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Graphic technology and photography — Viewing conditions

Technologie graphique et photographie — Conditions d'examen visuel

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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 3664 was prepared by Technical Committee ISO/TC 42, *Photography*, in collaboration with Technical Committee ISO/TC 130, *Graphic technology*.

This third edition cancels and replaces the second edition (ISO 3664:2000), which has been technically revised by tightening the compliance tolerances on the ultraviolet portion of the D50 spectral power distribution, by adding additional optional illumination conditions, and by increasing the luminance levels of displays used for image appraisal.

Introduction

While colour and density measurements play important roles in the control of colour reproduction, they cannot replace the human observer for final assessment of the quality of complex images. Colour reflection artwork, photographic transparencies, photographic prints, and photomechanical reproductions such as on-press and off-press proofs or press sheets, are commonly evaluated for their image and colour quality or compared critically with one another for fidelity of colour matching. Paper and other substrates contribute to the colour appearance, and controlling the colour of these is equally critical. However, it is noted that the paper industry has its own set of standards for unprinted paper, which differ in illumination conditions from those recommended in this International Standard.

There is no doubt that the best viewing condition for the visual assessment of colour is that in which the product will be finally seen. Where this is known and it is practical to do so, the various people in the production chain can sensibly agree to use this viewing condition for all evaluation and comparison. However, it is important that this be properly agreed upon in advance and that it be specified that such a viewing condition is not defined in this International Standard.

Unfortunately, such agreement is often not practical. Even if a particular end-use condition is known, it can be impractical to provide everybody in the production chain with sufficiently consistent viewing apparatus. Differences in illumination and viewing conditions can cause corresponding differences in the colour appearance of substrates, reproductions and artwork. Such differences are likely to cause misunderstandings about colour reproduction and processing. This International Standard provides specifications for illumination and viewing conditions that, when properly implemented, will reduce errors and misunderstandings caused by such deficiencies and inconsistencies.

The illumination used to view colour photographic prints, photomechanical reproductions and transparencies needs to provide adequate amounts of radiant power from all parts of the ultraviolet (UV) and visible spectrum to avoid distorting their appearance from that observed under commonly used sources of illumination, such as daylight. The UV content is important where fluorescent samples, which are excited in this region, are encountered – a phenomenon associated with many of the paper substrates on which images are reproduced, as well as with some of the dyes and pigments themselves.

To ensure consistency with previous editions of this International Standard, as well as with the majority of equipment in current use, the reference spectral power distribution specified in this International Standard is CIE illuminant D50. Many of the reasons for the selection of illuminant D50 in the first edition of this International Standard (ISO 3664:1975), as opposed to any other CIE daylight illuminant, are equally applicable today. In the development of the second edition of this International Standard (ISO 3664:2000), consideration was given to changing the reference illuminant to CIE F8, a 5 000 K illuminant more typical of fluorescent lamps. However, it was felt that this would provide only a minimal conformance advantage (as shown in Annex B), and the actual goal is for the illumination to simulate natural daylight.

Because it is very difficult to produce artificial sources of illumination that closely match the spectral power distribution of daylight, it is important that the tolerances specified within this International Standard provide a compromise between those required for lamp manufacturing purposes and those for consistent viewing. In this International Standard, three constraints apply which define the characteristics of the light falling on the viewing plane – one directly and two indirectly – and all three need to be met simultaneously if a viewing apparatus is to be in compliance.

The chromaticity, which directly defines the colour of the illumination at the viewing surface, is specified as that for illuminant D50, and the tolerance by a circle in the CIE 1976 Uniform Chromaticity Scale (UCS) diagram having a specified radius around that value. To establish the compliance of the spectral power distribution of the illumination to that of illuminant D50, the methods defined in CIE 13.3-1995 and ISO/CIE 23603 are both specified. One defines the colour rendering quality of a lamp and the other defines its ability to correctly predict metamers. Both requirements are important to the graphic technology and photographic industries. The virtual metamers for CIE illuminant D50 from ISO/CIE 23603 are used. In

addition, based on experimental work described in Annex B, a practical tolerance of acceptability has been defined, alongside a Colour Rendering Index requirement.

The perceived tonal scale and colours of a print or transparency can be significantly influenced by the chromaticity and luminance of other objects and surfaces in the field of view. For this reason, ambient conditions, which will possibly affect the state of visual adaptation, need to be designed to avoid any significant effects on the perception of colour and tone, and immediate surround conditions also need to be specified. Such specifications are provided in this International Standard.

Experience in the industries covered by this International Standard has revealed the need for two levels of illumination:

— a high level for critical evaluation and comparison, and

— a lower level for appraising the tone scale of an individual image under illumination levels similar to those under which it will be finally viewed.

This International Standard specifies these two levels of illumination.

The higher level is essential to graphic technology where comparison is being made, such as between original artwork and proof, or to evaluate small colour differences between proof and press sheet in order to control a printing operation. It is effective in these situations because it enhances the visibility of any differences. The high level of illumination is also appropriate in photography when comparing two or more transparencies or when critically evaluating a single image to assess the darkest tones that can be printed.

Since, despite adaptation, the level of illumination has quite a significant effect on the appearance of an image, the lower level is required in order to appraise the image at a level more similar to that in which it will be finally viewed. Although it is recognized that quite a wide range of illumination levels can be encountered in practical viewing situations, the lower level chosen is considered to be fairly representative of the range encountered. For this reason, it is applicable to aesthetic appraisal, including the conditions for routine inspection of prints.

The viewing of transparencies is specified both for direct viewing and by projection. Additional conditions are also specified for those situations where transparencies are to be compared to a print. The particular surround specified for transparencies recognizes the way that a transparency needs to be viewed for optimum visibility of the dark tones, but acknowledges that practical viewing equipment is likely to have ambient conditions that introduce some viewing flare. The combination of surround and flare produce an appearance that is fairly representative of how the transparency will look in a typically lighted room.

Small transparencies are commonly evaluated in graphic technology by direct viewing. When it is necessary to view transparencies directly, these need to be viewed in accordance with the conditions specified for the particular situation. However, for some purposes, smaller transparencies are not viewed directly because the viewing distance for correct perspective and perception of detail is too small for visual comfort. Furthermore, when small transparencies are reproduced for publication or other purposes, they are usually enlarged. To make comparison easier, it is helpful to enlarge the transparency image when comparing it to the print. For these reasons, a viewing condition can be required that provides a magnified image when viewed at an appropriate distance.

Colour monitors are being used increasingly to display and view digital images in graphic technology and photography. In order to ensure consistency of assessment in this situation, it is important that the viewing conditions in which the monitors are placed be reasonably well specified. However, it is important to note that adherence to these specifications does not ensure that the monitor will match the hardcopy without provision of a defined colour transformation to the displayed image or use of proper colour management. This aspect of matching is outside the scope of this International Standard.

The specifications provided in this International Standard for images viewed on colour monitors are for images viewed independently of any form of hardcopy. Conditions for direct comparisons between hardcopy and softcopy (even where a suitable colour transformation has been applied) are outside the scope of this International Standard, which can be seen as being primarily relevant where successive viewing of hardcopy and softcopy takes place. ISO 12646 provides more detailed recommendations where direct comparison is

required. When making such comparisons, it is generally desirable to view the colour monitor under the lower levels of ambient illumination specified in this International Standard and with the maximum level of luminance achievable and the hardcopy sample at the lower levels of illumination specified for printed matter in this International Standard (and their equivalent for transparencies). However, this will in turn affect the perceived tone and colourfulness of the hardcopy.

This International Standard meets the current needs of the graphic technology and photographic industries and minimizes differences between viewing equipment. It contains multiple specifications, each of which is appropriate to specific requirements. It is important that users ensure they employ the specification that is appropriate to their application.

Graphic technology and photography — Viewing conditions

1 Scope

This International Standard specifies viewing conditions for images on both reflective and transmissive media, such as prints (both photographic and photomechanical) and transparencies, as well as images displayed in isolation on colour monitors.

This International Standard applies in particular to:

— critical comparison between transparencies, reflection photographic or photomechanical prints and/or other objects or images;

— appraisal of the tone reproduction and colourfulness of prints and transparencies at illumination levels similar to those for practical use, including routine inspection;

— critical appraisal of transparencies that are viewed by projection, for comparison with prints, objects or other reproductions; and

— appraisal of images on colour monitors that are not viewed in comparison to any form of hardcopy.

This International Standard is not applicable to unprinted papers.

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 5-2, *Photography — Density measurements — Part 2: Geometric conditions for transmission density*

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

ISO 13655, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*

ISO/CIE 23603:2005, *Standard method of assessing the spectral quality of daylight simulators for visual appraisal and measurement of colour*

CIE 13.3-1995, *Method of measuring and specifying colour rendering properties of light sources*

CIE 15-2004, *Colorimetry*

CIE 69-1987, *Methods of characterizing illuminance meters and luminance meters — Performance, characteristics and specifications*

3 Terms and definitions

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

3.1
chromaticity
property of a colour stimulus defined by its chromaticity co-ordinates, or by its dominant or complementary wavelength and purity taken together

[CIE 17.4-1987, 845-03-34]

3.2
colour rendering index
measure of the degree to which the psychophysical colour of an object illuminated by a test illuminant conforms to that of the same object illuminated by the reference illuminant, suitable allowance having been made for the state of chromatic adaptation

[CIE 17.4-1987, 845-02-61]

3.3
correlated colour temperature
temperature of the Planckian radiator whose perceived colour most closely resembles that of a given stimulus at the same brightness and under specified viewing conditions

[CIE 17.4-1987, 845-03-50]

3.4
hardcopy
representation of an image on a substrate which is self-sustaining and reasonably permanent

EXAMPLE Prints, transparencies.

3.5
illuminance
⟨at a point of a surface⟩ quotient of the luminous flux incident on an element of the surface containing the point by the area of that element

[CIE 17.4-1987, 845-01-38]

3.6
illuminant
radiation with a relative spectral power distribution defined over the wavelength range that influences object-colour perception

[CIE 17.4-1987, 845-03-10]

3.7
luminance
L_v
⟨in a given direction, at a given point of a real or imaginary surface⟩ quantity defined by the formula

$$L_v = \frac{\mathrm{d}^2\phi_v}{\mathrm{d}A \times \cos\theta \times \mathrm{d}\Omega}$$

where

$\mathrm{d}^2\phi_v$ is the luminous flux transmitted by an elementary beam passing through the given point and propagating in the solid angle $\mathrm{d}\Omega$ containing the given direction;

dA is the area of a section of that beam containing the given point;

θ is the angle between the normal to that section and the direction of the beam

[CIE 17.4-1987, 845-01-35]

3.8
luminous reflectance
ratio of the luminous flux reflected from a surface to the luminous flux incident on the surface

3.9
off-press proof
print produced by a method other than press printing, whose purpose is to show the results of the colour separation process in a way that closely simulates the results on a production press

3.10
on-press proof
print produced by press printing, using either a proof press or a production press, whose purpose is to show the results of the colour separation process in a way that closely simulates the results on a production press

3.11
original
scene or hardcopy from which image information is obtained using an image capture device in a reproduction process

NOTE As used in graphic technology, the original is typically a print or transparency and the capture device is usually an input scanner or, occasionally, a process camera. In photography, the term "original scene" is sometimes used.

3.12
print
two-dimensional hardcopy form of an image intended for viewing

NOTE In still photography and graphic technology, the term "print" is reserved for reflection hardcopy, a medium designed to be viewed by reflected light.

3.13
relative spectral power distribution
ratio of the spectral power distribution of a source or illuminant to a fixed reference value

NOTE The fixed reference value can be an average value, a maximum value or an arbitrarily chosen value of this distribution

3.14
softcopy
representation of an image produced using a device capable of directly representing different digital images in succession and in a non-permanent form

NOTE The most common example is a monitor.

3.15
source
primary emitter of electromagnetic radiation

3.16
surround
area adjacent to the border of an image which, upon viewing the image, can affect the local state of adaptation of the eye

NOTE The surround, which can have a significant effect on the perceived tone and colour reproduction of an image, is not to be confused with any border immediately surrounding the image, such as any unprinted white substrate for reflection copy or the unexposed border present on many transparencies. For a colour monitor, the border will normally be dark grey or black, and hence the same as the surround. However, when simulating hardcopy, it will be similar to that hardcopy, both in terms of lightness and width.

3.17
transparency
two-dimensional hardcopy form of an image designed to be viewed by transmitted light

3.18
transparency illuminator
apparatus used for back illumination of a transparency

3.19
veiling flare
relatively uniform but unwanted irradiation in the image plane of an optical system, caused by the scattering and reflection of a proportion of the radiation which enters the system through its normal entrance aperture, where the radiation can be from inside or outside the field of view of the system

NOTE Light leaks in an optical system housing can cause additional unwanted irradiation of the image plane. This irradiation can resemble veiling flare.

3.20
veiling glare
light, reflected from an imaging medium, that has not been modulated by the means used to produce the image

NOTE 1 Veiling glare lightens and reduces the contrast of the darker parts of an image.

NOTE 2 In CIE 122-1996, the veiling glare of a cathode ray tube (CRT) display is referred to as ambient flare.

3.21
viewing flare
veiling glare that is observed in a viewing environment, but not accounted for in radiometric measurements made using a prescribed measurement geometry

NOTE The viewing flare is expressed as a percentage of the luminance of the adopted white.

3.22
virtual metamer
set of spectral radiance factors, not based on physical samples, which provide metameric matches for specific standard daylight illuminants

NOTE Virtual metamers are used to test and classify illumination sources which simulate daylight in accordance with the method provided in ISO/CIE 23603. This classification is accomplished by calculating the average of the colour differences obtained for these metamers between the illumination source in question and a CIE standard illuminant. Although it can be possible to construct physical realizations of some virtual metamers, the fact that they are not required to be real allows greater flexibility in their design.

4 Viewing condition requirements

4.1 General requirements

4.1.1 Applicability

Although 4.2 to 4.5 contain additional requirements specific to a variety of viewing applications, the requirements in this clause are general and apply to all viewing applications.

The specific viewing applications are:

— conditions for critical comparison;

— conditions for practical appraisal of prints;

— conditions for viewing small transparencies by projection;

— conditions for appraisal of images displayed on colour monitors.

NOTE For ease of reference, each viewing condition described in this International Standard has been given an alphanumeric designation. This can be useful in describing or specifying conditions, e.g. “ISO 3664 viewing condition P2”.

4.1.2 Viewing apparatus

To comply with this International Standard, the values specified shall be achieved at the surface of viewing. The specified relative spectral power distribution applies to the illuminated surface rather than to the source (or lamp) because the light from the source may be modified by reflecting and transmitting components of the apparatus, and the required relative spectral power distribution may be obtained from a mixture of light from different sources.

The source, image being viewed, and observer's eyes shall be positioned to minimize the amount of light specularly reflected toward the eyes of an observer on or near the normal to the centre of the viewing surface.

The surround of a print shall have a diffuse reflecting surface and shall have a CIELAB [1)] chroma value no greater than 2 relative to a perfect reflecting diffuser at the viewing surface, i.e. it shall appear neutral.

The surround of a transparency shall have a CIELAB chroma value no greater than 2 relative to the illuminating surface.

4.1.3 Spectral conditions for the reference illuminant

The relative spectral power distribution of the reference illuminant for both prints and transparencies shall be CIE illuminant D50, as defined in CIE 15-2004, Table T.1. This represents a phase of natural daylight having a correlated colour temperature of approximately 5 000 K. The chromaticity coordinates of illuminant D50 are $x_{10} = 0{,}347\ 8$ and $y_{10} = 0{,}359\ 5$ in the CIE chromaticity diagram, and $u'_{10} = 0{,}210\ 2$ and $v'_{10} = 0{,}488\ 9$ in the CIE 1976 Uniform Chromaticity Scale (UCS) diagram.

See Table 1.

NOTE 1 Chromaticity is specified for the CIE 1964 standard colorimetric observer to ensure compatibility with the method specified in ISO/CIE 23603, which is used to define the degree of compliance of the illumination to the reference illuminant specified in 4.2.2.

NOTE 2 The spectral power distribution specified in this International Standard corresponds to the spectral power distribution of measurement condition M1 specified in ISO 13655. ISO 13655 also specifies a measurement condition, M2, which adds a requirement that the radiation illuminating the sample pass through a UV-cut filter, which suppresses the UV content of the source radiation below 400 nm. This minimizes the effect of optical brightening agents on measured results. Consequently, the measured results obtained using measurement condition M2 will not correlate exactly with the colour appearance observed when the sample is viewed under D50 illumination.

4.1.4 Colour rendering index

The CIE general colour rendering index of the viewing surface shall be measured as specified in CIE 13.3-1995 and shall have a value of 90 or higher. In addition, the separate special colour rendering indices for samples 1 to 8, as specified in CIE 13.3-1995, shall each have a value of 80 or higher.

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1) See CIE 15-2004.