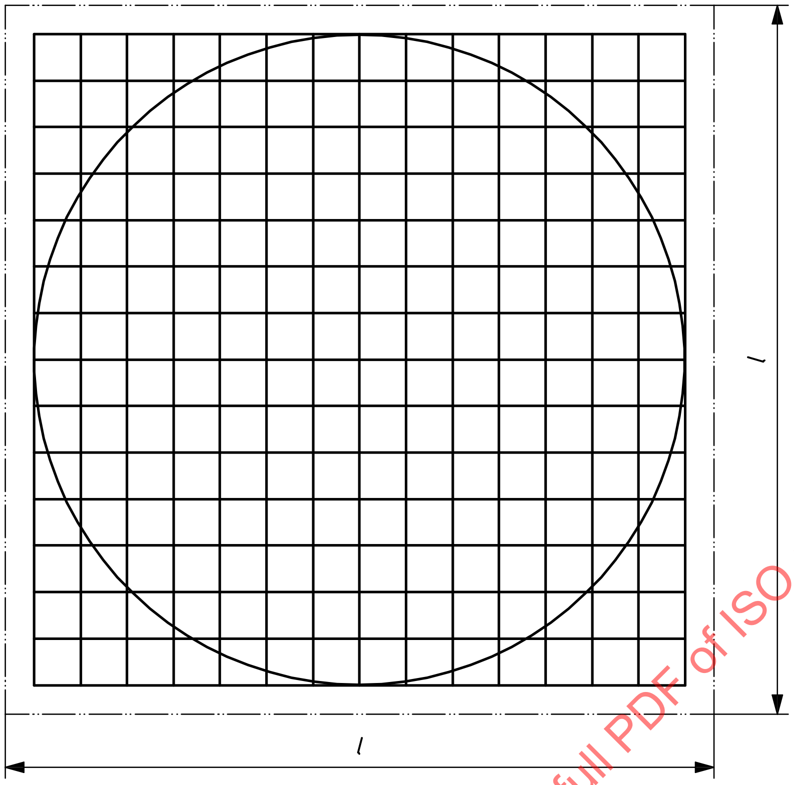

Key

l dimension of display

Figure 3 — Grid pattern for assessment of convergence and geometric accuracy

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5.5 Convergence (CRTs only)

Convergence shall be evaluated using the grid lines of the test pattern shown in Figure 3 and assessed visually.

NOTE As stated in 5.4, the grid lines of Figure 3 are 2 display pixels in width.

5.6 Measurement conditions

5.6.1 Photometric and colorimetric measurements

5.6.1.1 The following requirements pertain to measurements either at the faceplate of the display or at some distance. The measurement at the faceplate of the display shall be carried out using either a spectroradiometer or a tristimulus colorimeter. The measurement at some distance from the faceplate of the display shall be carried out in a dark room with the configuration shown in Figure 4. The distance d shall not be less than four times the effective screen height, h, i.e. $d \geqslant 4h$. For both cases, the optical axis of the instrument shall be perpendicular to the surface of the display.

5.6.1.2 Spectroradiometers shall comply with the following requirements.

a) The wavelength range shall extend from 400 nm to 720 nm.

b) The angular subtense of the field of measurement shall be less than 5°, see Figure 4. The distance d shall be chosen such that the number of pixels sampled during measurement is at least 150.

c) The reported chromaticity coordinates shall be of such a precision that the CIE xy results for illuminant A lie within a radius of less than 0,005.

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d) The 2k uncertainty of the wavelength, where k is the coverage factor defined in ISO 15790, should be less than 0,5 nm and shall be less than 1 nm, as described in the wavelength standard used.

e) The reference for spectral data shall be based on computed data at 1 nm intervals where the spectral response function is triangular with a 1 nm bandwidth at the half-power point.

f) The sampling interval should be 5 nm and shall not exceed 10 nm. The bandwidth, as defined in ISO 13655, shall be identical to the sampling interval. If the measurements are taken at sampling intervals smaller than 5 nm, the procedure for widening the bandwidth specified in ISO 13655:—, Annex A, shall be used for deriving and reporting data at 5 nm intervals.

g) At a luminance greater than 80 cd/m^2 and at a spectral distribution corresponding to that of the white state of the display (R = G = B = 255) the repeatability of the spectroradiometer shall be better than 0,001 for CIE xy and 0,5 % of the luminance.

h) For FPDs only, the polarization error of the instrument is limited as follows: the variations, measured at five azimuthal positions of the instrument, spaced 30° apart, shall be less than 5 % with respect to luminance and less than 0,002 with respect to CIE $u'v'$.

5.6.1.3 Tristimulus colorimeters shall comply with the following requirements.

a) The angular subtense of the field of measurement shall be less than 5°; see Figure 4. The distance d shall be chosen such that the number of pixels sampled during measurement is at least 150.

b) The repeatability (stability) shall be less than 0,001 for CIE xy and 0,5 % for the luminance using a stable light source having a luminance higher than 80 cd/m^2.

c) The reported chromaticity co-ordinates shall be so precise that the CIE xy results for illuminant A lie within a radius of less than 0,005.

NOTE Illuminant A is chosen for traceability measurements because of its practicality and ease of realization.

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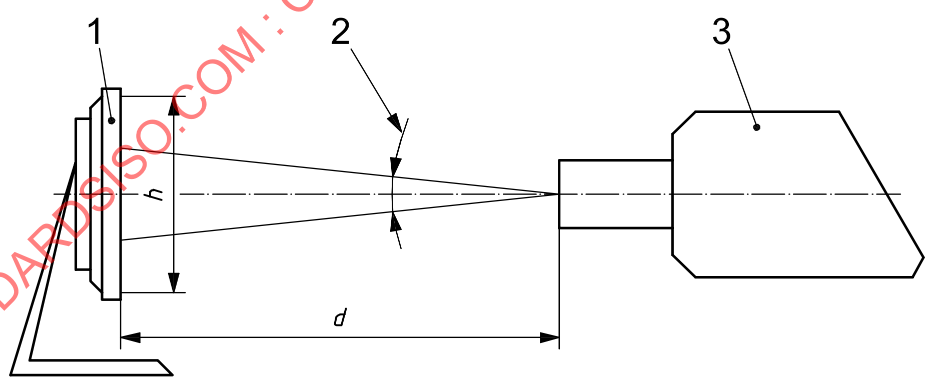

Key

1 FPD
2 field of measurement
3 spectroradiometer or colorimeter
h height of active display area
d distance

Figure 4 — Set-up for non-contact measurements (adapted from IEC 61966-4[10])

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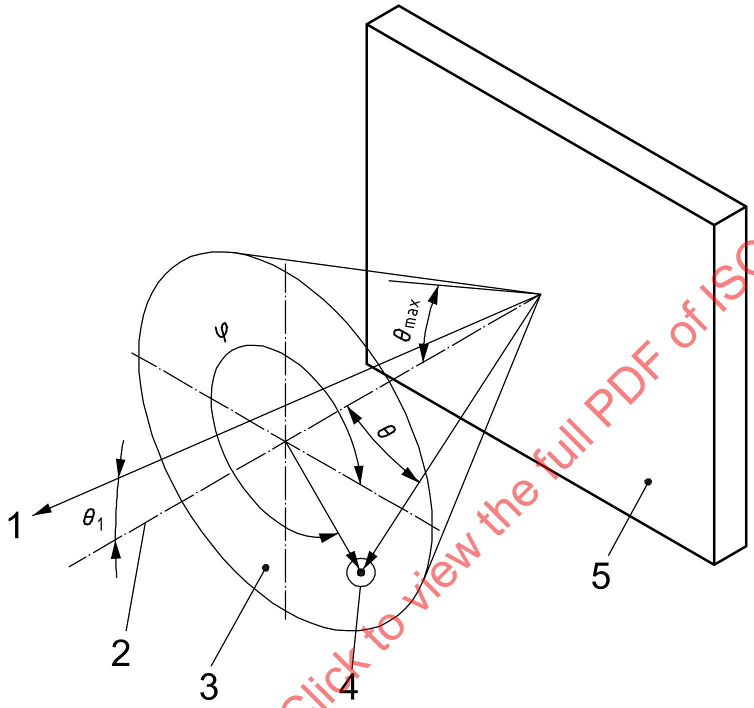
5.6.2 Measurements as a function of viewing direction

5.6.2.1 Angle definitions

For the purpose of these measurements, the following definitions apply. The azimuth angle, φ, is measured anti-clockwise from the 3 o'clock position; see Figure 5. The inclination angle, θ, is measured from the surface normal $\boldsymbol{n}$.

NOTE For more information on co-ordinates and viewing, see ISO 13406-2[6].



Key

1 DVD
2 surface normal ($\boldsymbol{n}$)
3 viewing cone
4 point defining the measurement direction with respect to θ and φ
5 FPD

θ angle of inclination of measurement direction with respect to the surface normal
θ_1 angle of inclination of the normal with respect to the DVD
θ_{max} maximum angle of inclination with respect to the surface normal
φ angle of azimuth of measurement direction

Figure 5 — Spherical co-ordinate system

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5.6.2.2 Viewing cone

Measurements of the directional luminance and colorimetric distribution shall be carried out in a darkroom, at the centre of the display, using conoscopical measurements or other instrumentation capable of measuring the colorimetric properties for different angles of azimuth and inclination (see Becker [17]).

The measurement shall be carried out in specific equally spaced directions of the so-called viewing cone; see Figure 5. The viewing cone is limited by the maximum angle of inclination, θ_{max}, which shall be at least ±30° but preferably at least ±60°. The minimal azimuth angle steps shall not exceed 45° but preferably should not

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exceed 15°. The minimum inclination angle steps shall not exceed 15° but preferably should not exceed 5°. This defines a lower limit of 17 directions within and including the edge of the viewing cone.

NOTE The viewing cone described corresponds to the viewing direction range class II of ISO 13406-2[6].

If two people are to view the monitor simultaneously, at a comfortable viewing distance, a cone angle of at least ±60° is considered essential.

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Annex A
(informative)

Characterization and calibration

A.1 Matching colour between hard copy and soft copy proofs

A.1.1 Even when the display meets the requirements of this International Standard, it does not guarantee that a displayed (soft copy) image will match the colour of the same image produced on the hard copy. To achieve a colour match, it is necessary to provide a colour transformation, such that the colour-data format in which the image is encoded can be transformed into that required by the colour display and the hard copy system. Thus, if an image is encoded in a CIE colour space or in some arbitrary RGB or CMYK (cyan — magenta — yellow — black) format, it will be necessary to transform it to provide a colour match between the proofs. This transformation will normally be achieved by means of a colour management system, possibly based on the use of ICC profiles which provide the relationship between the device-specific colour signals (e.g. monitor-drive voltage) and the colour co-ordinates of the profile connection space (PCS), as defined by ISO 15076-1 [7]. The principles which this software may well employ for achieving this are discussed below.

A.1.2 For colour CRT displays, the colour mixing required to produce a colorimetric match to any colour may be defined as a simple linear transformation of the tristimulus values with a correction for gain, offset and gamma, as discussed in CIE Publication 122 [14]. Other non-linear effects, such as cross-talk and internal flare, can usually be ignored for the quality of CRT displays used for this application. If this is not so, it will be necessary to modify the transformation calculation, as discussed in CIE Publication 122 [14]. Note that without the correction for gain and offset, the function for gamma will normally be more complex than a simple power function correction to take account of the non-linearity required in such a correction, particularly at low luminance levels. However, when parameters for gain and offset are included, a simple power function usually provides a reasonably acceptable model.

A.1.3 The simple model described in A.1.2 may not be applicable to colour LCD flat panel displays. In particular, the gamma function characteristic familiar to users of CRT displays may be quite different for LCD displays, in which it is quite possibly not a constant. However, although at the present time no general recommendations are available for the opto-electronic transfer characteristics of such displays, they can be included within this International Standard providing that the display drivers are modified to achieve this specification. This could be arranged, for example, by means of a three-dimensional look-up table stored in the ICC profile of interest.

A.1.4 It should also be noted that viewing conditions significantly affect colour appearance, and so when comparing different media in which the viewing conditions may differ and the physical stimulus characteristics differ also, a colorimetric match does not always accurately predict a perceived colour match. This makes it difficult to specify absolute colorimetric target values and tolerances for both print and display, unless viewing conditions are tightly specified and the colorimetric values are modified to take account of the influence of these conditions. In certain conditions when viewing the display and proof, a good colour appearance match is often obtained when the tristimulus values of the colours displayed match those of the proofs. In general this will be approximately true for the viewing conditions of display and proof specified in 4.7 as well as in ISO 3664. This also helps in the simulation of the proof. It is also necessary to use the print-viewing conditions from ISO 3664 which specifies a lower level of illumination (viewing condition P2) if the display and proof are to be compared. If such conditions are assumed, a simple measurement of colour difference for a range of colours will usually prove fairly effective in assessing characterization accuracy. However, in general the eye is used as the final arbiter in assessing the colour match between a soft copy and a hard copy proof and the colour transformation modified accordingly.

A.1.5 If the ambient conditions do not meet those specified in this International Standard, and particularly if excessive viewing flare is present, the colour management software will have to modify tone and colour reproduction accordingly and a colorimetric match will not be obtained. In such a situation, the use of a colour

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