

Ergonomics of human-system interaction

Part 307: Analysis and compliance test methods for electronic visual displays (ISO 9241-307:2008)

ICS 13.180; 35.180

National foreword

This British Standard is the UK implementation of EN ISO 9241-307:2008. Together with BS EN ISO 9241-302:2008, BS EN ISO 9241-303:2008, BS EN ISO 9241-304:2008 and BS EN ISO 9241-305:2008, it supersedes BS EN ISO 13406-1:1999, BS EN ISO 13406-2:2002, BS EN 29241-3:1993, BS EN ISO 9241-7:1998 and BS EN ISO 9241-8:1998, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PH/9, Applied ergonomics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN ISO 9241-307:2008) has been prepared by Technical Committee ISO/TC 159 "Ergonomics" in collaboration with Technical Committee CEN/TC 122 "Ergonomics", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2009, and conflicting national standards shall be withdrawn at the latest by May 2009.

This document supersedes EN 29241-3:1993, EN ISO 13406-2:2001, EN ISO 9241-7:1998.

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Endorsement notice

The text of ISO 9241-307:2008 has been approved by CEN as a EN ISO 9241-307:2008 without any modification.

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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.

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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 9241-307 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

This first edition of ISO 9241-307, together with ISO 9241-302, ISO 9241-303 and ISO 9241-305, cancels and replaces ISO 9241-7:1998 and ISO 13406-2:2001. Together with ISO 9241-302, ISO 9241-303 and ISO 9241-305, it partially replaces ISO 9241-3:1992. It constitutes a technical revision.

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 4: Keyboard requirements*
- *Part 5: Workstation layout and postural requirements*
- *Part 6: Guidance on the work environment*
- *Part 9: Requirements for non-keyboard input devices*
- *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*
- *Part 17: Form filling 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 110: Dialogue principles*
- *Part 151: Guidance on World Wide Web user interfaces*
- *Part 171: Guidance on software accessibility*
- *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 400: Principles and requirements for physical input devices*
- *Part 410: Design criteria for physical input devices*
- *Part 920: Guidance on tactile and haptic interactions*

For the other parts under preparation, see Annex A.

Introduction

This part of ISO 9241 addresses different technologies for a wide range of visual display tasks and environments. Its modular structure will allow it to be readily amended, as ongoing technological development enables new forms of display interaction or new contexts become available.

Using ISO 9241-303 and ISO 9241-305, together with the compliance method specified in this part of ISO 9241, it is possible to obtain a good understanding of how to analyse an environment for which there does not exist a specific analysis and compliance method.

Ergonomics of human-system interaction —

Part 307:

Analysis and compliance test methods for electronic visual displays

1 Scope

This part of ISO 9241 establishes test methods for the analysis of a variety of visual display technologies, tasks and environments. It uses the measurement procedures of ISO 9241-305 and the generic requirements of ISO 9241-303 to define compliance routes suitable for the different technologies and intended context of use.

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 9241-300, *Ergonomics of human-system interaction — Part 300: Introduction to electronic visual display requirements*

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

ISO 9241-303, *Ergonomics of human-system interaction — Part 303: Requirements for electronic visual displays*

ISO 9241-305, *Ergonomics of human-system interaction — Part 305: Optical laboratory test methods for electronic visual displays*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

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

4 Guiding principles

Compliance procedures and assessment methods for human-system interaction systems require a structure that addresses the relevant aspects of the context of use in regard to the physical technology for the intended application.

This part of ISO 9241 links the ergonomic requirements given in ISO 9241-303 with the measurement methods specified in ISO 9241-304, ISO 9241-305 and ISO 9241-306.

For this purpose, the compliance routes specified in Clause 5 are separated into the following integral parts of compliance assessment:

- ISO 9241-303 requirements (attributes);
- Pass/Fail criteria based on those requirements and the intended context of use;
- measuring method references;
- assessment and reporting.

Annex C presents general information on the structure of compliance routes.

5 Compliance routes

5.1 CRT displays for indoor use — Display laboratory method

5.1.1 Intended context of use

The attributes of the user, environment, tasks and use of CRT (cathode ray tube) displays are summarized in Table 1. Attributes are derived from analysis of the intended context of use and are an essential prerequisite for the compliance assessment. Therefore, context elements different from those described in this method could influence the Pass/Fail criteria.

The supplier shall specify the intended context of use as well as the value or value range of an attribute. The values specified shall match the intended context of use. The intended context of use is part of the compliance report.

NOTE CRT displays are considered in this compliance route for typical visual display tasks for indoor use.

Table 1 — Intended context of use — CRT displays

Element	Attribute	Quantification
User	Vision	User with normal or corrected to normal vision of any age, 7 years or older (any literate user).
Environment	Design screen illuminance, E_s	At indoor locations (see References [5], [9], [19], [25]): — up to 200 lx, e.g. (mostly) general building areas; — up to 300 lx, e.g. (mostly) general machine work, rough assembly work, (general) museum; — vertical $250 \text{ lx} + 250 \text{ lx} \times \cos(\alpha)$ in offices, where α is the screen tilt angle; — up to 500 lx, e.g. medium assembly and decorative work, simple inspection, counters, libraries, (mostly) educational areas, control rooms; — up to 750 lx, e.g. fine work, technical drawing; — up to 1 000 lx, e.g. precision work, quality control, inspection, medical examination and treatment; — up to 1 500 lx, e.g. high precision work; — > 1 500 lx, e.g. special workplaces in the medical area; — controlled and/or adjustable illuminance, e.g. projection rooms, film and video studios and radio stations, theatres, concert halls, X-ray departments. The supplier shall specify the maximum design screen illuminance as well as the intended environment. The screen tilt angle is considered to be 75°, if not otherwise specified by the supplier.
	Typical components of the illumination: large aperture source (15°) and small aperture source (1°) illumination	At indoor locations (see References [13], [19]): — $L_{\text{REF,EXT}} = 500 \text{ cd/m}^2$, $L_{\text{REF,SML}} = \text{not applicable}$; — $L_{\text{REF,EXT}} = 300 \text{ cd/m}^2$, $L_{\text{REF,SML}} = \text{not applicable}$; — $L_{\text{REF,EXT}} = 200 \text{ cd/m}^2$, $L_{\text{REF,SML}} = 2\,000 \text{ cd/m}^2$ (suitable for general office use); — $L_{\text{REF,EXT}} = 125 \text{ cd/m}^2$, $L_{\text{REF,SML}} = 200 \text{ cd/m}^2$ (requires a specially controlled luminous environment); where $L_{\text{REF,EXT}}$ is the luminance of the large aperture source (15°); $L_{\text{REF,SML}}$ is the luminance of the small aperture source (1°). The supplier shall specify the luminance of the large and small aperture source of the illumination.
	Illuminant	For this compliance route, CIE illuminants A, D65, F11 and F12 are considered ^[1]. The supplier may specify the intended illuminant. NOTE 1 All these illuminants exist at every illuminance level of indoors use, often in combinations. It is assumed that by verifying that the visual display complies in each of the illuminants, the visual display will also comply with any combination of illuminants. NOTE 2 The compliance assessment need only be performed once, with a spectrally broad-band laboratory illumination. The compliance calculations are then made using spectral calculations and repeated for each of the specified illumination levels and illuminants.

Table 1 (continued)

Element	Attribute	Quantification
Environment	Ambient temperature	For this compliance route, an ambient temperature of approximately 15 °C to 35 °C is considered, if not otherwise specified by the supplier.
Task	Content and perception	For this compliance route, the following two contexts for perception of information are considered, if not otherwise specified by the supplier ^[38]. a) Artificial information Visualization of objects and scenes that do not have originals in our world — text (i.e. alphanumeric characters), graphical signs, symbols, etc. — in monochrome (including achromatic) and/or multicolour (including full-colour) presentation. b) Reality information Imaging of objects and scenes that do have existing originals in our world — faces, people, landscapes, etc. — in monochrome (including achromatic) or multicolour (including full-colour) presentation. The supplier shall specify whether the visual display is designed predominantly for artificial information or reality information. If both types of information are used in a work environment, Pass/Fail criteria for both types of information are applied.
	Amount of information	Preferred screen size for sufficient amount of information with appropriate object size and resolution.
	Image type	For this compliance route, still, quasi-static or moving images are considered, if not otherwise specified by the supplier.
	Design viewing distance, $D_{\text{design,view}}$	The supplier shall specify the design viewing distance depending on the predominant information. If both types of information are used in a work environment, the design viewing distance for artificial information is selected. a) Artificial information The typical design viewing distance is calculated based on the optimum position for the most important visual display that is within $\pm 15^\circ$ in the vertical and horizontal directions from the line-of-sight ^[11]. — If $W_{\text{view}} > H_{\text{view}}$: $D_{\text{design,view}} = W_{\text{view}}/2 \times \tan(15^\circ) = W_{\text{view}}/0,536$ — If $H_{\text{view}} > W_{\text{view}}$: $D_{\text{design,view}} = H_{\text{view}}/2 \times \tan(15^\circ) = H_{\text{view}}/0,536$ where H_{view} is the height of the active display area; W_{view} is the width of the active display area. b) Reality information Depending on the aspect ratio of the active display area, the typical design viewing distance, $D_{\text{design,view}}$, is as follows ^[30]. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{\text{view}} \leq 1,53 \text{ m}$: $D_{\text{design,view}} = 1 \text{ m} + 4 \times H_{\text{view}}$ If $H_{\text{view}} > 1,53 \text{ m}$: $D_{\text{design,view}} = 4,7 \times H_{\text{view}}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{\text{design,view}} = 3 \times H_{\text{view}}$

Table 1 (continued)

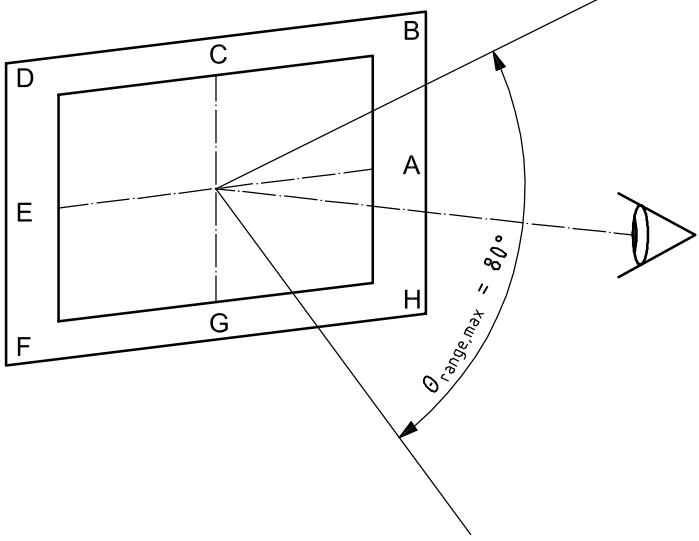
Element	Attribute	Quantification
Task	Design viewing direction (θ_D , ϕ_D)	Within a specific range of angles from the normal. For this compliance route, perpendicular viewing direction is assumed, if not otherwise specified by the supplier. Therefore, the default design viewing direction (θ_D , ϕ_D) is (0° , $-$).
	Design viewing direction range (angle of inclination and azimuth)	For this compliance route, a design viewing direction range of up to 80° is considered, if not otherwise specified by the supplier (see Figure 1). Therefore, the maximum angle of inclination, θ , is 40° . The azimuth angle, ϕ , is 0° to 360° . 
	Eye and head position	From fixed to moving.
	Number of users	Typically single or multiple.
Usage	Display handling	For this compliance route, stationary display handling is considered, if not otherwise specified by the supplier.

Figure 1 — Design viewing direction for CRT displays

5.1.2 Information about the technology

The basic physical attributes of CRT visual display technology are given in Table 2. The supplier shall submit a detailed technical specification — rated voltage, rated frequency, rated current, rated power consumption, CRT, CRT specification, CRT technology, dot/stripe pitch, max. resolution, phosphor and phosphor decay time, anti-reflection treatment, vertical frequency bandwidth, horizontal frequency bandwidth, max. video bandwidth, video/computer compatibilities, prepared gamma value, factory setting of “brightness”, “contrast”, “colour” control, reference colour gamut, e.g. as defined by the ITU ¹⁾, etc.

Table 2 — Basic physical attributes of CRT visual displays

Basic physical attributes	Description
Optical mode of operation	Emissive
Mode of observation	Direct view
Diagonal of the active display area	Depending on application
Resolution	Depending on application
Aspect ratio	Depending on application, e.g. 4:3, 5:4 or 16:9

5.1.3 Compliance assessment method

The compliance assessment for CRT displays shall be made in accordance with Tables 3 to 37.

Where necessary, the assessment and reporting contains evaluation steps. These serve as a guide through the complex assessment and give an overview of the assessment and its intent. Owing to individual physical attributes of the technology in relation to the attributes to be assessed, some basic parameters such as illumination condition, object (test pattern), measurement location and measurement direction are described in short form as well. The procedure also specifies the corresponding free parameters of the measuring method of ISO 9142-305.

1) International Telecommunications Union.

Table 3 — Viewing conditions

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Design viewing distance	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information The typical design viewing distance, $D_{\text{design,view}}$, shall be calculated on optimum position for the most important visual display that is within $\pm 15^\circ$ in the vertical and horizontal directions from the line-of-sight. — If $W_{\text{view}} > H_{\text{view}}$: $D_{\text{design,view}} = W_{\text{view}}/2 \times \tan(15^\circ) = W_{\text{view}}/0,536$ — If $H_{\text{view}} > W_{\text{view}}$: $D_{\text{design,view}} = H_{\text{view}}/2 \times \tan(15^\circ) = H_{\text{view}}/0,536$ where H_{view} is the height of the active display area; W_{view} is the width of the active display area. b) Reality information Depending on the aspect ratio of the active display area, the typical design viewing distance, $D_{\text{design,view}}$, shall be as follows. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{\text{view}} \leq 1,53 \text{ m}$: $D_{\text{design,view}} = 1 \text{ m} + 4 \times H_{\text{view}}$ If $H_{\text{view}} > 1,53 \text{ m}$: $D_{\text{design,view}} = 4,7 \times H_{\text{view}}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{\text{design,view}} = 3 \times H_{\text{view}}$ where H_{view} is the height of the active display area.	Supplier specification, intended context of use.	Use supplier-specified value or value obtained from intended context of use. Report the resulting value.
Design viewing direction	The visual display shall conform to all optical requirements over a relevant range of viewing directions. The design viewing direction, (ϕ_D, Φ_D), as well as the design viewing direction range shall be specified.	Supplier specification, intended context of use.	See Table 4.

Table 4 — Assessment and reporting for design viewing direction

According to Table 3	Assessment and reporting
	Step 1 Examine isotropy of the visual display and report the result. NOTE 1 For isotropic visual displays, only lateral optical measurements are performed. NOTE 2 For anisotropic visual displays, lateral and directional optical measurements are performed. NOTE 3 Visual displays in CRT technology are always treated as isotropic visual displays. Step 2 For the design viewing direction as well as for the design viewing direction range, use values obtained from the intended context of use or use supplier-specified values. Report the resulting values. If the visual display is designed predominantly for artificial information, follow step 3. If the visual display is designed predominantly for reality information, follow step 4. Step 3 Carry out optical measurements at measurement locations UL, UR, LL, LR and CL, as shown in Figure 2. Throughout the measurements, align the measuring instrument perpendicular to the screen if not otherwise stated. Figure 2 — Measurement locations on CRT displays — Artificial information predominant Step 4 Carry out optical measurements at measurement locations 1 to 9, as shown in Figure 3. Throughout the measurements, align the measuring instrument perpendicular to the screen if not otherwise stated.

Table 4 (continued)

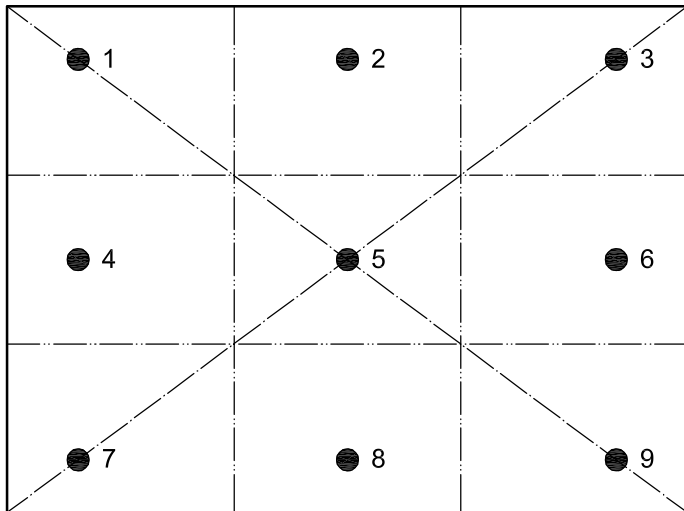
According to Table 3	Assessment and reporting
	 Figure 3 — Measurement locations on CRT displays — Reality information predominant

Table 5 — Viewing conditions

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Gaze and head tilt angles	The workplace and the visual display should permit the user to view the screen with a gaze angle from 0° to 40° and a head tilt angle from 0° to 25°.	Not applicable.	Not applicable.
Virtual images	Not applicable.	Not applicable.	Not applicable.
Illuminance	The supplier shall specify the maximum design screen illuminance, E_S , as well as the illuminant.	Supplier specification, intended context of use.	Use supplier-specified value or value obtained from intended context of use. Report the resulting value.

Table 6 — Display luminance

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Display luminance	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Under darkroom conditions, the visual display shall have a minimum display luminance of 35 cd/m² over all relevant viewing directions (see design viewing direction) ^[10]. 2) Under darkroom conditions, the visual display should have a minimum display luminance of 100 cd/m² over all relevant viewing directions (see design viewing direction) ^[10]. b) Reality information 1) Under darkroom conditions, the visual display shall have a minimum display luminance of 80 cd/m² over all relevant viewing directions (see design viewing direction), ^[21]. 2) Under darkroom conditions, the visual display should have a minimum display luminance of 200 cd/m² over all relevant viewing directions (see design viewing direction) ^[30]. NOTE The display luminance under ambient illumination is explicitly considered in the attribute <i>luminance contrast</i>.	ISO 9241-305 P 12.5 M 12.1	For artificial information, see Table 7. For reality information, see Table 8.

Table 7 — Assessment and reporting for display luminance — Artificial information

According to Table 6	Assessment and reporting
a)	Measure the display luminance, $L_{ill,object(mloc-mdir)}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 100 % grey level for monochrome visual displays or full-screen test pattern with combination R=G=B = 100 % for multicolour visual displays; — measurement locations: UL, UR, LL, LR and CL (see Figure 2); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 8 — Assessment and reporting for display luminance — Reality information

According to Table 6	Assessment and reporting
b)	Measure the display luminance, $L_{ill,object(mloc-mdir)}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 100 % grey level for monochrome visual displays or full-screen test pattern with combination R=G=B = 100 % for multicolour visual displays; — measurement locations: 1 to 9 (see Figure 3); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 9 — Luminance

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance balance and glare	a) In work environments, the luminance of task areas, $L_{\text{task,area}}$, that are frequently viewed in sequence while using the visual display (document, covers, etc.) should be between $0,1 \times L_{\text{task,area}} \leq L_{\text{Ea,HS}} \leq 10 \times L_{\text{task,area}}$ where $L_{\text{Ea,HS}}$ is the area average luminance of the visual display. b) For prolonged use in work environments, check that the design of the visual display screen and surrounding area of the product housing does not produce disturbing glare in the prevailing environmental lighting conditions. NOTE 1 Glare is defined by CIE (845-02-52; glare) as: “condition of vision in which there is discomfort or a reduction in the ability to see details or objects, caused by an unsuitable distribution or range of luminance, or too extreme contrasts” (International Lighting Vocabulary, CIE Publication 17.4, 1987). Disturbing glare thus is a condition of vision in which there is a disturbing degree of visual discomfort or/and a noticeable reduction in the ability to see details or objects. NOTE 2: In general, a matt surface design does not produce glare, whereas a gloss surface may do so, depending on its shape and size and environmental lighting. NOTE 3: Designers are advised to take into account the inter-relationship and interaction between the number of gloss units and the colour and reflectance, size and shape of the underlying surface. See also Reference [40]. NOTE 4: For housings with non-flat surfaces, the non-glossy or semi-non-glossy properties can be evaluated with suitable test methods, for example, gloss reference sample sheets. NOTE 5 At the time of publication of this part of ISO 9241, there was no international scientific consensus regarding the exact level of gloss that may produce disturbing levels of glare in relation to the relevant housing surface characteristics. Different gloss values were proposed but further research into this area, with experimental conditions that are fully specified, is encouraged. Since, due to interocular scattering, elderly people suffer in particular from glare, such research needs also to be done with elderly subjects. It is planned to publish the results in an annex to a future edition of this part of ISO 9241.	ISO 9241-305	a) Not applicable. b) Measure the gloss of the housing and report the resulting value for passed or failed.

Table 9 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance and contrast adjustment	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) The display luminance (luminance of the low and/or high state) shall be adjustable manually or automatically to the ambient illumination conditions. 2) The display luminance of the low state should be adjustable. 3) The display luminance of the high state shall be adjustable. 4) The luminance of the low and high state should be adjustable independently. 5) Adjustment of the display luminance (luminance of the low and/or high state) should not affect the electro-optical transfer function (EOTF) or the gamma value. b) Reality information 1) The display luminance (luminance of the low and/or high state) shall be adjustable manually or automatically to the ambient illumination conditions. 2) The display luminance of the low state shall be adjustable. 3) The display luminance of the high state shall be adjustable. 4) The luminance of the low and high state shall be adjustable independently. 5) Adjustment of the display luminance (luminance of the low and/or high state) shall not affect the electro-optical transfer function (EOTF) or the gamma value.	ISO 9241-305 P 14.1	See Table 10.

Table 10 — Assessment and reporting for luminance and contrast adjustment

According to Table 9	Assessment and reporting
a) 1); b) 1)	Step 1 Report the available controls for manual or automatic adjustment. Step 2 Describe the effect of the controls based on the supplier's information. NOTE In the case of a CRT, the "brightness control" sets the minimum luminance level and the "contrast control" sets the maximum luminance level. Step 3 Report the resulting values for passed or failed.
a) 2); b) 2)	Step 1 Adjust the control responsible for the display luminance of the high state to maximum. Step 2 Adjust the control responsible for the display luminance of the low state between minimum and maximum. Measure the display luminance, $L_{ill,object(mloc-mdir)}$, for each adjustment, where: — illumination condition: darkroom; — object: full-screen test pattern with minimum grey level for monochrome visual displays or combination R=G=B = 0 % for multicolour visual displays; — measurement location: CL or 5 (see Figure 2 or 3); — measurement direction: 0 (perpendicular). Step 3 Report the resulting values for passed or failed.
a) 3); b) 3)	Step 1 Adjust the control responsible for the display luminance of the low state to maximum. Step 2 Adjust the control responsible for the display luminance of the high state between minimum and maximum. Measure the display luminance, $L_{ill,object(mloc-mdir)}$, for each adjustment, where: — illumination condition: darkroom; — object: full-screen test pattern with minimum grey level for monochrome visual displays or combination R=G=B = 0 % for multicolour visual displays; — measurement location: CL or 5 (see Figure 2 or 3); — measurement direction: 0 (perpendicular). Step 3 Report the resulting values for passed or failed.
a) 4), 5); b) 4), 5)	Not applicable. NOTE Automatically given by the technology.

Table 11 — Special physical environments

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Vibration	Frequencies above 0,5 Hz of the visual display should be avoided.	Not applicable.	Not applicable.
Wind and rain	Visual displays that may be used outdoors should be mechanically shielded from strong winds and rain drops falling on the display screen.	Not applicable.	Not applicable.
Extreme temperatures	When operation of visual display devices is required in environments where temperatures are approaching 0 °C or +40 °C, users should take equipment and personal precautions to ensure that they are able to complete their tasks satisfactorily and safely.	ISO 9241-305	Use supplier-specified value or value obtained from intended context of use. Check whether the supplier specifies the use for extreme temperatures and report the resulting value.

Table 12 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance non-uniformity	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Lateral uniformity criterion Depending on the angular distance of test object separation at the design viewing distance, the luminance non-uniformity of a colour shall not exceed the following luminance ratio: 1,1° to < 2°: 1,3:1 ≥ 2° to < 4°: 1,4:1 ≥ 4° to < 5°: 1,5:1 ≥ 5° to < 7°: 1,6:1 ≥ 7°: 1,7:1 2) The maximum luminance ratio of a colour should not exceed the following luminance ratio: 1,1° to < 2°: 1,1: ≥ 2° to < 4°: 1,2:1 ≥ 4° to < 5°: 1,3:1 ≥ 5° to < 7°: 1,35:1 ≥ 7°: 1,4:1 3) Directional uniformity criterion Within the design viewing direction range, the luminance non-uniformity of a colour shall not exceed a maximum luminance ratio of 1,7:1 and should not exceed a luminance ratio of 1,4:1. b) Reality information 1) Lateral uniformity criterion Depending on the angular distance of test object separation at the design viewing distance, the luminance non-uniformity of a colour shall not exceed the following luminance ratio: 1,1° to < 2°: 1,1:1 ≥ 2° to < 4°: 1,2:1 ≥ 4° to < 5°: 1,3:1 ≥ 5° to < 7°: 1,35:1 ≥ 7°: 1,4:1 2) Directional uniformity criterion Within the design viewing direction range, the luminance non-uniformity of a colour shall not exceed a maximum luminance ratio of 1,4:1.	ISO 9241-305 P 14.1 P 14.2	See Table 13.

Table 13 — Assessment and reporting for luminance non-uniformity

According to Table 12	Assessment and reporting
a) 1), 2); b) 1)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$ where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combination R=G=B = 50 % and R=G=B = 100 % for multicolour visual displays; — measurement locations: UL, UR, LL, LR and CL or 1 to 9 (see Figure 2 or 3); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion. Determine the angular distance of the measurement locations, where the centre location is used as the reference, and calculate the corresponding ratios. Report the resulting value for passed or failed.
a) 3); b) 2)	Not applicable.

Table 14 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Colour non-uniformity	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Lateral uniformity criterion For an intended uniform colour appearance, the chromaticity uniformity difference, $\Delta u', v'$, of a colour at different locations on the visual display shall not exceed $\Delta u', v' = 0,02 \text{ for } D_{\text{active}}/D_{\text{design,view}} < 0,75$ $\Delta u', v' = 0,03 \text{ for } D_{\text{active}}/D_{\text{design,view}} \geq 0,75$ where D_{active} is the diagonal of the active display area; $D_{\text{design,view}}$ is the design viewing distance. 2) Directional uniformity criterion The visual display shall have sufficient chromaticity uniformity over all relevant viewing directions (see design viewing direction). The maximum chromaticity uniformity difference, $\Delta u', v'$, of a colour shall not exceed the above-mentioned limits. b) Reality information 1) Lateral uniformity criterion For an intended uniform colour appearance, the chromaticity uniformity difference, $\Delta u', v'$, of a colour at different locations on the visual display shall not exceed 0,02. 2) Directional uniformity criterion The visual display shall have sufficient chromaticity uniformity over all relevant viewing directions (see design viewing direction). The maximum chromaticity uniformity difference, $\Delta u', v'$, of a colour shall not exceed 0,02.	ISO 9241-305 P 19.2 P 19.3	See Table 15.

Table 15 — Assessment and reporting for colour non-uniformity

According to Table 14	Assessment and reporting
a) 1), b) 1)	Step 1 Measure the chromaticity coordinates, u', v'_{ill,object(mloc-mdir)}, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R,G,B = 100 %, combination R=G=B = 75 % and combinations R,G,B = 50 % for multicolour visual displays; — measurement locations: UL, UR, LL, LR and CL or 1 to 9 (see Figure 2 or 3); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion and calculate the maximum chromaticity uniformity difference. Report the resulting value for passed or failed.
a) 2), b) 2)	Not applicable.

Table 16 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Contrast non-uniformity	a) Lateral uniformity criterion For an intended uniform appearance, the contrast non-uniformity, $CR_{\text{nonuniformity}} = 1 - CR_{\text{min}}/CR_{\text{max}}$ shall not exceed 50 % where CR is the luminance contrast. b) Directional uniformity criterion The visual display shall have sufficient contrast uniformity over all relevant viewing directions (see design viewing direction). 1) The luminance contrast, CR, shall exceed the limit of CR_{min}. 2) There shall be no contrast inversion.	ISO 9241-305 P 18.5	Not applicable.

Table 16 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Geometric distortions	Depending on the type of information shown, the visual display shall fulfil the following requirements: a) Artificial information 1) For different rows or columns of text, the difference of length shall not exceed 1 % of the length of that column or row. 2) The horizontal [vertical] displacement of a symbol position relative to the symbol positions directly above and below [right and left] shall not vary by more than 5 % of the character width [character height]. b) Reality information For different rows or columns, the difference of length shall not exceed 1 % of the length of that column or row.	ISO 9241-305 M 21.1 M 21.4 P 21.2 P 21.5	Evaluate the geometric distortions and report the resulting value for passed or failed.
Screen and faceplate defects	The visual display shall be free of phosphor screen and faceplate defects.	ISO 9241-305	Observe the phosphor screen and faceplate for defects and report the resulting value for passed or failed.

Table 17 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Temporal instability (flicker)	The entire image area shall be free of flicker for at least 90 % of the user population.	ISO 9241-305 P 15.3	Evaluate the temporal instability. Report the resulting value for passed or failed. Use full-screen test pattern at maximum grey level for monochrome visual displays and combination $R=G=B = 100\%$ for multicolour visual displays.
Spatial instability (jitter)	The image shall be free of jitter in the intended display environment. The peak-to-peak variation in the geometric location of image elements shall not exceed 0,000 1 mm per mm of design viewing distance for the frequency range of 0,5 Hz to 30 Hz.	ISO 9241-305 P 15.4	Evaluate the spatial instability. Report the resulting value for passed or failed.
Moiré effects	For colour displays the entire image area shall be free of moiré patterns to enable the user to perform the task in an effective and efficient way. For colour displays, moiré patterns should not have more than 6 just noticeable differences (JND) of modulation at their fundamental spatial frequency.	ISO 9241-305	Display on the entire image area horizontal and vertical bars with maximum resolution as well as a pixel checkerboard and observe the screen for moiré patterns. Report the resulting value for passed or failed.
Other visual artefacts	The entire image area shall be free of other visual artefacts to enable the user to perform the task in an effective and efficient way.	ISO 9241-305	Evaluate other visual artefacts by visual inspection and report the resulting value for passed or failed.

Table 17 (continued)

Attribute	Pass/Fail criterion based on requirements and intended context of use	Measuring method	Assessment and reporting
Unwanted reflections	Depending on the type of information shown, the visual display shall fulfil the following requirement: a) Artificial information The visual display shall be suitable for the intended environment. Over all relevant viewing directions (see design viewing direction), the following requirements shall be fulfilled. 1) $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geq 2,2 + 4,84 \times (L_L + L_D + L_S)^{-0,65}$ 2) For visual displays using positive polarity: $\frac{L_H + L_D + L_S}{L_H + L_D} \leq 1,25$ 3) For visual displays using negative polarity: $\frac{L_L + L_D + L_S}{L_L + L_D} \leq 1,2 + \frac{1}{15} \times \frac{L_H + L_D}{L_L + L_D}$ b) Reality information The visual display shall be suitable for the intended environment. Over all relevant viewing directions (see design viewing direction), the following requirement shall be fulfilled: $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geq 6,7 + 6,7^2 \times (L_L + L_D + L_S)^{-0,65}$ where L_H is the display luminance of the high state; L_L is the display luminance of the low state; L_D is the luminance component reflected from diffuse illumination; L_S is the luminance component specularly reflected from large and/or small aperture sources of illumination.	ISO 9241-305 P 16.3	For artificial information, see Table 18. For reality information, see Table 19.

Table 18 — Assessment and reporting for unwanted reflections — Artificial information

According to Table 17	Assessment and reporting
a)	Step 1 Measure the display luminance $L_{\text{ill,object(mloc-mdir)}}$ where: — illumination condition: darkroom; — object: 5 cm × 5 cm block cursor in screen centre with an 80 % loading in positive polarity to 20 % loading in negative polarity with 0 % and 100 % grey level for monochrome visual displays or with combination R=G=B = 0 % and 100 % for multicolour visual displays; — measurement location: CL (see Figure 2); — measurement direction: $\theta = 15^\circ$. Report the resulting values. Step 2 Based on the reflectometer value, R_D, for the diffuse reflection characteristic of the visual display and the design screen illuminance, E_S, determine the luminance component, L_D, reflected from diffuse illumination. Report the resulting values. Step 3 Based on the reflectometer value, $R_{S,EXT}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,EXT}$, of the large aperture source, determine the luminance component, $L_{S,EXT}$, specularly reflected from large aperture sources of illumination. Report the resulting values. Step 4 Based on the reflectometer value, $R_{S,SML}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,SML}$, of the small aperture source, determine the luminance component, $L_{S,SML}$, specularly reflected from small aperture sources of illumination. Report the resulting values. Step 5 Evaluate the requirements of 1), 2) and 3) and report the resulting values for passed or failed.

Table 19 — Assessment and reporting for unwanted reflections — Reality information

According to Table 17	Assessment and reporting
b)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 0 % and 100 % grey level for monochrome visual displays or full-screen test pattern with combination R=G=B = 0 % and 100 % for multicolour visual displays; — measurement location: 5 (see Figure 3); — measurement direction: $\theta = 15^\circ$. Report the resulting values. Step 2 Based on the reflectometer value, R_D, for the diffuse reflection characteristic of the visual display and the design screen illuminance, E_S, determine the luminance component, L_D, reflected from diffuse illumination. Report the resulting value. Step 3 Based on the reflectometer value, $R_{S,EXT}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,EXT}$, of the large aperture source, determine the luminance component, $L_{S,EXT}$, specularly reflected from large aperture sources of illumination. Report the resulting value. Step 4 Based on the reflectometer value, $R_{S,SML}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,SML}$, of the small aperture source, determine the luminance component, $L_{S,SML}$, specularly reflected from small aperture sources of illumination. Report the resulting value. Step 5 Evaluate the requirement and report the resulting value for passed or failed.

Table 20 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Unintended depth effects	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information Spectrally extreme colours that produce unintended depths (chromostereopsis) effects shall be avoided. b) Reality information Not applicable.	ISO 9241-305 P 19.1	Applicable only in software applications.

Table 21 — Legibility and readability

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance contrast	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information The visual display shall be suitable for the intended environment. Over all relevant viewing directions (see design viewing direction), the luminance contrast, CR, shall exceed the minimum luminance contrast of: $CR_{\min} = \frac{L_H + L_D + L_S}{L_L + L_D + L_S}$ $CR_{\min} = 2,2 + 4,84 \times (L_1)^{-0,65}$ $L_1 = L_L + L_D + L_S$ where L_H is the display luminance of the high state; L_L is the display luminance of the low state; L_D is the luminance component reflected from diffuse illumination; L_S is the luminance component specularly reflected from large aperture sources of illumination.	ISO 9241-305 P 18.2 P 18.3	For artificial information, see Table 22. For reality information, see Table 23.

Table 21 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	b) Reality information The visual display shall be suitable for the intended environment. Over all relevant viewing directions (see design viewing direction), the luminance contrast CR shall exceed a minimum luminance contrast of ^[30]: $CR_{\min} = \frac{L_H + L_D + L_S}{L_L + L_D + L_S}$ $CR_{\min} = 6,7 + 44,89 \times (L_1)^{-0,65}$ $L_1 = L_L + L_D + L_S$ where L_H is the display luminance of the high state; L_L is the display luminance of the low state; L_D is the luminance component reflected from diffuse illumination; L_S is the luminance component specularly reflected from large aperture sources of illumination.		

Table 22 — Assessment and reporting for luminance contrast — Artificial information

According to Table 21	Assessment and reporting
a)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 0 % and 100 % grey level for monochrome visual displays or full-screen test pattern with combination R=G=B = 0 % and 100 % for multicolour visual displays; — measurement locations: UL, UR, LL, LR and CL (see Figure 2); — measurement direction: 0 (perpendicular). Step 2 Based on the reflectometer value, R_D, for the diffuse reflection characteristic of the visual display and the design screen illuminance, E_S, determine the luminance component, L_D, reflected from diffuse illumination. Report the resulting value. Step 3 Based on the reflectometer value, $R_{S,EXT}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,EXT}$, of the large aperture source, determine the luminance component, $L_{S,EXT}$, specularly reflected from large aperture sources of illumination. Report the resulting value. Step 4 Evaluate the requirements and report the resulting values for passed or failed.

Table 23 — Assessment and reporting for luminance contrast — Reality information

According to Table 21	Assessment and reporting
b)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 0 % and 100 % grey level for monochrome visual displays or full-screen test pattern with combination R = G = B = 0 % and 100 % for multicolour visual displays; — measurement locations: 1 to 9 (see Figure 3); — measurement direction: 0 (perpendicular). Step 2 Based on the reflectometer value, R_D, for the diffuse reflection characteristic of the visual display and the design screen illuminance, E_S, determine the luminance component, L_D, reflected from diffuse illumination. Report the resulting value. Step 3 Based on the reflectometer value, $R_{S,EXT}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,EXT}$, of the large aperture source, determine the luminance component, $L_{S,EXT}$, specularly reflected from large aperture sources of illumination. Report the resulting value. Step 4 Evaluate the requirements and report the resulting values for passed or failed.

Table 24 — Legibility and readability

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image polarity	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information If the display provides positive and negative polarity, it shall meet all requirements of this compliance route for each image polarity. b) Reality information Not applicable.	Not applicable.	Check requirements for unwanted reflections and character attributes for positive and negative polarity.

Table 24 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Character height	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) For Latin-origin characters, the minimum character height shall be 16' of arc at the design viewing distance. The preferred character height is 20' to 22' of arc. 2) For Japanese characters, the minimum character height shall be 20' of arc at the design viewing distance. The preferred character height is 25' to 35' of arc. 3) A default mode shall be available in which Latin-origin characters are presented with a character height of 20' to 22' of arc and Japanese characters with a character height of 25' to 35' of arc at the design viewing distance. b) Reality information Not applicable.	ISO 9241-305 P 20.4	Measure the character height in millimetres and calculate the character height in minutes of arc at the design viewing distance. Report the resulting value for passed or failed. Report the font used as well as $N_{H,Height}$ which is the number of pixels in the height of an unaccented, upper-case letter H. Evaluate the default mode and report the character height in mm, character height in minutes of arc, the font used and the character height number $N_{H,Height}$.
Text size constancy	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information The height, H, and width, W, of a specific character and of a specific character font shall not vary by more than $\pm 3\%$ of the character height of that character set, regardless of where it is presented on the display surface. b) Reality information Not applicable.	ISO 9241-305 P 20.4	Determine: $\frac{(W_{M,max} - W_{M,mean})}{H_{E,mean}} \times 100\%$ $\frac{(W_{M,mean} - W_{M,min})}{H_{E,mean}} \times 100\%$ $\frac{(H_{E,max} - H_{E,mean})}{H_{E,mean}} \times 100\%$ $\frac{(H_{E,mean} - H_{E,min})}{H_{E,mean}} \times 100\%$ where $W_{M,min}$ is the minimum character width of Latin-origin character M in millimetres; $W_{M,max}$ is the maximum character width of Latin-origin character M in millimetres; $W_{M,mean}$ is the mean character width of Latin-origin character M in millimetres; $H_{E,min}$ is the minimum character height of Latin-origin character E in millimetres; $H_{E,max}$ is the maximum character height of Latin-origin character E in millimetres; $H_{E,mean}$ is the mean character height of Latin-origin character E in millimetres. Each term shall be $\leq 3\%$. Report the resulting values for passed or failed.

Table 24 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Character stroke width	Depending on the type of information shown, the visual display shall fulfil the following requirement: a) Artificial information For Latin-origin characters, the stroke width shall be within the range of 10 % to 17 % of character height. b) Reality information Not applicable.	ISO 9241-305 P 20.6	Measure and evaluate the character stroke width. Report the resulting value for passed or failed.
Character width-to-height ratio	Depending on the type of information shown, the visual display shall fulfil the following requirement: a) Artificial information 1) The character width-to-height ratio shall be within the range from 0,5:1 to 1:1. 2) A character width-to-height ratio of from 0,7:1 to 0,9:1 is recommended. b) Reality information Not applicable.	ISO 9241-305 P 20.8	Measure and evaluate the character width-to-height ratio. Report the resulting value for passed or failed.
Character format	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) For Latin-origin characters, the minimum character matrix for continuous reading is 7 × 9 (width-to-height). 2) For Latin-origin characters, the minimum character matrix for numeric and upper-case-only presentations is 5 × 7 (width-to-height). 3) For Latin-origin characters, the character matrix shall be increased upwards by at least two pixels if diacritics are used. 4) If lower case is used with Latin-origin characters, the character matrix shall be increased downwards by at least two pixels. 5) For Latin-origin characters and for higher density character matrices, the number of pixels used for diacritics should follow conventional designs for printed text.	ISO 9241-305	Evaluate and report the character matrix. Report the resulting values for passed or failed.

Table 24 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	6) For Latin-origin characters, a 4×5 (width-to-height) character matrix shall be the minimum used for subscripts and superscripts, and for numerators and denominators of fractions displayed in a single character position. 7) For Latin-origin characters, the 4×5 matrix may also be used for alphanumeric information not related to the operator's task, such as copyright information. 8) For Japanese characters, a minimum matrix of 11×11 elements is recommended, whereas a matrix of 15×15 elements is preferred. b) Reality information Not applicable.		
Between-character spacing	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information The minimum between-character spacing shall be one stroke width or one pixel. b) Reality information Not applicable.	ISO 9241-305 P 20.12	Measure and evaluate the between-character spacing. Report the resulting value for passed or failed.
Between-word spacing	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information The minimum number of pixels between words shall be the number of pixels in the width of an unaccented upper-case letter H. The number of pixels in the width of the letter N shall be used for proportionally spaced fonts. b) Reality information Not applicable.	ISO 9241-305 P 20.13	Measure and evaluate the between-word spacing. Report the resulting value for passed or failed.
Between-line spacing	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information For tasks that require continuous reading of text, a minimum of one pixel shall be used for spacing between lines of text. This area may not contain parts of characters or diacritics, but may contain underscores. b) Reality information Not applicable.	ISO 9241-305 P 20.14	Measure and evaluate the between-line spacing. Report the resulting value for passed or failed.

Table 25 — Legibility of information coding

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance coding	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information Over all relevant viewing directions (see design viewing direction), the ratio between area luminances of adjacent levels of a single area shall exceed 1,5:1 under ambient illumination. b) Reality information Not applicable.	ISO 9241-305 P 17.6	See Table 26.

Table 26 — Assessment and reporting for luminance coding — Artificial information

According to Table 25	Assessment and reporting
a)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 100 %, 75 % and 50 % grey level for monochrome visual displays or full-screen test pattern with combination R = G = B = 100 %, 75 % and 50 % for multicolour visual displays; — measurement location: CL (see Figure 2); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Based on the reflectometer value, R_D, for the diffuse reflection characteristic of the visual display and the design screen illuminance, E_S, determine the luminance component, L_D, reflected from diffuse illumination. Report the resulting value. Step 3 Based on the reflectometer value, $R_{S,EXT}$, for the specular reflection characteristic of the visual display and the luminance, $L_{REF,EXT}$, of the large aperture source, determine the luminance component, $L_{S,EXT}$, specularly reflected from large aperture sources of illumination. Report the resulting value. Step 4 Determine the display luminances under ambient illumination. Determine the ratios between adjacent levels and report the resulting values for passed or failed.

Table 27 — Legibility of information coding

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Blink coding	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information Where blink coding is used solely to attract attention, a single blink frequency of from 1 Hz to 5 Hz, with a duty cycle of 50 %, is recommended. Where readability is required during blinking, a single blink rate of 1/3 Hz to 1 Hz, with a duty cycle of 70 %, is recommended. It should be possible to switch off the blinking of the cursor. b) Reality information Not applicable.	ISO 9241-305 P 15.5	Applicable only in software applications.
Colour coding	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information Over all relevant viewing directions (see design viewing direction), coded colours shall have a minimum colour difference of $\Delta E^*_{uv} \geq 20$ under ambient illumination. b) Reality information Not applicable.	ISO 9241-305 P 19.4	See Table 28.

Table 28 — Assessment and reporting for colour coding — Artificial information

According to Table 27	Assessment and reporting
a)	Step 1 Measure the tristimulus values, $X_{ill,object(mloc-mdir)}$, $Y_{ill,object(mloc-mdir)}$, $Z_{ill,object(mloc-mdir)}$, where — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full-screen test pattern with combinations R, G, B = 100 %, combination R=G=B = 75 % and combinations R, G, B = 50 %; — measurement location: CL (see Figure 2); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Based on the design screen illuminance, E_S, determine the (reflectometer) tristimulus values, X_D, Y_D and Z_D, for the component reflected from diffuse illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values. Step 3 Based on the luminance of the large aperture source, determine the (reflectometer) tristimulus values, $X_{S,EXT}$, $Y_{S,EXT}$, $Z_{S,EXT}$, for the component specularly reflected from large aperture sources of illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values. Step 4 Determine the chromaticity coordinates of the colours under ambient illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Determine the colour difference between the colours. Combinations R, G, B = 100 % and combination R=G=B = 75 % shall fulfil the requirement. Combinations R, G, B = 50 % should fulfil the requirement. Report the resulting values for passed or failed.

Table 29 — Legibility of information coding

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Geometrical coding	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information Geometrical coding is a particular type of graphical coding. The distinction of different classes of information in a graph may be facilitated by the use of different geometrical shapes, such as triangles or circles. These shapes should be easy to distinguish, which means that their number should be limited. b) Reality information Not applicable.	Not applicable.	Applicable only in software applications.

Table 30 — Legibility of graphics

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Monochrome and multicolour object size	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Critical details such as symbols or text within the icon should have a minimum height of 20' of arc. Heights subtending 25' of arc to 35' of arc are preferred. 2) For graphical objects and other small objects where legibility is the primary concern, refer to <i>luminance contrast</i>. 3) For isolated images where accurate colour identification is required, the image shall subtend 30' of arc; 45' of arc is preferred. b) Reality information Not applicable.	See character height, luminance contrast. ISO 9241-305 P 20.4	Applicable only in software applications.
Contrast for object legibility	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information Where accurate identification of an isolated, multicolour image (e.g. a single character or a symbol) is required, the same conditions for display luminance and luminance contrast shall apply. b) Reality information Not applicable.	See display luminance, luminance contrast.	Applicable only in software applications.

Table 30 (continued)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Colour considerations for graphics	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Where accurate colour identification of characters or symbols is required, the minimum size of them shall be at least 20' of arc at the design viewing distance. 2) When an application requires the user to discriminate or identify colours, it shall offer a default set of colours. 3) Colour pairs that are to be discriminated shall have values of $\Delta E_{uv}^* > 20$. 4) Negative polarity: spectrally extreme blue ($v' < 0,2$) on a dark background shall not be used. Spectrally extreme red ($u' > 0,4$) shall not be used on a spectrally extreme blue ($v' < 0,2$) background. 5) Positive polarity: spectrally extreme blue ($v' < 0,2$) shall not be used on a spectrally extreme red ($u' > 0,4$) background. Spectrally extreme red ($u' > 0,4$) shall not be used on a spectrally extreme blue ($v' < 0,2$) background. b) Reality information Not applicable.	See character height, colour coding. ISO 9241-305 P 19.1	Applicable only in software applications.
Background and surrounding image effects	Depending on the type of information shown, the visual display shall fulfil the following requirement. a) Artificial information To better discriminate and identify colours, systems and applications should use an achromatic background behind chromatic foreground image colours or achromatic foreground image colours on chromatic backgrounds. b) Reality information Not applicable.	Not applicable.	Applicable only in software applications.
Number of colours	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Simultaneous colour presentation: for accurate identification, the default colour set(s) for colour coding should consist of no more than eleven colours for each set. 2) Visual search for colour images: when a rapid visual search based on colour discrimination is required, no more than six colours should be used. 3) Colour interpretation from memory: if the meaning of each colour of a set of colours is to be recalled from memory, no more than six colours should be used. b) Reality information Not applicable.	Not applicable.	Applicable only in software applications.

Table 31 — Fidelity

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Colour gamut and reference white	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Colour gamut Over all relevant viewing directions (see design viewing direction), the chromaticity diagram area under ambient illumination shall exceed a minimum of 5 % of the total area of the CIE 1976 UCS chromaticity diagram, centred about the chromaticity of the reference white. 2) Reference white A reference white shall be displayable on the visual display with a maximum deviation of the correlated colour temperature of ± 500 K. Preferred correlated colour temperatures are e.g. 5 000 K, 5 500 K, 6 500 K, 7 500 K and/or 9 300 K. 3) The reference white shall be adjustable by the user. b) Reality information 1) Colour gamut Over all relevant viewing directions (see design viewing direction), the chromaticity diagram area under ambient illumination should be optimal to more than 90 % of the population and shall be optimal to more than 75 % of the population (see Figure 4) [37], [44]. NOTE Using colour points deviating from the EBU or those of IEC 61966-2-1, sRGB or ITU-R BT. 709 colour points and their tolerances implies that colour mapping is applied. 2) Reference white A reference white in accordance with the regional regulations as defined by the ITU shall be displayable on the visual display with a maximum deviation of the correlated colour temperature of ± 300 K. NOTE Typical correlated colour temperatures are 6 500 K, 6 774 K or 9 300 K. 3) Skin tones Objects or scenes taken from reality (especially skin tones) shall have accurate colour rendering when visualized on a display [34]. Under darkroom conditions at the design viewing direction, the skin tone should have chromaticity coordinates $u' = 0,222\ 1$, $v' = 0,488\ 4$ and shall be within a circle of radius 0,01 from this point with a luminance of $Y = 0,440\ 4 \pm 10\ \%$, normalized to a unit value of white. Over all relevant viewing directions (see design viewing direction), the skin tone under ambient illumination shall not exceed the maximum chromaticity uniformity difference of $\Delta u', v' = [(0,222\ 1 - u')^2 + (0,488\ 1 - v')^2]^{0,5} = 0,02$	ISO 9241-305 P 19.5 P 19.7	For artificial information, see Table 32. For reality information, see Table 33.

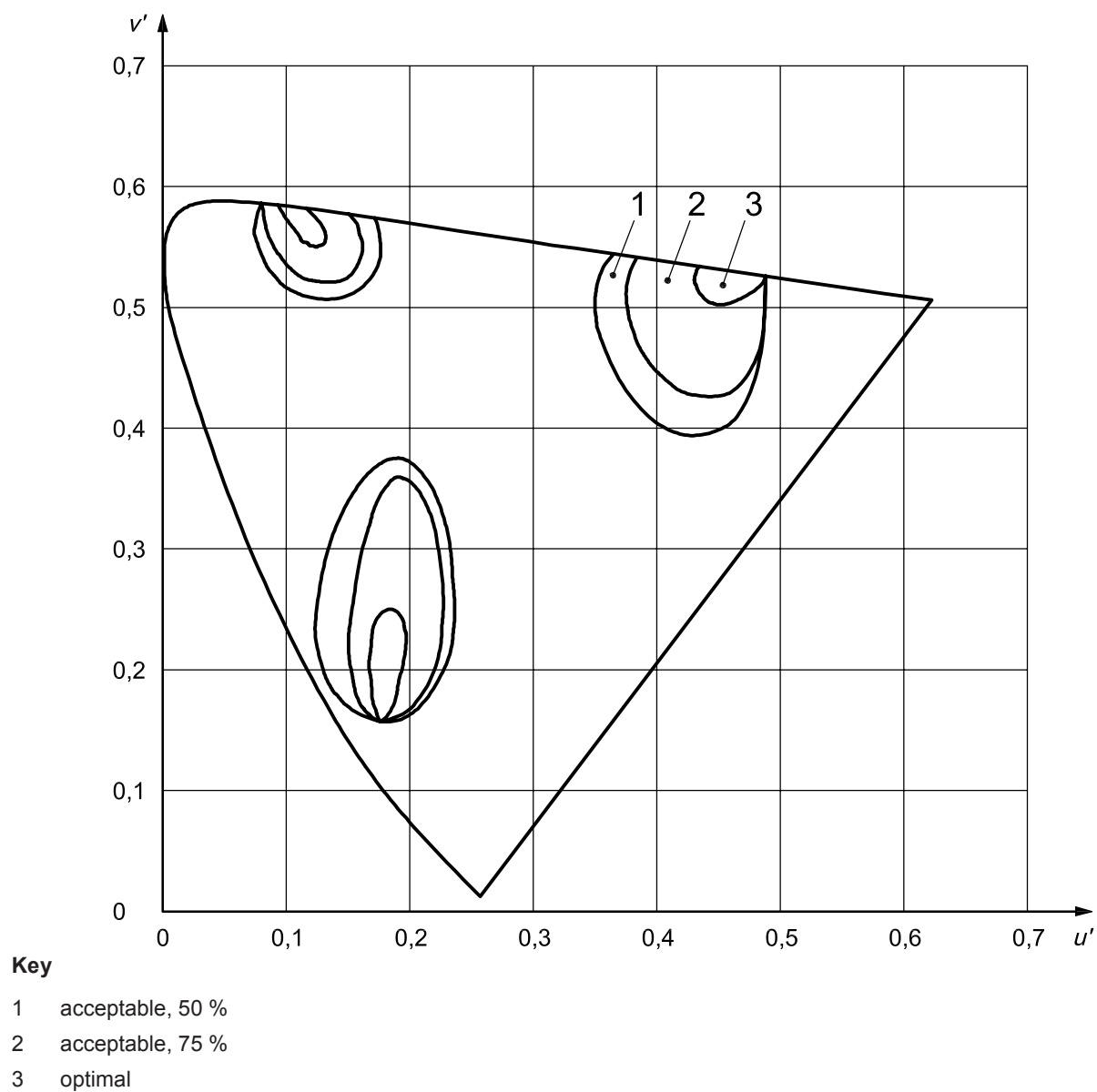


Figure 4 — Optimal and acceptable chromaticity ranges — CRT displays

Table 32 — Assessment and reporting for colour gamut and reference white — Artificial information

According to Table 31	Assessment and reporting
a) 1)	Step 1 Measure the tristimulus values, $X_{\text{ill,object(mloc-mdir)}}$, $Y_{\text{ill,object(mloc-mdir)}}$, $Z_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full-screen test pattern of the primaries R = 100 %, G = 100 % and B = 100 %; — measurement location: CL (see Figure 2); — measurement direction: 0 (perpendicular). Report the resulting values. Determine the chromaticity coordinates of the primaries and the colour gamut under darkroom conditions. Report the resulting values and show the chromaticity coordinates of the primaries in the CIE 1976 UCS diagram. Step 2 Based on the design screen illuminance, E_S, determine the (reflectometer) tristimulus values, X_D, Y_D and Z_D, for the component reflected from diffuse illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values. Step 3 Based on the luminance of the large aperture source, determine the (reflectometer) tristimulus values, $X_{S,EXT}$, $Y_{S,EXT}$, $Z_{S,EXT}$, for the component specularly reflected from large aperture sources of illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values. Step 4 Determine the chromaticity coordinates of the primaries under ambient illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values and show the chromaticity coordinates of the primaries in the CIE 1976 UCS diagram. Calculate the colour gamut. Report the resulting value for passed or failed.
a) 2)	Step 1 Measure the chromaticity coordinates, u', $v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 100 % grey level for monochrome visual displays or full-screen test pattern with combination R = G = B = 100 % for multicolour visual displays; — measurement location: CL (see Figure 2); — measurement direction: 0 (perpendicular); Step 2 Report the resulting values and show the chromaticity coordinates of the primary (primaries) in the CIE 1976 UCS diagram and determine the colour temperature. Report the resulting value for passed or failed.
a) 3)	Report whether the reference white is adjustable by the user. Report the possible settings.

Table 33 — Assessment and reporting for colour gamut and reference white — Reality information

According to Table 31	Assessment and reporting
b) 1)	Step 1 Measure the tristimulus values, $X_{\text{ill,object(mloc-mdir)}}$, $Y_{\text{ill,object(mloc-mdir)}}$, $Z_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full-screen test pattern of the primaries R = 100 %, G = 100 % and B = 100 %; — measurement location: 5 (see Figure 3); — measurement direction: 0 (perpendicular). Report the resulting values. Determine the chromaticity coordinates of the primaries and the colour gamut under darkroom conditions. Report the resulting values and show the chromaticity coordinates of the primaries in the CIE 1976 UCS diagram. Step 2 Based on the design screen illuminance, E_S, determine the (reflectometer) tristimulus values, X_D, Y_D and Z_D, for the component reflected from diffuse illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values. Step 3 Based on the luminance of the large aperture source, determine the (reflectometer) tristimulus values, $X_{S,EXT}$, $Y_{S,EXT}$, $Z_{S,EXT}$, for the component specularly reflected from large aperture sources of illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values. Step 4 Determine the chromaticity coordinates of the primaries under ambient illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values and show the chromaticity coordinates of the primaries in the CIE 1976 UCS diagram. Calculate the colour gamut. Report the colour gamut and whether the reproduction of natural colours is optimal to more than 90 %, acceptable to 75 % or acceptable to 50 % of the population (see also Annex B for the boundaries).
b) 2)	Step 1 Measure the chromaticity coordinates, $u', v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern at 100 % grey level for monochrome visual displays or full-screen test pattern with combination R = G = B = 100 % for multicolour visual displays; — measurement location: 5 (see Figure 3); — measurement direction: 0 (perpendicular). Step 2 Report the resulting values and show the chromaticity coordinates of the primary (primaries) in the CIE 1976 UCS diagram and determine the colour temperature. Report the resulting value for passed or failed.
b) 3)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, and chromaticity coordinates, $u', v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full screen drive of the visual display with a determined signal in accordance with the regional regulations as defined by the ITU; — measurement location: 5 (see Figure 3); — measurement direction: 0 (perpendicular). Step 2 Report the resulting values for passed or failed and show the chromaticity coordinates of the skin tone in the CIE 1976 UCS diagram.

Table 33 (continued)

According to Table 31	Assessment and reporting
b) 3)	Step 3 Measure the tristimulus values, $X_{\text{ill,object(mloc-mdir)}}$, $Y_{\text{ill,object(mloc-mdir)}}$, $Z_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full screen drive of the visual display with a determined signal in accordance with the regional regulations as defined by the ITU; — measurement location: 5 (see Figure 3); — measurement direction: 0 (perpendicular). Report the resulting values. Step 4 Determine the chromaticity coordinates of the skin tone under ambient illumination of CIE illuminants A and D65, and the illuminant specified by the supplier. Report the resulting values and show the chromaticity coordinates of the skin tone in the CIE 1976 UCS diagram.

Table 34 — Fidelity

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Electro-optical transfer function (EOTF) and grey scale	Depending on the type of information shown, the visual display shall fulfil the following requirements. a) Artificial information 1) Over all relevant viewing directions (see design viewing direction), the EOTF and its first derivative for each of the three primary colours shall be ascending in a monotonous way. 2) Over all relevant viewing directions (see design viewing direction), the chromaticity uniformity difference, $\Delta u', v'$, between grey levels shall not exceed 0,02. b) Reality information 1) Over all relevant viewing directions (see design viewing direction), the EOTF and its first derivative for each of the three primary colours shall ascend in a monotonous way and the gamma value shall be in accordance with the intended specification with a maximum deviation of $\pm 0,2$. 2) Over all relevant viewing directions (see design viewing direction), the chromaticity uniformity difference, $\Delta u', v'$, between grey levels shall not exceed 0,02.	ISO 9241-305 P 14.1 P 14.2 P 17.5 P 19.2 P 19.3	For artificial information, see Table 35. For reality information, see Table 36. NOTE The chromatic fidelity of a visual display is evaluated on the basis of additive colour mixing of the three primaries. In order to reduce the number of measurements required for assessment and reporting, the EOTF is not measured for each primary colour individually, but only the achromatic states are evaluated. This serves as a compact but significant measure for characterization of the chromatic fidelity of the visual display.

Table 35 — Assessment and reporting for electro-optical transfer functions and grey scale — Artificial information

According to Table 34	Assessment and reporting
a) 1)	Step 1 Measure the display luminance, $L_{\text{ill,object}(mloc-mdir)}$, where: — illumination condition: darkroom; — object: full-screen test pattern of different grey levels (R=G=B) between 0 % and 100 % (equidistantly spaced in 2,5 % steps) for monochrome or multicolour visual displays; — measurement location: CL (see Figure 2); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Determine the monotonicities. Report the resulting value for passed or failed.
a) 2)	Step 1 Measure the chromaticity coordinates, $u', v'_{\text{ill,object}(mloc-mdir)}$, where — illumination condition: darkroom; — object: full-screen test pattern at 100 %, 75 % and 50 % grey level for monochrome visual displays or full-screen test pattern with combination R=G=B = 100 %, 75 %, 50 % and 25 % for multicolour visual displays; — measurement location: CL (see Figure 2); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 36 — Assessment and reporting for electro-optical transfer functions and grey scale — Reality information

According to Table 34	Assessment and reporting
b) 1)	Step 1 Measure the display luminance, $L_{\text{ill,object}(mloc-mdir)}$, where: — illumination condition: darkroom; — object: full-screen test pattern of different grey levels (R=G=B) between 0 % and 100 % (equidistantly spaced in 2,5 % steps) for monochrome or multicolour visual displays; — measurement location: 5 (see Figure 3); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Determine the monotonicities and the gamma values. Report the resulting value for passed or failed. NOTE The gamma values are determined in accordance with Reference [36].

Table 36 (continued)

According to Table 34	Assessment and reporting
b) 2)	Step 1 Measure the chromaticity coordinates, $u', v'_{ill, object(mloc-mdir)}$ where — illumination condition: darkroom; — object: full-screen test pattern at 100 %, 75 % and 50 % grey level for monochrome visual displays or full-screen test pattern with combination R = G = B = 100 %, 75 %, 50 % and 25 % for multicolour visual displays; — measurement location: 5 (see Figure 3); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 37 — Fidelity

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Rendering of moving images	The visual display shall have sufficient temporal fidelity to show moving images without any blur, smear or other noticeable artefacts.	ISO 9241-305	Not applicable. Display a wheel on the screen. The wheel and the spokes shall be displayed with 0 % to 100 % grey level on a background of 50 % grey level for monochrome visual displays, or combination R=G=B = 0 % to combination R=G=B = 100 % on a background with combination R=G=B = 50 % for multicolour visual displays. The lateral velocity, v_x, in the horizontal direction as well as the rotating velocity, ω, shall be adjustable. Allow the wheel to continuously move and rotate. Observe the visual display for any blur, smear or other noticeable artefacts. Report the resulting value for passed or failed.
Colour misconvergence	The level of misconvergence at any location on the visual display shall not be greater than 3,4' of arc and preferably should be less than 2,3' of arc at the design viewing distance.	ISO 9241-305 M 21.8	Measure the misconvergence and report the resulting value for passed or failed.