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Ergonomics of human-system interaction —

Part 391: Requirements, analysis and compliance test methods for the reduction of photosensitive seizures

Ergonomie de l'interaction homme-système —

Partie 391: Exigences, analyses et méthodes d'essai de conformité pour la réduction des saisies photosensibles

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

ISO 9241 consists of the following parts, under the general title *Ergonomic requirements for office work with visual display terminals (VDTs)*:

— *Part 1: General introduction*

— *Part 2: Guidance on task requirements*

— *Part 5: Workstation layout and postural requirements*

— *Part 6: Guidance on the work environment*

— *Part 11: Guidance on usability*

— *Part 12: Presentation of information*

— *Part 13: User guidance*

— *Part 14: Menu dialogues*

— *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

ISO 9241 also consists of the following parts, under the general title *Ergonomics of human-system interaction:*

— *Part 20: Accessibility guidelines for information/communication technology (ICT) equipment and services*

— *Part 100: Introduction to standards related to software ergonomics* [Technical Report]

— *Part 110: Dialogue principles*

— *Part 112: Principles for the presentation of information*[1)]

— *Part 129: Guidance on software individualization*

— *Part 143: Forms*

— *Part 151: Guidance on World Wide Web user interfaces*

— *Part 154: Interactive voice response (IVR) applications*

— *Part 161: Guidance on visual user-interface elements*

— *Part 171: Guidance on software accessibility*

— *Part 210: Human-centred design for interactive systems*

— *Part 220: Processes for enabling, executing and assessing human-centred design within organizations*[1)]

— *Part 300: Introduction to electronic visual display requirements*

— *Part 302: Terminology for electronic visual displays*

— *Part 303: Requirements for electronic visual displays*

— *Part 304: User performance test methods for electronic visual displays*

— *Part 305: Optical laboratory test methods for electronic visual displays*

— *Part 306: Field assessment methods for electronic visual displays*

— *Part 307: Analysis and compliance test methods for electronic visual displays*

— *Part 308: Surface-conduction electron-emitter displays (SED)* [Technical Report]

— *Part 309: Organic light-emitting diode (OLED) displays* [Technical Report]

— *Part 310: Visibility, aesthetics and ergonomics of pixel defects* [Technical Report]

— *Part 331: Optical characteristics of autostereoscopic displays* [Technical Report]

— *Part 391: Requirements, analysis and compliance test methods for the reduction of photosensitive seizures*

— *Part 392: Ergonomic recommendations for the reduction of visual fatigue from stereoscopic images*

— *Part 400: Principles and requirements for physical input devices*

— *Part 410: Design criteria for physical input devices*

— *Part 411: Evaluation methods for the design of physical input devices* [Technical Specification]

— *Part 420: Selection of physical input devices*

— *Part 910: Framework for tactile and haptic interaction*

— *Part 920: Guidance on tactile and haptic interactions*

— *Part 940: Evaluation of tactile and haptic interactions*[1)]

— *Part 960: Framework and guidance for gesture interactions*[1)]

The following parts are under preparation:

— *Part 125: Guidance on visual presentation of information*

1) To be published.

— *Part 333: Stereoscopic displays using glasses*

For the other parts under preparation, see Annex A.

Introduction

Recent progress of technology enables us to watch high-definition images, some of which can be stereoscopic. When those images are projected onto the retina of both eyes and processed as visual information, undesirable biomedical effects, such as photosensitive seizures, visually induced motion sickness, and visual fatigue from stereoscopic images can be induced. These undesirable biomedical effects need to be reduced where feasible. The prevention of these undesirable biomedical effects on human health has been referred to as “image safety”.

Image safety was first discussed by the ISO in the ISO/COPOLCO with respect to the users of image products. Then, in 2004, the ISO/International Workshop on Image Safety was held and resulted in the publication of ISO/IWA 3:2005 as the international workshop agreement.[1] Following those discussions, the study group (ISO/TC 159/SC 4/SG on Image Safety) continued to evaluate strategies of the international standardizations until 2009. The basic concept of Image Safety is common with ISO/IEC Guide 71:2014[18], in which the idea is that accessibility to and usability of products and services should be available to all people.

This part of ISO 9241 will help promote the production of safer images by reducing the risk of photosensitive seizures, and thereby result in the wider distribution of images that are free from constraints on which consumers can view them. A small proportion of the population is susceptible to seizures and other neurological effects when watching motion picture and video content with certain display features. Since these reactions depend on individual susceptibility have been documented with programming viewed through cathode-ray tube (CRT) displays, there is as yet less experience with high-definition displays.

This part of ISO 9241 belongs to a family of human-system interaction standards. Readers who need guidance on other aspects of human-system interaction should refer to the ISO 9241-series.

Ergonomics of human-system interaction —

Part 391:
Requirements, analysis and compliance test methods for the reduction of photosensitive seizures

1 Scope

This part of ISO 9241 provides requirements and recommendations for reducing photosensitive seizures (PSS), while viewing images on electronic displays.

The requirements and recommendations in this part of ISO 9241 are designed to be applied to image contents. By image contents, reference is made to the images independent of the device or environment in which they are displayed.

The requirements and recommendations in this part of ISO 9241 are for the protection of the vulnerable individuals in the viewing population who are photosensitive and who are therefore liable to seizures triggered by flashing lights and regular patterns, including certain repetitive images.

NOTE 1 ITU considers the image safety issues in relation to broadcasting. Some of these are described in ITU-R BT.1702.[2]

NOTE 2 There are some related recommendations in ISO/IEC 40500:2012, *W3C Web Content Accessibility Guidelines (WCAG) 2.0*, for web contents accessibility.

NOTE 3 Photosensitive seizures and photosensitive epilepsy, that is, chronic conditions characterized by those repeated seizures are medical conditions. Clinical aspects of photosensitivity appear in Annex C. Visually induced seizures are equivalent to PSS.

2 Normative references

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

ISO 9241-302, *Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9241-302 and the following apply.

3.1
flash
pair of opposing changes in relative luminance

Note 1 to entry: A “pair of opposing changes” is an increase followed by a decrease or a decrease followed by an increase.

3.2
electroencephalogram
EEG
record of electrical changes caused by neuronal activities in the brain through electrodes attached to the scalp

3.3
photoparoxysmal response
PPR
EEG (3.2) response to *flash* (3.1) or pattern, consisting of spikes, spike–waves, or intermittent slow waves, which include spike-waves at around 3 Hz that can be detected bilaterally and simultaneously in all areas of the scalp

3.4
photosensitivity
human individual sensitivity to flashing or intermittent light stimulation and/or visual patterns, evidenced by the occurrence of a *photoparoxysmal response* (3.3) in the *EEG* (3.2)

Note 1 to entry: Visual sensitivity is a term recently sometimes used as an alternative to the term "photosensitivity."

3.5
photosensitive seizure
PSS
epileptic seizure[3] triggered by visual stimulation as a result of *photosensitivity* (3.4) in a human individual

3.6
photosensitive epilepsy
chronic neurological condition characterized by recurrent *photosensitive seizures* (3.5), either convulsive or non-convulsive seizures, such as absence seizures

4 Image factors of photosensitive seizures

A photosensitive seizure may be produced in susceptible individuals by flashing lights or certain regular patterns.[3][16] A visual stimulus tending to provoke a seizure is bright light flashes of a certain number per second.[4] The light must also fill a large part of the visual field. For the light flashes, colour changes to or from saturated red, instead of luminance changes, also tend to provoke a seizure.[5][12]

Another potentially provocative visual stimulus for some individuals with photosensitivity is regular patterns with a certain number of bright stripes per a certain area.[6] The pattern must also fill a large part of the visual field, while the provocation depends on whether the patterns are stationary or oscillating (including flashing).[7][16][17]

PSS can be reduced, to some extent, by considering factors such as those shown below.[3][14] These factors need to be considered at the same time in an appropriate balance.[13][15]

— Potentially harmful flashes:
  — Luminance and contrast
  — Area of visual field
  — Number of flashes per unit time
— Rapid changes of image sequences
— Potentially harmful red flashes:
  — Colour
  — Area of visual field

  - Number of flashes per unit time
- Cumulative risk:
  - Duration of flashing
- Potentially harmful regular patterns:
  - Clearly discernible stripes
  - Number of stripes and area of visual field occupied
  - Moving/stationary
  - Luminance and contrast
  - Duration of patterns

5 Ergonomic requirements and recommendations

5.1 General

To obtain the condition that will sufficiently reduce the possibility of PSS, visual content, viewing environment, and characteristics of viewers need to be considered. However, in this part of ISO 9241, characteristics of visual content, such as flashing and regular patterns, are the principal concern. For viewing environment to be considered, Annex D provides the information.

The requirements in 5.2.1 to 5.2.3 are based on a wide range of flash rates and differences in brightness that have been demonstrated to cause PPRs in almost all photosensitive individuals, although each such individual is likely to respond to a narrower set of flash rates and brightness changes within that range. A small number of subjects, however, recorded PPRs at slower flash rates and others may be susceptible to smaller changes in brightness. A photosensitive individual's susceptibility to visual stimuli may vary with environmental factors and changing individual physical conditions. Therefore, even if visual content complies with the requirements in this part of ISO 9241 that does not preclude the possibility that some photosensitive individuals may have a PPR or PSS when viewing that content. The purpose of this part of ISO 9241 is to reduce the incidence of such events substantially through a framework for producers of the content that is reasonably practical to comply with.

NOTE 1 The following principles in 5.2 and 5.3 are easier to apply in the case of pre-recorded content, which can be analysed frame-by-frame. Interactive media, such as video games, may afford essentially limitless sequences through the game, depending upon user actions. In the case of video games, the requirements and recommendations apply to typical sequences of play, but cannot cover every eventuality of play.[8]

NOTE 2 The requirements and recommendations are based on the data obtained with the maximum screen luminance of 200 cd/m^2 and below, and the maximum screen size of 60 in.[15]

5.2 Flashes

5.2.1 Potentially harmful flashes

Potentially harmful flashes shall be avoided. Potentially harmful flashes are defined as those satisfying all the following conditions.

a) A pair of opposing changes in luminance (i.e. an increase in luminance followed by a decrease or a decrease followed by an increase) of 20 cd/m^2 or more when the luminance of the darker image is below 160 cd/m^2.

b) The combined area of flashes, satisfying (a) above, occurring concurrently, occupies more than one quarter of the displayed screen area.

c) There are more than 3 flashes and fewer than 65 flashes within any one-second period.

Potentially harmful flashes can be produced by playing images at fast speed. Therefore, it is useful for viewers to be informed of this possibility.

5.2.2 Rapid changes of image sequences

Rapidly changing image sequences (for example, "fast cuts", see Note below), shall be avoided if they result in areas of the screen that produce a potentially harmful flash.

NOTE "Fast cuts" denote switching briefly and abruptly from one scene to another in movies, videos, and other image products.

5.2.3 Potentially harmful red flashes

Potentially harmful red flashes shall be avoided, irrespective of luminance change. Potentially harmful red flashes are defined as those satisfying all the following conditions.

a) A transition between a saturated red and a colour differing more than 0,2 in CIE 1976 UCS chromaticity diagram.

b) The combined area of red flashes, satisfying (a) above, occurring concurrently, occupies more than one quarter of the displayed screen area.

c) There are more than 3 red flashes and fewer than 65 red flashes, those satisfying (a) above, within any one-second period.

NOTE 1 Saturated red can be defined in the CIE chromaticity diagram (see Annex E).

NOTE 2 Increment of colour difference can increase incidence of PPR.[22][23]

5.2.4 Cumulative risk

It should be noted that the level of any cumulative risk arising from successive sequences of "potentially harmful" flashes over a prolonged period is unknown. If, as medical opinion suggests, the risk of seizures increases with the duration of flashing, it should be noted that a sequence of flashing images lasting more than 5 s might constitute a risk, even when it complies with 5.2.1 to 5.2.3.

5.2.5 Prior warning

If it is not possible to correct the image or to check all possible image sequences to meet the requirements in 5.2.1 to 5.2.3, then a prior warning shall be given.

5.3 Potentially harmful regular patterns

Potentially harmful regular patterns should be avoided. Potentially harmful regular patterns are defined as those satisfying all the following conditions.[15]

a) Clearly discernible stripes, which may be parallel or radial, curved or straight, in any orientation.

b) If the patterns are stationary, the stripes are more than eight light-dark pairs occupying more than 40 % of the displayed screen area, or if the pattern changes direction, oscillates, flashes or reverses in contrast, the stripes are more than five light-dark pairs occupying more than 25 % of the displayed screen area.

c) Luminance difference of the stripes is 20 cd/m^2 or more when the luminance of the darker bar is below 160 cd/m^2.

d) Pattern persists for 0,5 s and more.

NOTE 1 If the patterns obviously flow smoothly across, into, or out of the screen in one direction, they are not potentially harmful.[20]

NOTE 2 Chequer boards are not provocative,[21] while in highly photosensitive individuals, text can be provocative[16][24] with certain spacing producing the striped pattern satisfying the condition described in 5.3.

6 Conformance

6.1 General

To comply with the requirements in Clause 5, the procedure described in 6.3 should be followed using the test methods described in 6.2.

6.2 Test methods

To test the electronic visual image in light of the ergonomic requirements given in Clause 5, measurements and assessments of video signals transmitted to electronic visual displays are essential.

The test method needs to measure and analyse flash from video signals (see Figure 1). For the typical relationship between signal voltage and the emitted light output of a display, see Annex F.

The example procedure for judging conformity of requirements in Clause 5 is illustrated in Figure 2 as flow charts.

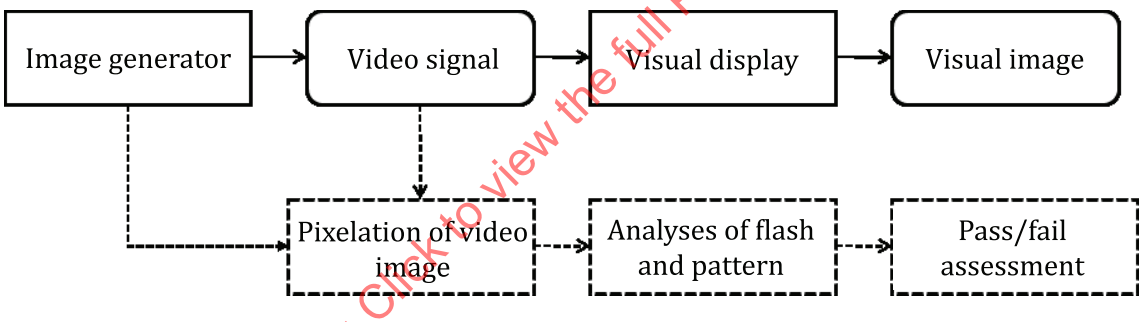
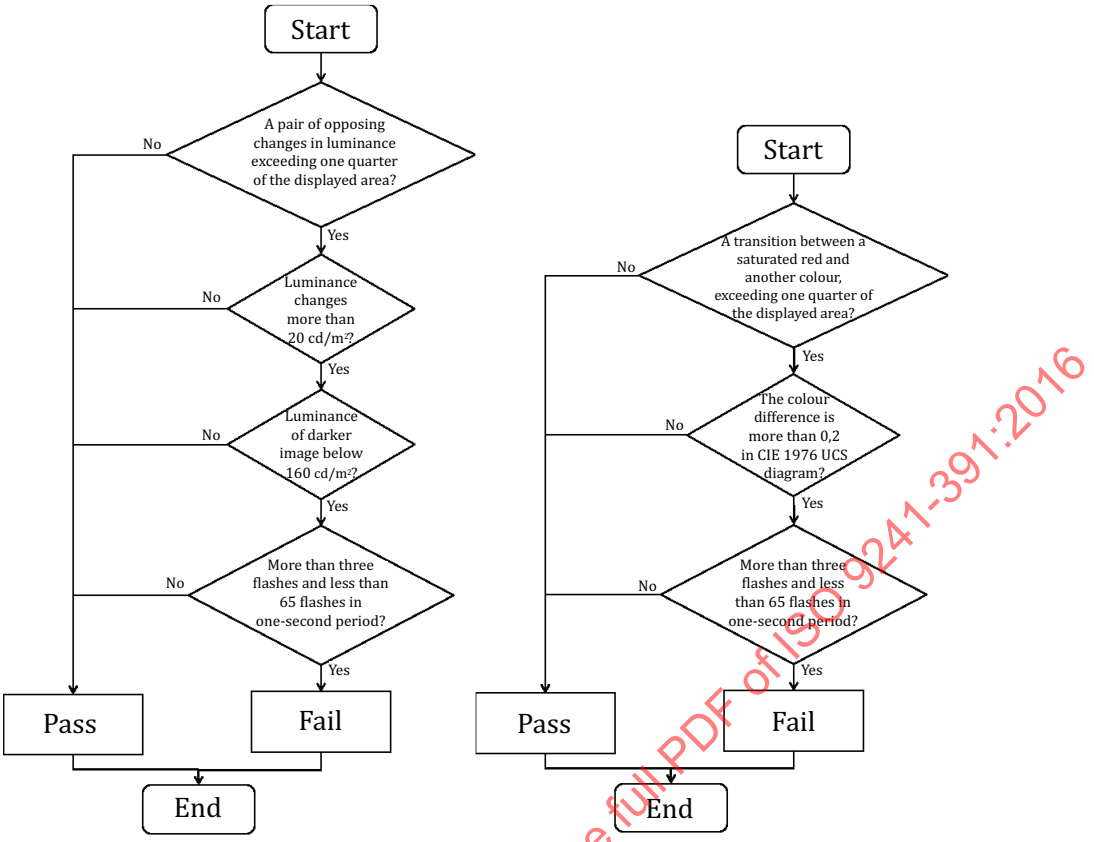


Figure 1 — Signal stream of moving images and measurement process for testing



(a) For flash **(b) For red flash**

Figure 2 — Example flow charts for test methods

The use of automatic video analysers to help alert production staff to requirements is beneficial.

6.3 Procedure of conformance

Conformance with this part of ISO 9241 is achieved by satisfying all the applicable requirements. For reference purposes, all the clauses including requirements are listed in G.1. Users of this part of ISO 9241 shall evaluate the applicability of each requirement (a "shall" statement) to determine whether it is applicable. If a product is claimed to have met the applicable requirements in this part of ISO 9241, the procedure used in evaluating the image material shall be specified.

Annex G provides an example both for determining and recording the applicability of all the requirements and for reporting that they have been followed. Other equivalent forms of report are acceptable.

Annex A
(informative)

Overview of the ISO 9241-series

The annex presents an overview of the structure of ISO 9241, see Table A.1. For an up-to-date overview of its structure, subject areas and the current status of both published and projected parts, please refer to:

ISO 9241- series

The structure reflects the numbering of the original ISO 9241 standard; for example, displays were originally ISO 9241-3 and are now the ISO 9241-300 series. In each section, the "hundred" is an introduction to the section; for example, ISO 9241-100 gives an introduction to the software ergonomics parts.

Table A.1 — Structure of ISO 9241, *Ergonomics of human–system interaction*

Part	Title
1	Introduction
2	Job design
11	Hardware and software usability
20	Accessibility and human-system interaction
21–99	Reserved numbers
100	Software ergonomics
200	Human–system interaction processes
300	Displays and display-related hardware
400	Physical input devices — Ergonomics principles
500	Workplace ergonomics
600	Environment ergonomics
700	Control rooms
900	Tactile and haptic interactions

Annex B
(informative)

Abbreviated terms

The abbreviated terms used in this part of ISO 9241 are listed below:

CIE International Commission on Illumination

HDTV High-definition television

NTSC National Television System Committee

PAL Phase Alternation by Line

PVD Preferred viewing distance

UCS Uniform Colour Space

Annex C
(informative)

Clinical aspects of photosensitivity

C.1 Diagnosis

Photosensitivity is clinically diagnosed on the basis of the patient's signs and symptoms. Diagnoses are confirmed with an electroencephalogram or EEG while the patient is exposed to intermittent photic stimulation (IPS).[9] If the patient is photosensitive, the EEG recording shows a photoparoxysmal response (PPR) or a polyspike-wave discharge.[4][10] The EEG responses to IPS can be classified on the basis of their shape and scalp distribution. They are classified into the following four types.[9]

a) GSW: Generalized ir/regular, spike-and-waves, or polyspike-and-waves.

b) OGSW: Generalizing ir/regular, spike-and-waves, or polyspike-and-waves, which start occipitally and spread to frontal regions. Both OGSW and GSW show no saturation with contrast.[11]

c) OSW: Ir/regular, spike-and-waves, or polyspike-and-waves, which are confined to the occipital area. Occipital spikes show a saturation at 30 % contrast pattern reversal.[11]

d) OR: Other responses, including generalized spikes.

C.2 Photic stimulation

There is now an internationally agreed method of photic stimulation.[9] The photic stimulator should be 30 cm from the patient's eyes, while the diameter of circular field should be 13 cm. The time averaged intensity of the flash stimulus should be around 200 cd/m^2, and surround illumination should be provided dimly enough for observing the patient. Flashes should be presented in separate trains of 10 s for each frequency, with intervals of 7 s minimum. For the 10 s stimulation, the eyes should be initially open for 5 s, and then the eyes should be closed until the stimulation ceases. The flash stimuli should be provided at 1 Hz, 2 Hz, 3 Hz, 4 Hz, 6 Hz, 8 Hz, 10 Hz, 12 Hz, 14 Hz, 16 Hz, 18 Hz, and 20 Hz, in this order, unless generalized epileptiform discharges are not induced. Then, the flash should be provided at 60 Hz, 50 Hz, 40 Hz, 30 Hz, 25 Hz, and 20 Hz. Binocular and monocular stimulation should be compared.

C.3 Prevalence and incidence

Prevalence of photosensitive epilepsy is approximately 0,025 % of the population aged 20 years or under.[4] There is, however, an unknown number of photosensitive persons who have not yet experienced a seizure but are at risk of doing so if sufficiently provoked. Most patients have their first seizure between the ages of 9 and 15 years.[4] After the early 20's, a first seizure due to photosensitivity is rare.[4] Seventy five percent of people with this condition remain photosensitive for life.[4] In young people, the incidence of photosensitive seizures is 5,7 per 100 000 of the population per annum.[4] In females, photosensitivity is approximately twice as common as in males. However, amongst video game players, for example, seizures appear to be more common in males in terms of absolute numbers, since more males than females play video games.[4]

Annex D
(informative)

Viewing environments

D.1 General

To reduce the incidence of photosensitive seizures, viewing environments are important. The following information may be useful not only for image providers but also viewers.

D.2 Screen size and viewing distance

Photosensitive seizures depend upon the angle of the screen subtended at the eye, which, in turn, depend on both the size of the screen and the distance from which it is viewed. Large screens viewed from a short distance are more provocative.

The preferred viewing distance, or PVD, described in ITU-R BT.500, increases with screen height; PVD increases from 160 cm to 450 cm for screen height from 18 cm to 90 cm, respectively. The minimum recommended viewing distance for hand-held devices is 20 cm, which is determined in ISO 9241-307.

D.3 Screen luminance

Lower levels of screen luminance can reduce the incidence of photosensitive seizures.[11]

D.4 Environmental illuminance

Higher levels of environmental illuminance can reduce the incidence of photosensitive seizures.[11]

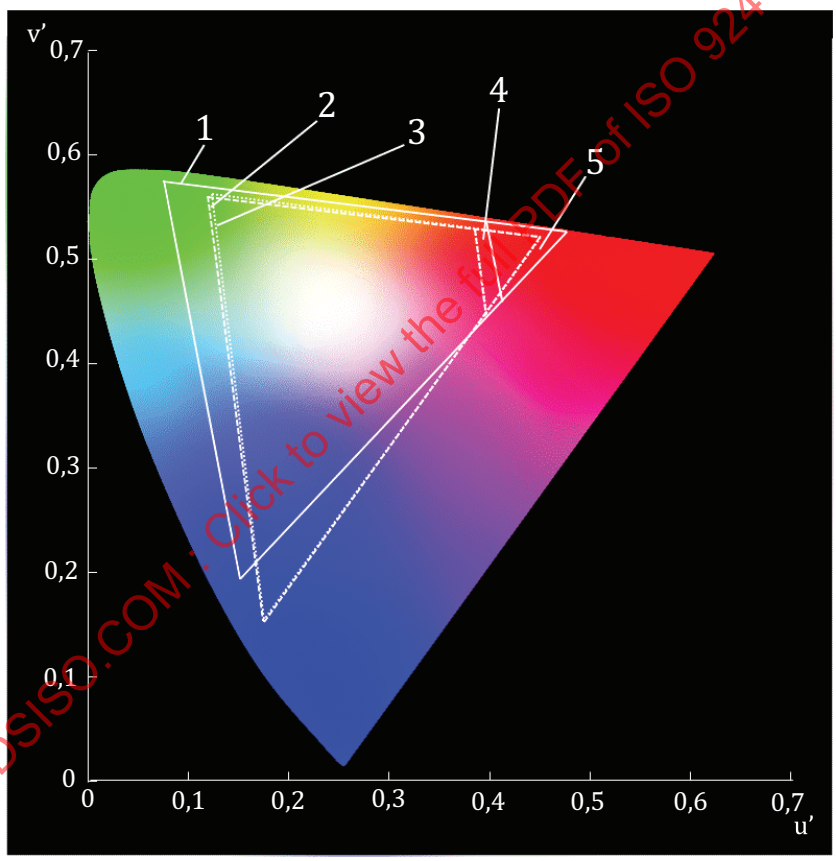
Annex E
(informative)

Saturated red

The colour of saturated red is defined as shown in Formula E.1:

$$\left(\frac{R}{R+G+B}\right)\times 100 \geq 80 \qquad \text{(E.1)}$$

Here, R, G, and B values are between 0 and 1, as specified in "relative luminance" definition. The colour gamut of saturated red is shown in the CIE 1976 chromaticity diagram in Figure E.1.



Key

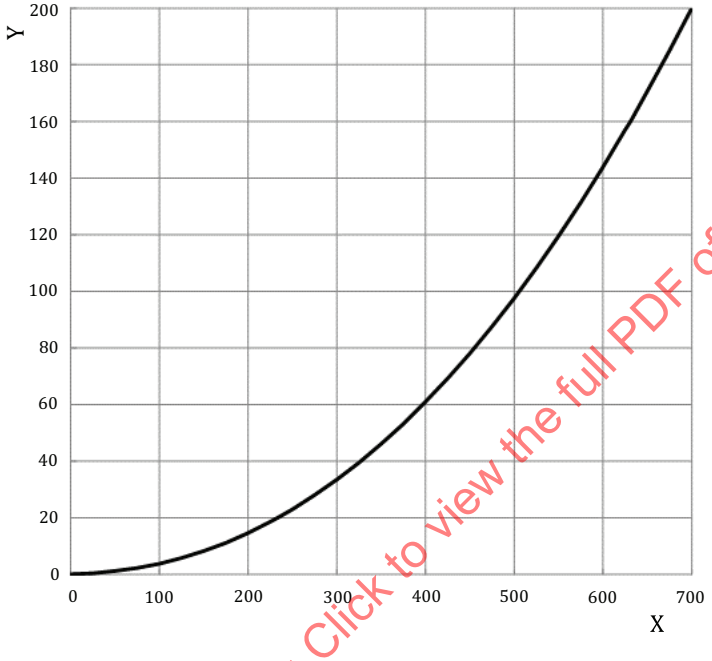
1 NTSC
2 PAL
3 HDTV
4 saturated red for PAL and HDTV
5 saturated red for NTSC

Figure E.1 — Colour gamut of saturated red in CIE 1976 chromaticity diagram

Annex F
(informative)

Typical relation between screen luminance and signal voltage

For measuring and analysing flash from video signals, the typical relationship between signal voltage and screen luminance shown in Figure F.1 can be used. The relationship is based on the characteristics of CRT, but still it is widely used in industries.



Voltage mV	Luminance cd/m^2
0	0,1
25	0,4
50	1,2
75	2,3
100	3,8
125	5,8
150	8,3
175	11,2
200	14,6
225	18,6
234	20,1
250	23
275	28
300	33,5
325	39,5
350	46,1
375	53,2
400	61
425	69,3
450	78,1
475	87,6
500	97,6
525	108,3
550	119,5
575	131,4
600	143,9
625	157
631	160
650	170,7
675	185
700	200

Key

X voltage, millivolt (mV)

Y luminance, candela per square meter (cd/m^2)

Figure F.1 — Typical relationship between signal voltage and screen luminance