INTERNATIONAL STANDARD

ISO 3664

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Viewing conditions — Graphic technology and photography

Conditions d'examen visuel — Technologie graphique et photographie

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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 3.

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 fact that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 3664 was prepared jointly by Technical Committees ISO/TC 42, *Photography* and ISO/TC 130, *Graphic technology*, with input from ISO/TC 6, *Paper, board and pulps*.

This second edition cancels and replaces the first edition (ISO3664:1975) which has been technically revised. This revision of the 1974 version of the International Standard meets the current needs of the Graphic Technology and Photographic industries and minimizes differences between viewing equipment. It should be noted that this revision contains multiple specifications, each of which is appropriate to specific requirements. Users should ensure that they employ the specification which is appropriate to their application.

Annexes A to C of this International Standard are for information only.

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 should be noted that the paper industry has its own set of International 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 may 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 ISO-defined.

Unfortunately, such agreement is often not practical. Even if a particular end-use condition is known, it may be impractical to provide everybody in the production chain with sufficiently consistent viewing apparatus. Since deficiencies in light sources and viewing conditions, and inconsistencies between colour viewing facilities, can distort the colour appearance of substrates, reproductions and artwork, they are likely to cause miscommunication 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 and visible spectrum to avoid distorting their appearance from that observed under commonly used sources of illumination such as daylight. The ultraviolet 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 the 1974 International Standard, as well as the majority of equipment in current use, the reference spectral power distribution specified in this International Standard is CIE Illuminant D_{50}. Many of the reasons for the selection of illuminant D_{50} in 1974, as opposed to any other CIE daylight illuminant, are equally applicable today. Much consideration was given to changing the reference illuminant to be CIE F8, a 5 000 Kelvin illuminant more typical of fluorescent lamps. However, it was felt that this would provide only a

minimal conformance advantage (as shown in informative 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 which closely match the spectral power distribution of daylight, it is important that the tolerances specified within this International Standard provide a compromise between that required for lamp manufacturing purposes and that for consistent viewing. In this International Standard three constraints which define the colour of the light falling on the viewing plane apply, one directly and two indirectly, and all three must 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 D_{50} 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 D_{50} the methods defined in CIE Publications No. 13.3 and No. 51 are both specified. One defines the colour rendering quality of a lamp; the other its ability to correctly predict metamers. Both requirements are important to the graphic technology and photographic industries.

Because CIE Publication No. 51 does not currently address illuminant D_{50}, additional virtual metamers for this illuminant, for both visible and ultraviolet evaluation, were calculated and are defined in this International Standard. They were derived from those published in CIE Publication No. 51 and are equivalent to them. Also, based on experimental work described in annex B, a practical tolerance of acceptability has been defined, alongside a Colour Rendering Index requirement. (It should be noted that subsequent to the preparation of the final draft of this International Standard, the CIE has prepared and published Supplement 1 to CIE Publication 51 which incorporates the virtual metamers for CIE illuminant D_{50}. The combination of CIE Publication 51 and Supplement 1 is identified as CIE Publication 51.2-1999.)

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 may 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 need to be specified also. 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 provides 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 may 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 conditions where transparencies are to be compared to a print. The particular surround specified for transparencies recognises the way that a transparency should 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, they should be viewed according to the conditions specified for that 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 ease comparison, it is helpful to enlarge the transparency image when comparing it to the print. For these reasons, a viewing condition may be required which provides a magnified image when viewed at an appropriate distance.

Colour monitors are increasingly being used 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 are reasonably well specified. However, it should be noted 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 beyond the scope of this International Standard. In practice, even with high quality colour management, an accurate match is difficult to achieve because the luminance levels generally differ significantly between hardcopy (print or transparency) and softcopy (monitor).

Thus, it should be noted that the specifications for images viewed on colour monitors, provided in this International Standard, 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 beyond 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, Graphic Technology **-** Colour proofing using a colour display, currently at Working Draft level in TC 130, is being prepared to provide more detailed recommendations where direct comparison is required. In general it may be stated that for such comparisons it is 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, it should be noted that this will, in turn, affect the perceived tone and colourfulness of the hardcopy.

Viewing conditions — Graphic technology and photography

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. Specifically, it shall be used for:

— 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 which are viewed by projection, for comparison with prints, objects, or other reproductions, and

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

This International Standard is not applicable to unprinted papers.

2 Normative references

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

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

ISO 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions.*

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

ISO 12646:[1)], *Graphic technology — Displays for colour proofing — Characteristics and viewing conditions.*

CIE Publication No. 13.3, 1995, *Method of measuring and specifying the colour rendering properties of light sources*, 2nd edition.

CIE Publication No. 15.2, 1986, *Colorimetry.*

CIE Publication No. 51, 1981, *A method for assessing the quality of daylight simulators for colorimetry.*

CIE Publication No. 17.4, 1987, *International lighting vocabulary.*

3 Terms and definitions

For the purposes of this International Standard, 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 Publication No. 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

1) To be published.

illuminant, suitable allowance having been made for the state of chromatic adaptation.
[CIE Publication No. 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 Publication No. 17.4:1987, 845-03-50]

3.4
flare
light falling on an image, in an imaging system, which does not emanate from the subject point
SEE **image flare**, **veiling flare**, and **veiling glare**.

NOTE Veiling glare is also sometimes referred to as flare

3.5
hardcopy
representation of an image on a substrate which is self sustaining and reasonably permanent
SEE **softcopy**, **print**, and **transparency**

NOTE Examples include prints and transparencies.

3.6 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 Publication No. 17.4:1987, 845-01-38]

3.7
illuminant
radiation with a relative spectral power distribution defined over the wavelength range that influences object-colour perception
[CIE Publication No. 17.4:1987, 845-03-10]

3.8
image flare
light from a subject point that is scattered by the optical system to areas of the image plane other than the appropriate image point

NOTE The distribution of image-flare light resulting from any subject point is specified by the image point spread function. Point spread functions tend to fall off rapidly as the distance from the image point is increased, are variable for different image-point locations and are typically not radially symmetric for image points some distance from the optical system axis.

3.9
luminance (in a given direction, at a given point of a real or imaginary surface)
quantity defined by the formula:

$$L_v = \frac{d\varphi_v}{dA \times \cos\theta \times d\Omega}$$

where $d\phi_v$ is the luminous flux transmitted by an elementary beam passing through the given point and propagating in the solid angle $d\Omega$ 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 Publication No. 17.4:1987, 845-01-35]

3.10
off-press proof print
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

3.11
on-press proof print
print produced by press printing (production or proof 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

3.12
original
the 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.

3.13
print
two-dimensional hardcopy form of an image intended for viewing
SEE **hardcopy**, **softcopy**, **transparency**

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

3.14
relative spectral power distribution
ratio of the spectral power distribution of a source or illuminant to a fixed reference value which can be an average value, a maximum value, or an arbitrarily chosen value of this distribution.

3.15
softcopy
representation of an image produced using a device capable of directly representing different digital images in succession and in a non-permanent form

EXAMPLE the most common example is a monitor
SEE **hardcopy**

3.16
source
primary emitter of electromagnetic radiation

3.17
surround
area adjacent to the border of an image which, upon viewing the image, may 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, should not 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.

3.18
transparency
two-dimensional hardcopy form of an image designed to be viewed by transmitted light
SEE **hardcopy**, **softcopy**, **print**

3.19
transparency illuminator
apparatus used for back illumination of a transparency

3.20
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 may 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 may resemble veiling flare.

3.21
veiling glare
light falling on a radiant image surface, such as a back illuminated transparency or monitor, which adds to the luminance of the image

NOTE Veiling glare lightens and reduces the apparent contrast of the darker parts of an image. It differs from veiling flare in that it is used exclusively for the perception of images in which no entrance aperture is defined.

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 according to the method provided in CIE Publication No. 51. 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 may be possible to construct physical realizations of some virtual metamers, the fact that they may not be real allows greater flexibility in their design.

4 Viewing condition requirements

4.1 General requirements

In this clause, the requirements that apply to all of the specified viewing conditions are stated. The requirements specific to each of these viewing conditions are defined in 4.2 (Critical comparison), 4.3 (Practical appraisal of prints) and 4.4 (Projection viewing of small transparencies).

NOTE For ease of reference, each viewing condition described in the International Standard has been given an alpha-numeric designation. This may be useful in describing or specifying conditions: e.g. ISO viewing condition P2 as specified in this International Standard.

4.1.1 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 or transparency shall have a diffusing surface and shall have a CIELAB chroma value no greater than 2; i.e. shall appear neutral.

4.1.2 Spectral conditions for the reference illuminant

The relative spectral power distribution of the reference illuminant for both prints and transparencies shall be CIE illuminant D_{50} as defined in CIE 15.2 (see Table 1). This represents a phase of natural daylight having a correlated colour temperature of approximately 5 000 K. The chromaticity coordinates of illuminant D_{50} are x_{10} = 0,347 8 and y_{10} = 0,359 5 in the CIE chromaticity diagram

Table 1 — Relative spectral power of reference illuminant D_{50}.

Wavelength nm	Relative power for illuminant D_{50}	Wavelength nm	Relative power for illuminant D_{50}
300	0,02	550	102,32
305	1,03	555	101,16
310	2,05	560	100,00
315	4,91	565	98,87
320	7,78	570	97,74
325	11,26	575	98,33
330	14,75	580	98,92
335	16,35	585	96,21
340	17,95	590	93,50
345	19,48	595	95,59
350	21,01	600	97,69
355	22,48	605	98,48
360	23,94	610	99,27
365	25,45	615	99,16
370	26,96	620	99,04
375	25,72	625	97,38
380	24,49	630	95,72
385	27,18	635	97,29
390	29,87	640	98,86
395	39,59	645	97,26
400	49,31	650	95,67
405	52,91	655	96,93
410	56,51	660	98,19
415	58,27	665	100,60
420	60,03	670	103,00
425	58,93	675	101,07
430	57,82	680	99,13
435	66,32	685	93,26
440	74,82	690	87,38
445	81,04	695	89,49
450	87,25	700	91,60
455	88,93	705	92,25
460	90,61	710	92,89
465	90,99	715	84,87
470	91,37	720	76,85
475	93,24	725	81,68
480	95,11	730	86,51
485	93,54	735	89,55
490	91,96	740	92,58
495	93,84	745	85,40
500	95,72	750	78,23
505	96,17	755	67,96
510	96,61	760	57,69
515	96,87	765	70,31
520	97,13	770	82,92
525	99,61	775	80,60
530	102,10	780	78,27
535	101,43		
540	100,75		
545	101,54		

NOTE The wavelength specification has been extended beyond the normal visual range because of the need to consider brighteners or dyes which may fluoresce.