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Ergonomics of human-system interaction —

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

Ergonomie de l'interaction homme-système —

Partie 307: Méthodes d'essais d'analyse et de conformité pour écrans de visualisation électroniques

Reference number
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Foreword

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

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

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

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

ISO 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.

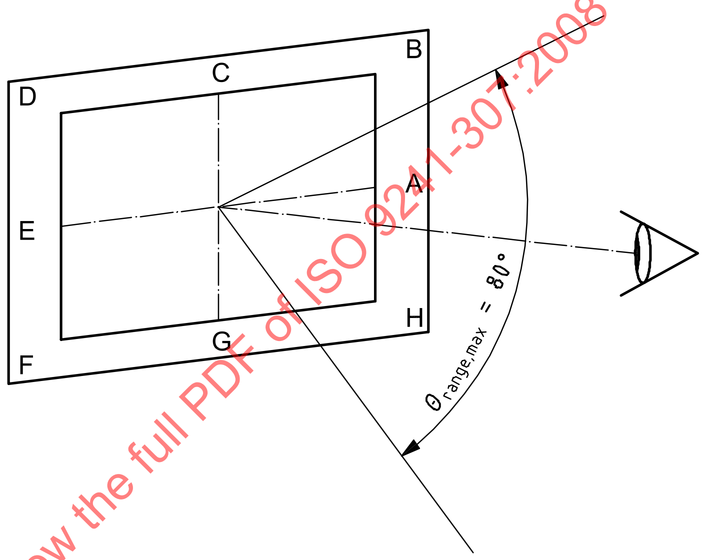
Table 1 — Intended context of use — CRT displays

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 lx + 250 lx × cos(α) 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]): — $L_{REF,EXT}$ = 500 cd/m^2, $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 300 cd/m^2, $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 200 cd/m^2, $L_{REF,SML}$ = 2 000 cd/m^2 (suitable for general office use); — $L_{REF,EXT}$ = 125 cd/m^2, $L_{REF,SML}$ = 200 cd/m^2 (requires a specially controlled luminous environment); where $L_{REF,EXT}$ is the luminance of the large aperture source (15°); $L_{REF,SML}$ 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, $D_{design,view}$	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 ± 15° in the vertical and horizontal directions from the line-of-sight [11]. — If $W_{view} > H_{view}$: $D_{design,view} = W_{view}/2 \times \tan(15°) = W_{view}/0{,}536$ — If $H_{view} > W_{view}$: $D_{design,view} = H_{view}/2 \times \tan(15°) = H_{view}/0{,}536$ 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, $D_{design,view}$, is as follows [30]. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{view} \leqslant 1{,}53$ m: $D_{design,view} = 1\text{ m} + 4 \times H_{view}$ If $H_{view} > 1{,}53$ m: $D_{design,view} = 4{,}7 \times H_{view}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{design,view} = 3 \times H_{view}$

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°.  **Figure 1 — Design viewing direction for CRT displays**
	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.

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, $D_{design,view}$, shall be calculated on optimum position for the most important visual display that is within ± 15° in the vertical and horizontal directions from the line-of-sight. — If $W_{view} > H_{view}$: $D_{design,view} = W_{view}/2 \times \tan(15°) = W_{view}/0{,}536$ — If $H_{view} > W_{view}$: $D_{design,view} = H_{view}/2 \times \tan(15°) = H_{view}/0{,}536$ 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, $D_{design,view}$, shall be as follows. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{view} \leqslant 1{,}53$ m: $D_{design,view} = 1\ \text{m} + 4 \times H_{view}$ If $H_{view} > 1{,}53$ m: $D_{design,view} = 4{,}7 \times H_{view}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{design,view} = 3 \times H_{view}$ 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, (Θ_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

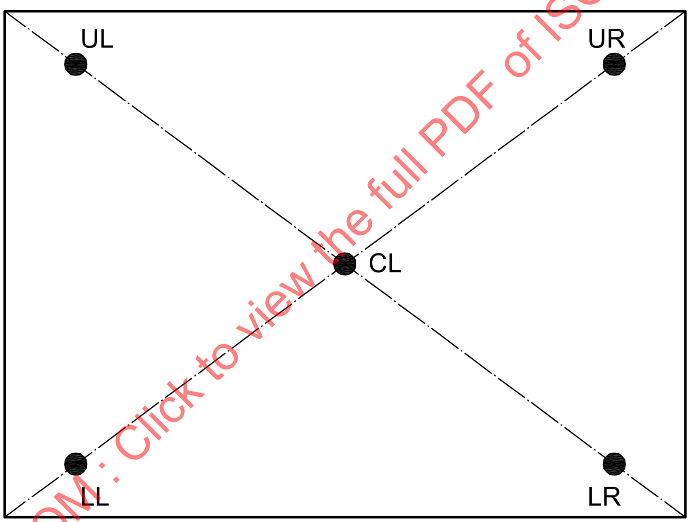
According to Table 3	Assessment and reporting
	Step 1 Examine isotropy of the visual display and report the result. NOTE 1 For isotropic visual displays, only lateral optical measurements are performed. NOTE 2 For anisotropic visual displays, lateral and directional optical measurements are performed. 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*)

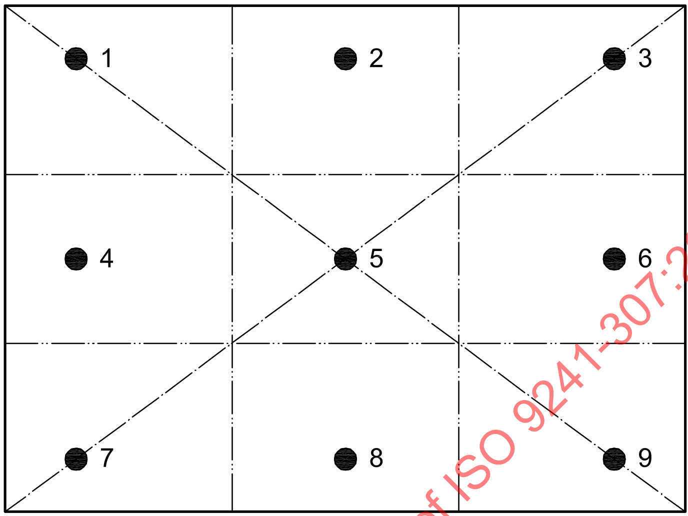
According to Table 3	Assessment and reporting
	 **Figure 3 — Measurement locations on CRT displays — Reality information predominant**

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/m^2 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/m^2 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/m^2 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/m^2 over all relevant viewing directions (see design viewing direction) [30]. NOTE The display luminance under ambient illumination is explicitly considered in the attribute *luminance contrast*.	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, $L_{\text{ill,object(mloc-mdir)}}$, 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 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, $L_{\text{ill,object(mloc-mdir)}}$, 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 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, $L_{task,area}$, that are frequently viewed in sequence while using the visual display (document, covers, etc.) should be between $0,1 \times L_{task,area} \leqslant L_{Ea,HS} \leqslant 10 \times L_{task,area}$ where $L_{Ea,HS}$ 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, $L_{\text{ill,object(mloc-mdir)}}$, 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, $L_{\text{ill,object(mloc-mdir)}}$, 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, $L_{ill,object(mloc\text{-}mdir)}$, 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 $\Delta u',v' = 0{,}02$ for $D_{active}/D_{design,view} < 0{,}75$ $\Delta u',v' = 0{,}03$ for $D_{active}/D_{design,view} \geqslant 0{,}75$ where D_{active} is the diagonal of the active display area; $D_{design,view}$ 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, $u',v'_{ill,object(mloc\text{-}mdir)}$, 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, $CR_{nonuniformity} = 1 - CR_{min}/CR_{max}$, 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) $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 2{,}2 + 4{,}84 \times (L_L + L_D + L_S)^{-0{,}65}$ 2) For visual displays using positive polarity: $\frac{L_H + L_D + L_S}{L_H + L_D} \leqslant 1{,}25$ 3) For visual displays using negative polarity: $\frac{L_L + L_D + L_S}{L_L + L_D} \leqslant 1{,}2 + \frac{1}{15} \times \frac{L_H + L_D}{L_L + L_D}$ **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: $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 6{,}7 + 6{,}7^2 \times \left(L_L + L_D + L_S\right)^{-0{,}65}$ 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 $L_{\mathrm{ill,object(mloc\text{-}mdir)}}$ 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: $\Theta = 15°$. 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, $R_{\mathrm{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\mathrm{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\mathrm{S,EXT}}$, specularly reflected from large aperture sources of illumination. Report the resulting values. Step 4 Based on the reflectometer value, $R_{\mathrm{S,SML}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\mathrm{REF,SML}}$, of the small aperture source, determine the luminance component, $L_{\mathrm{S,SML}}$, 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, $L_{\mathrm{ill,object(mloc\text{-}mdir)}}$, 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: $\Theta = 15°$. 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, $R_{\mathrm{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\mathrm{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\mathrm{S,EXT}}$, specularly reflected from large aperture sources of illumination. Report the resulting value. Step 4 Based on the reflectometer value, $R_{\mathrm{S,SML}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\mathrm{REF,SML}}$, of the small aperture source, determine the luminance component, $L_{\mathrm{S,SML}}$, 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]: $\mathrm{CR}_{\mathrm{min}} = \frac{L_{\mathrm{H}} + L_{\mathrm{D}} + L_{\mathrm{S}}}{L_{\mathrm{L}} + L_{\mathrm{D}} + L_{\mathrm{S}}}$ $\mathrm{CR}_{\mathrm{min}} = 6{,}7 + 44{,}89 \times (L_1)^{-0{,}65}$ $L_1 = L_{\mathrm{L}} + L_{\mathrm{D}} + L_{\mathrm{S}}$ 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, $L_{\mathrm{ill,object(mloc\text{-}mdir)}}$, 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, $R_{\mathrm{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\mathrm{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\mathrm{S,EXT}}$, 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, $R_{\text{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\text{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\text{S,EXT}}$, 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 $N_{\text{H,Height}}$ 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 $N_{\text{H,Height}}$.
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 ± 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: $(W_{\text{M,max}} - W_{\text{M,mean}})/H_{\text{E,mean}} \times 100\ \%$ $(W_{\text{M,mean}} - W_{\text{M,min}})/H_{\text{E,mean}} \times 100\ \%$ $(H_{\text{E,max}} - H_{\text{E,mean}})/H_{\text{E,mean}} \times 100\ \%$ $(H_{\text{E,mean}} - H_{\text{E,min}})/H_{\text{E,mean}} \times 100\ \%$ where $W_{\text{M,min}}$ is the minimum character width of Latin-origin character M in millimetres; $W_{\text{M,max}}$ is the maximum character width of Latin-origin character M in millimetres; $W_{\text{M,mean}}$ is the mean character width of Latin-origin character M in millimetres; $H_{\text{E,min}}$ is the minimum character height of Latin-origin character E in millimetres; $H_{\text{E,max}}$ is the maximum character height of Latin-origin character E in millimetres; $H_{\text{E,mean}}$ is the mean character height of Latin-origin character E in millimetres. Each term shall be $\leqslant$ 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, $R_{\text{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\text{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\text{S,EXT}}$, 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 $\Delta E^*_{uv} \geqslant 20$ 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, $X_{\text{ill,object(mloc-mdir)}}$, $Y_{\text{ill,object(mloc-mdir)}}$, $Z_{\text{ill,object(mloc-mdir)}}$, where — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full-screen test pattern 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

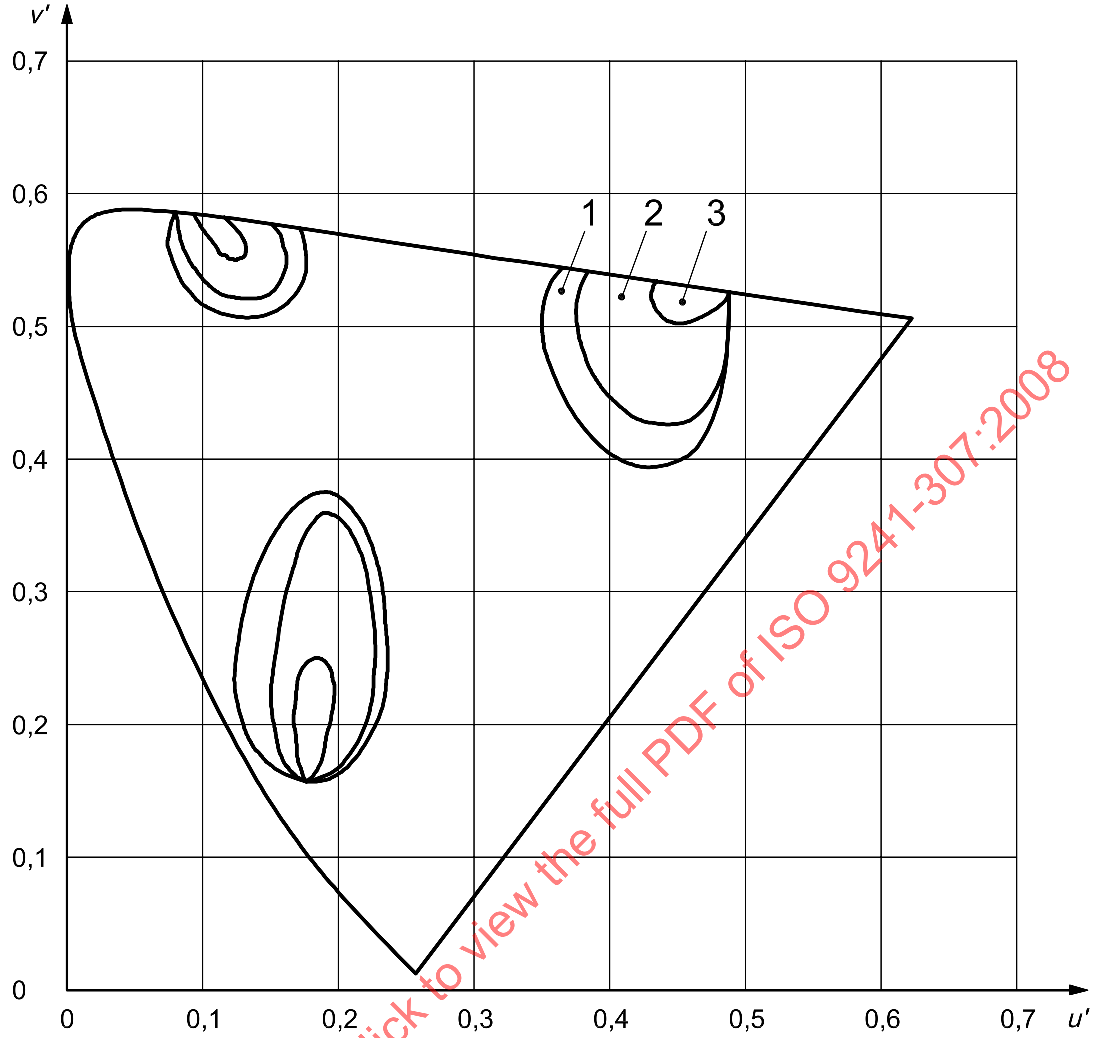
Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Monochrome and multicolour object size	Depending on the type of information shown, the visual display shall fulfil the following requirements. **a) Artificial information** 1) Critical 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 *luminance contrast*. 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 ± 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.



Key

1 acceptable, 50 %

2 acceptable, 75 %

3 optimal

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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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, $X_{ill,object(mloc-mdir)}$, $Y_{ill,object(mloc-mdir)}$, $Z_{ill,object(mloc-mdir)}$, where: — illumination condition: darkroom; — object: monochrome visual displays — not applicable; multicolour visual displays — full screen 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 ± 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, $L_{ill,object(mloc\text{-}mdir)}$, 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, $u',v'_{ill,object(mloc\text{-}mdir)}$, 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, $L_{ill,object(mloc\text{-}mdir)}$, 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, $u',v'_{\text{ill,object(mloc-mdir)}}$, 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: 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.

Table 37 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image formation time	Depending on the image type, the image formation time (IFT) shall fulfil the following requirements. **a) Still images** Not applicable. **b) Quasi-static images** — IFT > 200 ms Noticeable loss of contrast observed during key entry, scrolling, animation, and blink coding. Pointing devices with rapid cursor positioning can be used only with special techniques. — 55 ms < IFT $\leqslant$ 200 ms Applications using scrolling, animation and pointing devices lose detectable contrast. Blink coding from 0,33 Hz to 5 Hz is operable. — 10 ms < IFT $\leqslant$ 55 ms Contrast is stable for most applications. Motion artefacts can be distracting. **c) Moving images** — IFT $\leqslant$ 10 ms However, for displays that keep displaying each part of the image over a large part of the frame period, the duration of the frame period is also a limiting factor. If the IFT or frame period duration is too long while the display produces the image during a large part of the frame period, then blurred or jerky images result, and contrast may be reduced.	ISO 9241-305 P 15.2 P 15.2A	Not applicable.
Spatial resolution	a) Resolution of the visual display should enable a satisfying reproduction of the original image. The minimum resolution of the display should be (horizontal × vertical): — VGA: $\geqslant$ 640 × 480 — PAL: 768 × 576 — NTSC: 720 × 480 b) The visual display should have a spatial resolution of less than 1′ of arc at the design viewing distance.	Intended context of use/supplier specification ISO 9241-305 P 20.10	Report the resolution of the visual display. Use the dot pitch as a basis for evaluation of the spatial resolution, α, expressed in minutes of arc. Calculate and report the resulting value: $\alpha = 60 \times 2 \times \arctan (b/2/D_{design,view})$ where b is the dot pitch, in millimetres; $D_{design,view}$ is the design viewing distance, in millimetres.

Table 37 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Raster modulation	For visual displays having a pixel density of less than 30 pixels per degree at the design viewing distance, the luminance modulation in the direction perpendicular to adjacent raster lines shall not exceed $C_m = 0{,}4$ for monochrome displays or $C_m = 0{,}7$ for multicolour displays when all pixels are in their high state.	ISO 9241-305 P 21.9	Measure the luminance modulation and report the resulting value for passed or failed.
Fill factor	a) For a visual display having a pixel density of less than 30 pixels per degree at the design viewing distance, the fill factor shall exceed 0,3. b) The supplier shall submit the sub-pixel drawing or specify the fill factor.	Supplier specification ISO 9241-305 M 21.10	Not applicable.
Pixel density	The supplier shall specify the pixel density.	Supplier specification	Report the resulting value.

5.2 Emissive flat-panel LCD for indoor use — Display laboratory method

5.2.1 Intended context of use

The attributes of user, environment, tasks and use of emissive flat-panel LCD (liquid crystal displays) are summarized in Table 38. 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 Flat-panel LCD are considered in this compliance route for typical visual display tasks for indoor use.

Table 38 — Intended context of use — Emissive flat-panel LCD

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 lx, + 250 lx × cos(α) 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 80°, 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 [13], [19]: — $L_{REF,EXT}$ = 500 cd/m^2, $L_{REF,SML}$ = not applicable — $L_{REF,EXT}$ = 300 cd/m^2, $L_{REF,SML}$ = not applicable — $L_{REF,EXT}$ = 200 cd/m^2, $L_{REF,SML}$ = 2 000 cd/m^2 (suitable for general office use) — $L_{REF,EXT}$ = 125 cd/m^2, $L_{REF,SML}$ = 200 cd/m^2 (requires a specially controlled luminous environment) where $L_{REF,EXT}$ is the luminance of the large aperture source (15°); $L_{REF,SML}$ 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.
	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.

Table 38 (*continued*)

Element	Attribute	Quantification
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 — e.g. 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.
Task	Design viewing distance, $D_{design,view}$	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 on optimum position for the most important visual display that is within ±15° in the vertical and horizontal directions from the line-of-sight [11]. — If $W_{view} > H_{view}$: $D_{design,view} = W_{view}/2 \times \tan(15°) = W_{view}/0{,}536$ — If $H_{view} > W_{view}$: $D_{design,view} = H_{view}/2 \times \tan(15°) = H_{view}/0{,}536$ 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, $D_{design,view}$, is as follows. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{view} \leqslant 1{,}53$ m: $D_{design,view} = 1\text{ m} + 4 \times H_{view}$ If $H_{view} > 1{,}53$ m: $D_{design,view} = 4{,}7 \times H_{view}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{design,view} = 3 \times H_{view}$

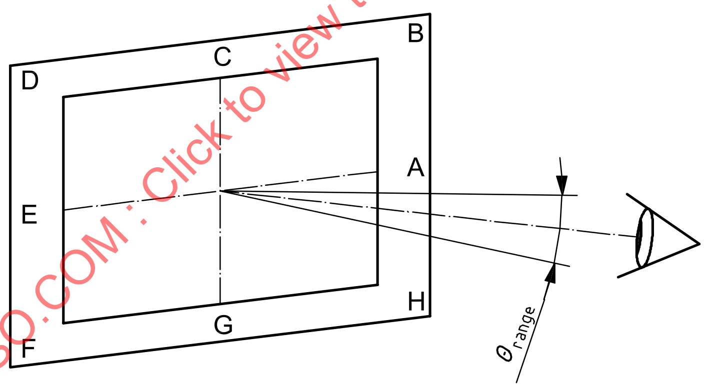
Table 38 (*continued*)

Element	Attribute	Quantification
	Design viewing direction (Θ_D, Φ_D).	Within a specific range of angles from the normal. The supplier shall specify the design viewing direction. If the visual display is designed for reality information predominantly, 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)	The supplier shall specify the design viewing direction range according to one of the cases presented in Table 39, a) to e).
	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.

Table 39 — Design viewing direction range

Design viewing direction range (angle of inclination and azimuth)

a) Restriction of the viewing cone with special treatments on the surface of the visual display for privacy applications, e.g. at a cash dispenser or in crowded environments. See Figure 5.



The supplier shall specify the maximum inclination angle range Θ_{range}. The azimuth angle Φ is 0° to 360°.

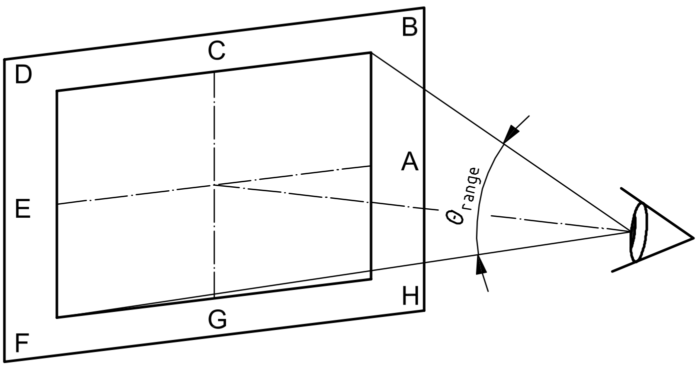
NOTE A typical maximum inclination angle range is about 10° to 20°.

Figure 5 — Restricted viewing cone — Emissive flat-panel LCD

Table 39 (*continued*)

Design viewing direction range (angle of inclination and azimuth)

b) Viewing cone with a single visual display. See Figure 6.



The maximum inclination angle range, Θ_{range}, is:

$$\Theta_{range} = 2 \times \arctan(D_{active}/2 \times D_{design,view})$$

where

D_{active} is the diagonal of the active display area;

$D_{design,view}$ is the design viewing distance.

The design inclination angle is within:

$$0° \leqslant \Theta_D \leqslant 40° - \Theta_{range}/2.$$

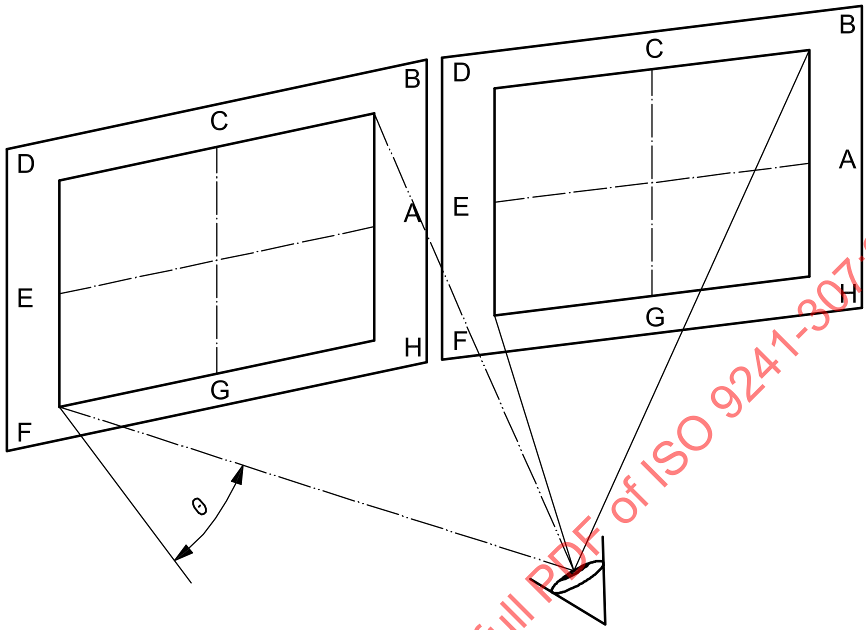
The azimuth angle Φ is 0° to 360°.

NOTE This definition corresponds to viewing direction range class, $Class_{viewing}$ III, see Reference [19].

Figure 6 — Viewing cone with single visual display — Emissive flat-panel LCD

Table 39 (*continued*)

Design viewing direction range (angle of inclination and azimuth)
c) Viewing cone with one or two visual displays and moving head position. See Figure 7.



The maximum inclination angle, Θ, is:

$$\Theta = 2 \times \arctan(D_{active}/D_{design,view})$$

where

D_{active} is the diagonal of the active display area;

$D_{design,view}$ is the design viewing distance.

The maximum inclination angle range, $\Theta_{range,max}$ is:

$$\Theta_{range,max} = 2 \times \Theta = 80°$$

The azimuth angle, Φ, is 0° to 360°.

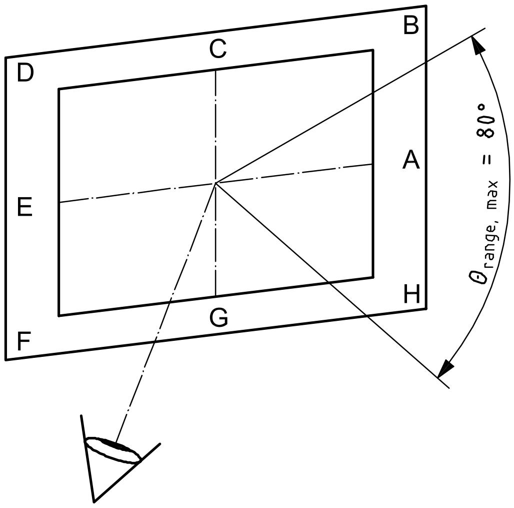
NOTE This definition corresponds to viewing direction range class, $Class_{viewing}$ II, see Reference [19].

Figure 7 — Viewing cone with one or two visual displays and moving head position — Emissive flat-panel LCD

Table 39 (*continued*)

Design viewing direction range (angle of inclination and azimuth)

d) Viewing cone with multiple visual displays and moving head position. See Figure 8.



Depending on the application, the inclination angle, Θ, may exceed 40° outside a viewing cone with a maximum inclination angle range, $\Theta_{range,max}$, of 80°. The supplier shall specify the maximum inclination angle range, Θ_{range}. The azimuth angle, Φ, is 0° to 360°.

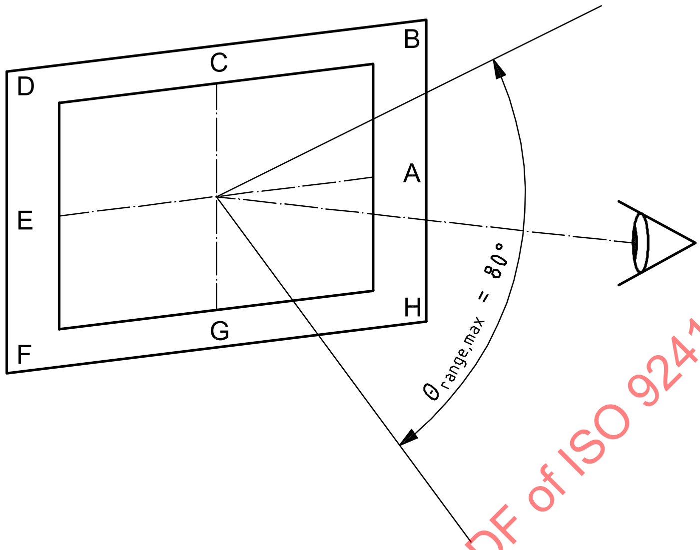
NOTE 1 This definition corresponds to the viewing direction range class, $Class_{viewing}$ I, see Reference [19].

NOTE 2 For single-viewer legibility, a value of Θ_{range} greater than 80° will not add value. For all displays and printed material, as the inclination angle increases, the characters appear geometrically shorter. At 40°, a character appears about 25 % shorter. For example, a 16′ character, viewed at an inclination angle of 40°, is shortened to only 12′. It is unnecessary to require isotropy for larger inclination angles since even printed matter suffers from more severe off-angle viewing. Independence of parameters with viewing direction outside this 80° viewing cone may be useful when multiple viewers use a single display and character distortion is not a problem.

Figure 8 — Viewing cone with multiple visual displays and moving head position — Emissive flat-panel LCD

Table 39 (*continued*)

Design viewing direction range (angle of inclination and azimuth)
e) Viewing cone with visual displays, predominantly reality information. See Figure 9.



For this compliance route, a maximum inclination angle range of $\Theta_{range,max}$ = 80° is considered, if not otherwise specified by the supplier. Therefore, the maximum angle of inclination, Θ, is 40°. The azimuth angle, Φ, is 0° to 360°.

Figure 9 — Viewing cone with visual displays — Emissive flat-panel LCD — Reality information predominant

5.2.2 Information about the technology

The basic physical attributes of emissive flat-panel LCD technology are given in Table 40. The supplier shall submit a detailed technical specification — rated voltage, rated frequency, rated current, rated power consumption, LCD, LCD panel specification, horizontal/vertical pixel size, original resolution, sub-pixel drawing, anti-reflection treatment, pixel fault declaration, LCD mode, LCD effect, 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, etc.

Table 40 — Basic physical attributes of emissive flat-panel LCD

Basic physical attributes	Description
Optical mode of operation	Emissive
Mode of observation	Direct view
Diagonal of the active display area	Depending on application
Resolution (addressable pixels)	Depending on application
Format	Landscape and/or portrait

5.2.3 Compliance assessment

The compliance assessment for emissive flat-panel LCD shall be made in accordance with Tables 41 to 91.

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.

Table 41 — 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 requirement: **a) Artificial information** The typical design viewing distance is calculated on optimum position for the most important visual display that is within ± 15° in the vertical and horizontal directions from the line-of-sight. — If $W_{view} > H_{view}$: $D_{design,view} = W_{view}/2 \times \tan(15°) = W_{view}/0{,}536$ — If $H_{view} > W_{view}$: $D_{design,view} = H_{view}/2 \times \tan(15°) = H_{view}/0{,}536$ 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, $D_{design,view}$, is as follows. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{view} \leqslant 1{,}53$ m: $D_{design,view} = 1\text{ m} + 4 \times H_{view}$ If $H_{view} > 1{,}53$ m: $D_{design,view} = 4{,}7 \times H_{view}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{design,view} = 3 \times H_{view}$ 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, (Θ_D, Φ_D), as well as the design viewing direction range shall be specified.	Intended context of use, ISO 9241-305 P 14.1 P 14.2	See Table 42.

Table 42 — Assessment and reporting for design viewing direction

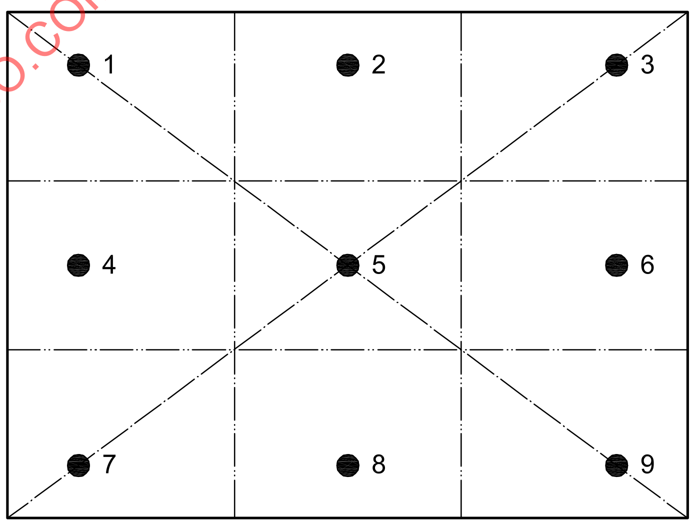
According to Table 41	Assessment and reporting
	Step 1 Examine isotropy of the visual display and report the result. Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, where — illumination condition: darkroom; — object: full-screen test pattern with maximum grey level for monochrome visual displays or combination R=G=B = 100 % for multicolour visual displays; — measurement location: centre of screen; — measurement direction: perpendicular and at $\Theta = 40°$ for all azimuth angles, Φ, 0° to 360° (if required). Report the resulting values. Determine and report the minimum ratio of the luminance, L_Θ, at $\Theta = 40°$ for all azimuth angles, Φ, 0° to 360° (if required) to the luminance, $L_\perp$, perpendicular to the screen: — if $L_\Theta / L_\perp \leqslant 0{,}8$, the visual display has optically anisotropic behaviour; — if $L_\Theta / L_\perp > 0{,}8$, the visual display has optically isotropic behaviour. Report the result for isotropy. **For isotropic visual displays, follow step 2 (only lateral optical measurements are performed). For anisotropic visual displays, follow step 3 (lateral and directional optical measurements are performed).** Step 2 (For isotropic visual displays) a) Determine the design viewing direction (Θ_D, Φ_D). Use a design viewing direction (Θ_D, Φ_D) of (0°, –), which is the perpendicular viewing direction. Report the resulting value. b) Determine the design viewing direction range: Use the design viewing direction range as specified by the supplier. Or use the value obtained from the intended context of use. Report the resulting value. c) Determine the measurement locations: carry out optical measurements at measurement locations 1 to 9 as shown in Figure 10. Throughout the measurements, align the measuring instrument perpendicular to the screen, unless otherwise stated.  **Figure 10 — Measurement locations on isotropic emissive flat-panel LCD**

Table 42 (*continued*)

According to Table 41	**Assessment and reporting**
	Step 3 (For anisotropic visual displays) a) Determine the design viewing direction, (Θ_D, Φ_D): Use the design viewing direction obtained from the intended context of use or specified by the supplier. Alternatively, evaluate the luminance profile in a scan for vertical and, if necessary, for horizontal direction in gradations of 1° by measurement of display luminance $L_{ill,object(mloc-mdir)}$ where: — illumination condition: darkroom; — object: full-screen test pattern with maximum grey level for monochrome visual displays or combination R=G=B = 100 % for multicolour visual displays; — measurement location: centre of screen; — measurement direction: vertical direction (Θ = 0° to 20° in steps of 1° for the azimuth angles Φ = 90° and 180°) and horizontal direction (Θ = 0° to 20° in steps of 1° for the azimuth angles Φ = 0° and 270°). Report the resulting values. Determine the direction, (Θ, Φ), of the maximum luminance, which is the design viewing direction (Θ_D, Φ_D). Report the resulting value. b) Determine the design viewing direction range: Use the design viewing direction range as specified by the supplier. Or use the value obtained from intended context of use. Report the resulting value. **If the visual display is predominantly designed for artificial information, follow step 4 a), below. If the visual display is designed for reality information predominantly, follow step 4 b), below.** Step 4 a) Determine the measurement locations (predominantly artificial information). Normal photometric practice is to use a target that is at least 60 % larger than the luminance meter image to guarantee that edge effects are eliminated. When possible, 85 % or more is preferred. With noted exceptions, all measurements shall be made with 1° targets imaged in the luminance meter focused in the centre of the target (see ISO 9241-305). Depending on the diagonal of the active display area, choose three final measurement locations from an odd number of initial locations. The number of initial locations is from 5 up to a maximum of 11. The initial locations should not overlap. Display the initial locations with maximum grey level for monochrome visual displays or combination R=G=B = 100 % for multicolour visual displays. The locations are screened for their darkroom area luminance under the perpendicular measurement direction. Select the site that has the lowest measured luminance (called LL for “low location”) and the site that has the highest measured luminance (called HL for “high location”). The centre site (called CL for “centre location”) is always selected. If there are locations on the screen outside the assessed initial locations that in typical ambient-lighting user conditions are visibly worse than the LL or HL, then the measurements shall be performed in those locations in addition to the LL and HL. The judgement of “visibly worse” shall be made in darkroom conditions and by a trained person. NOTE 1 The “visibly worse” definition is not unambiguous. The aim is to find the locations that are visible by an average user in ambient lighting. When the judgement is made in darkroom conditions and by a trained person, the detection threshold is significantly lower than for the average user. Therefore the risk that an average user would detect a worst location that the test laboratory did not detect can be neglected. NOTE 2 Most flat panels that currently meet the conditions of this part of ISO 9241 do not have such “visibly worse” locations. NOTE 3 With an automatic test device, the visibly worst location can be found, for example, by scanning the whole screen in steps of 1° (subtended angle). Carry out optical measurements at the measurement locations HL, LL and CL. An example is shown in Figure 11.

Table 42 (*continued*)

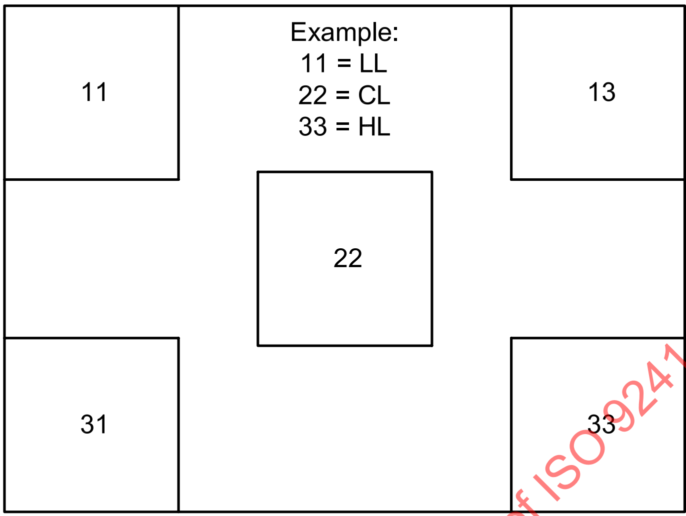
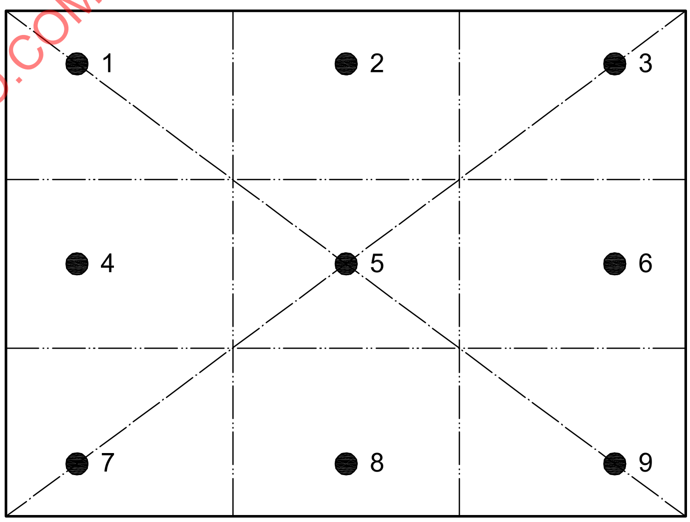
According to Table 41	Assessment and reporting
	 **Figure 11 — Initial locations on anisotropic emissive flat-panel LCD with example of measurement locations — Artificial information predominant** b) Determine the measurement locations (predominantly reality information). Carry out optical measurements at the measurement locations 1 to 9 as shown in Figure 12. NOTE 4 To reduce the number of measurements, it is possible to choose three final measurement locations from the nine measurement locations by following the procedure given in step 4 a). **If the visual display is designed predominantly for artificial information, follow step 4 c), below. If the visual display is designed predominantly for reality information, follow step 4 d), below.**  **Figure 12 — Measurement locations on anisotropic emissive flat-panel LCD — Reality information predominant**

Table 42 (*continued*)

According to Table 41	Assessment and reporting
	c) Determine the measurement directions (predominantly artificial information). Eight measurement directions are defined as follows: — measurement direction 0: $\Theta = 0°$, Φ = not applicable (perpendicular); — measurement direction 1: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D + 2 \times \Phi_C$; — measurement direction 2: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D + \Phi_C$; — measurement direction 3: $\Theta = 0{,}5 \times \Theta_{range} - \Theta_D$, $\Phi = \Phi_D - 180°$; — measurement direction 4: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D$; — measurement direction 5: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D - \Phi_C$; — measurement direction 6: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D - 2 \times \Phi_C$; — measurement direction 7: $\Theta = \Theta_D$, $\Phi = \Phi_D$ (design viewing direction); where $\Phi_C = 90° - 0{,}5 \times \arctan(W_{view}/H_{view})$, when $W_{view}/H_{view} > 0{,}727$; $\Phi_C = 72°$, when $W_{view}/H_{view} \leqslant 0{,}727$; where H_{view} is the height of the active display area; W_{view} is the width of the active display area. d) Determine the measurement directions (predominantly reality information). Nine measurements directions are defined as follows: — measurement direction A: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 0°$; — measurement direction B: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = \arctan(H_{view}/W_{view})$; — measurement direction C: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 90°$; — measurement direction D: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 90° + \arctan(W_{view}/H_{view})$; — measurement direction E: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 180°$; — measurement direction F: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 180° + \arctan(H_{view}/W_{view})$; — measurement direction G: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 270°$; — measurement direction H: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = 270° + \arctan(W_{view}/H_{view})$; — measurement direction I: $\Theta = \Theta_D = 0°$, $\Phi = \Phi_D$ = not applicable (perpendicular, design viewing direction); where H_{view} is the height of the active display area; W_{view} is the width of the active display area.

Table 43 — 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.

Table 44 — Luminance

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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.
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 20 cd/m^2 over all relevant viewing directions (see design viewing direction) [19]. 2) Under darkroom conditions, the visual display should have a minimum display luminance of 150 cd/m^2 over all relevant viewing directions (see design viewing direction and ISO 9241-303). **b) Reality information** 1) Under darkroom conditions, the visual display shall have a minimum display luminance of 80 cd/m^2 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/m^2 over all relevant viewing directions (see design viewing direction) [30]. NOTE The display luminance under ambient illumination is explicitly considered in the attribute *luminance contrast*.	ISO 9241-305 P 12.5 M 12.1	For artificial information and isotropic visual displays, see Table 45. For artificial information and anisotropic visual displays, see Table 46. For reality information and isotropic visual displays, see Table 47. For reality information and anisotropic visual displays, see Table 48.

Table 45 — Assessment and reporting for display luminance — Artificial information and isotropic visual displays

According to Table 44	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: 1 to 9 (see Figure 12); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 46 — Assessment and reporting for display luminance — Artificial information and anisotropic visual displays

According to Table 44	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: CL, HL and LL (see Figure 11); — measurement direction: 0 to 7. Report the resulting values for passed or failed.

Table 47 — Assessment and reporting for display luminance — Reality information and isotropic visual displays

According to Table 44	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 location: 1 to 9 (see Figure 12); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 48 — Assessment and reporting for display luminance — Reality information and anisotropic visual displays

According to Table 44	Assessment and reporting
b)	Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, 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: 1, 3, 5, 7 and 9 (see Figure 12); — measurement direction: A to I. Report the resulting values for passed or failed.

Table 49 — 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 $0{,}1 \times L_{\text{task,area}} \leqslant L_{\text{Ea,HS}} \leqslant 10 \times L_{\text{task,area}}$ 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 do 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 instance 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 49 (*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 states 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 states 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 5.1.2.5 P 14.1	See Table 50.

Table 50 — Assessment and reporting for luminance and contrast adjustment

According to Table 49	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 suppliers information. 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, $L_{\text{ill,object(mloc-mdir)}}$, 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 11 or 12) — measurement direction: 0 (perpendicular). Step 3 Report the resulting values for passed or failed.

Table 50 (*continued*)

According to Table 49	Assessment and reporting
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, $L_{\text{ill,object(mloc-mdir)}}$, 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 11 or 12); — measurement direction: 0 (perpendicular). Step 3 Report the resulting values for passed or failed.
a) 4, b) 4 a) 5, b) 5	Step 1 Display a full screen grey scale (equidistantly spaced in 5 % steps). Step 2 Adjust the control responsible for the display luminance of the high state to the middle position. Adjust the control responsible for the display luminance of the low state between minimum and maximum. Perform a visual inspection of the whole grey scale as well as the 0 %, 5 % and 10 % areas of the grey scale. Step 3 Adjust the control responsible for the display luminance of the low state to the middle position. Adjust the control responsible for the display luminance of the high state between minimum and maximum. Perform a visual inspection of the whole grey scale as well as the 90 %, 95 % and 100 % areas of the grey scale. Step 4 Observe the visual display for independency between adjustments of the display luminance of the low and high state. Step 5 Observe the visual display for discrimination between the grey levels. Step 6 Report the resulting values for passed or failed.

Table 51 — Special physical environments

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Vibration	Built in vibration frequency shall be less than 6 Hz for less than 30 s.	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.
Excessive 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 excessive temperatures and report the resulting value.

Table 52 — 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°: 1,1:1 ⩾ 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	For artificial information and isotropic visual displays, see Table 53. For artificial information and anisotropic visual displays, see Table 54. For reality information and isotropic visual displays, see Table 55. For reality information and anisotropic visual displays, see Table 56.

Table 53 — Assessment and reporting for luminance non-uniformity — Artificial information — Isotropic visual displays

According to Table 52	Assessment and reporting
a) 1), 2)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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: 1 to 9 (see Figure 12); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion. Determine the angular distance of the measurement locations, using the centre location as the reference, and calculate the corresponding ratios. Report the resulting value for passed or failed.
a) 3)	Not applicable.

Table 54 — Assessment and reporting for luminance non-uniformity — Artificial information — Anisotropic visual displays

According to Table 52	Assessment and reporting
a) 1), 2)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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: CL, HL and LL (see Figure 11); — measurement direction: 7 (design viewing direction). 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)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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 location: CL (see Figure 11); — measurement direction: in steps of 1° within maximum inclination angle range, Θ_{range}, in horizontal and vertical direction. Report the resulting values. Step 2 Evaluate the directional uniformity criterion. If the requirement is not fulfilled within Θ_{range}, specify the maximum inclination angle at which the maximum luminance ratio is reached.

Table 55 — Assessment and reporting for luminance non-uniformity — Reality information — Isotropic visual displays

According to Table 52	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 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: 1 to 9 (see Figure 12); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion. Determine the angular distance of the measurement locations, using the centre location as the reference, and calculate the corresponding ratios. Report the resulting value for passed or failed.
b) 2)	Not applicable.

Table 56 — Assessment and reporting for luminance non-uniformity — Reality information — Anisotropic visual displays

According to Table 52	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 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: 1 to 9 (see Figure 12); — measurement direction: I (design viewing direction). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion. Determine the angular distance of the measurement locations, using the centre location as the reference, and calculate the corresponding ratios. Report the resulting value for passed or failed.
b) 2)	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 location: 5 (see Figure 12); — measurement direction: in steps of 1° within maximum inclination angle range, Θ_{range}, in horizontal and vertical direction. Report the resulting values. Step 2 Evaluate the directional uniformity criterion. If the requirement is not fulfilled within Θ_{range}, specify the maximum inclination angle for which the maximum luminance ratio is reached.

Table 57 — 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 the following limits: $\Delta u',v'$ = 0,02 for $D_{active}/D_{design,view} < 0,75$ $\Delta u',v'$ = 0,03 for $D_{active}/D_{design,view} \geqslant 0,75$ where D_{active} is the diagonal of the active display area and $D_{design,view}$ is the design viewing distance. 2) Directional uniformity criterion The visual display shall have a 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.	ISO 9241-305 P 19.2 P 19.3	For artificial information and isotropic visual displays, see Table 58. For artificial information and anisotropic visual displays, see Table 59. For reality information and isotropic visual displays, see Table 60. For reality information and anisotropic visual displays, see Table 61.
	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 a 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.		

Table 58 — Assessment and reporting for colour non-uniformity — Artificial information — Isotropic visual displays

According to Table 57	Assessment and reporting
a) 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: 1 to 9 (see Figure 12); — 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)	Not applicable.

Table 59 — Assessment and reporting for colour non-uniformity — Artificial information — Anisotropic visual displays

According to Table 57	Assessment and reporting
a) 1)	Step 1 Measure the chromaticity coordinates $u',v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R, G, B = 100 %, combination R=G=B = 75 % and combinations R, G, B = 50 % for multicolour visual displays; — measurement locations: CL, HL and LL (see Figure 11); — measurement direction: 7 (design viewing direction). 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)	Step 1 Measure the chromaticity coordinates, $u',v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R, G, B = 100 %, combination R=G=B = 75 % and combinations R, G, B = 50 % for multicolour visual displays; — measurement locations: CL, HL and LL (see Figure 11); — measurement direction: 1 to 7. Report the resulting values. Step 2 Evaluate the directional uniformity criterion and calculate the maximum chromaticity uniformity difference. Step 3 If the requirement is not fulfilled within maximum inclination angle range, Θ_{range}, specify the maximum inclination angle for which the maximum chromaticity uniformity difference is reached. Step 4 (For multicolour visual displays only) Depending on the technology, the visual display may not fulfil the requirement for all displayed colours. The following differentiation is made. **High class chromaticity uniformity** The requirement is fulfilled for combinations R, G, B = 100 %, combination R=G=B = 75 % and combinations R, G, B = 50 %. **Medium class chromaticity uniformity** The requirement is fulfilled for combinations R, G, B = 100 % and combination R=G=B = 75 %. **Low class chromaticity uniformity** The requirement is fulfilled for primaries R = 100 %, G = 100 % and B = 100 % only. Report the resulting value as well as the class of the chromaticity uniformity.

Table 60 — Assessment and reporting for colour non-uniformity — Reality information — Isotropic visual displays

According to Table 57	Assessment and reporting
b) 1)	Step 1 Measure the chromaticity coordinates, $u',v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R, G, B = 100 %, combination R=G=B = 75 % and combinations R, G, B = 50 % for multicolour visual displays; — measurement locations: 1 to 9 (see Figure 12); — 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.
b) 2)	Not applicable.

Table 61 — Assessment and reporting for colour non-uniformity — Reality information — Anisotropic visual displays

According to Table 57	Assessment and reporting
b) 1)	Step 1 Measure the chromaticity coordinates, $u',v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R, G, B = 100 %, combination R=G=B = 75 % and combinations R, G, B = 50 % for multicolour visual displays; — measurement locations: 1 to 9 (see Figure 12); — measurement direction: I (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.

Table 61 (*continued*)

According to Table 57	Assessment and reporting
b) 2)	Step 1 Measure the chromaticity coordinates, $u',v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R,G,B = 100 %, combination R=G=B = 75 % and combinations R,G,B = 50 % for multicolour visual displays; — measurement locations: 1, 3, 5, 7 and 9 (see Figure 12); — measurement direction: A to I. Report the resulting values. Step 2 Evaluate the directional uniformity criterion and calculate the maximum chromaticity uniformity difference. Step 3 If the requirement is not fulfilled within the maximum inclination angle range, Θ_{range}, specify the maximum inclination angle for which the maximum chromaticity uniformity difference is reached. Step 4 (For multicolour visual displays only) Depending on the technology, the visual display may not fulfil the requirement for all displayed colours. The following differentiation is made. **High-class chromaticity uniformity** The requirement is fulfilled for combinations R,G,B = 100 %, combination R=G=B = 75 % and combinations R,G,B = 50 %. **Medium-class chromaticity uniformity** The requirement is fulfilled for combinations R,G,B = 100 % and combination R=G=B = 75 %. **Low-class chromaticity uniformity** The requirement is fulfilled for primaries R=100 %, G=100 % and B=100 % only. Report the resulting value as well as the class of the chromaticity uniformity.

Table 62 — 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, $CR_{\text{non-uniformity}} = 1 - CR_{\text{min}}/CR_{\text{max}}$, 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 CR_{min}. 2) There shall be no contrast inversion.	ISO 9241-305 P 18.5	Evaluate the contrast non-uniformity and report the resulting value for passed or failed.

Table 62 (*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	Not applicable.
Screen and faceplate defects	The visual display should be in the fault class, $\text{Class}_{\text{Pixel}}$ 0. If not in $\text{Class}_{\text{Pixel}}$ 0, the supplier shall specify the $\text{Class}_{\text{Pixel}}$ of the visual display in accordance with Table 63.	ISO 9241-305 M 21.6	Report supplier's declaration. Evaluate pixel and subpixel faults by direct observation. Determine and report the fault class. NOTE Rounding policy: round down: x,00 to x,49 → x; round up: x,50 to x,99 → x + 1.

Table 63 — Pixel fault classification

Class pixel	Type 1	Type 2	Type 3 (See Notes 1 to 7)		Cluster with more than one type 1 or type 2 fault	Cluster of type 3 faults
			Stuck high	Stuck low		
0	0	0	0	0	0	0
I (for type 3 = 5 PSU)	1	1	2	1	0	0
	1	1	1	3	0	0
	1	1	0	5	0	0
II (for type 3 = 10 PSU)	2	2	5	0	0	1
	2	2	$5 - 1 \times n_{\text{II}}$	$2 \times n_{\text{II}}$	0	1
	2	2	0	10	0	1
III (for type 3 = 100 PSU)	5	15	50	0	0	5
	5	15	$50 - 1 \times n_{\text{III}}$	$2 \times n_{\text{III}}$	0	5
	5	15	0	100	0	5
IV (for type 3 = 1 000 PSU)	50	150	500	0	5	50
	50	150	$500 - 1 \times n_{\text{IV}}$	$2 \times n_{\text{IV}}$	5	50
	50	150	0	1 000	5	50

NOTE 1 Faults that are below the visibility threshold at the design viewing distance and design luminance level are not considered.

NOTE 2 For ergonomics performance, the number, size and contrast of defects and pixel faults shall not exceed the threshold for performance decrease.

NOTE 3 These fault classes consider the following.

a) Bright subpixel faults are perceived as more sensitive than dark subpixel faults. Therefore, pixel faults are weighted in pixel shader sensitivity units (PSU), where type 3 stuck high fault ≡ 2 PSU and type 3 stuck low fault ≡ 1 PSU. Therefore, different combinations of type 3 faults in $\text{Class}_{\text{Pixel}}$ I, II, III and IV are possible.

b) For smaller displays < 9,1 in (23,1 cm) predominant, the pixel density is higher and less sensitive than for bigger displays > 9,1 in (23,1 cm) with less pixel density.

c) A class definition that addresses primarily the acceptance levels of the users and their related tasks and where, for example, the classes can reflect the following contexts:

1) $\text{Class}_{\text{Pixel}}$ 0, for special video display unit tasks with a very high sensitivity and importance in minimizing risks in the information perception, such as inspection of critical information in processes or critical process indicators with a high risk of wrong decisions and processing-inherent errors;

2) $\text{Class}_{\text{Pixel}}$ I, for specific video display tasks with high sensitivity and special importance to pixel faults, such as observation, surveillance, image quality inspection tasks with less risk of inherent faults in the case of reading and observation errors;

3) $\text{Class}_{\text{Pixel}}$ II, for general user display tasks with a sensitivity to pixel faults, such as reading and processing text information, perceiving object and symbol information with sufficient reading performance to operate the task;

4) $\text{Class}_{\text{Pixel}}$ III and $\text{Class}_{\text{Pixel}}$ IV, for display tasks with less sensitivity to pixel faults, such as processing public information and advertisements, text book reading, and reading of fast-moving images, with sufficient performance to perceive the information without discomfort to the user.

NOTE 4 Related ergonomics performance criteria with threshold values of defects for visibility and different tasks are under investigation.

NOTE 5 Type 3 faults include dim pixels of 25 % < L_x < 50 % (dark), 50 % ⩽ L_x < 75 % (bright), where L_x is the average pixel response to a maximum luminance command (e.g. white). Intermittent pixels or blinking pixels are rated with 2 PSU. The weighting of the PSU is indicated in front of the multiplier $n_{\text{ClassPixel}}$ of type 3 faults.

NOTE 6 The multiplier, $n_{\text{ClassPixel}}$, can vary with the PSU and can take n_{II} = 1 to 4, n_{III} = 1 to 49, n_{IV} = 1 to 499. If not fault class $\text{Class}_{\text{Pixel}}$ 0 or I, the supplier shall specify the fault class, $\text{Class}_{\text{Pixel}}$, as well as $n_{\text{ClassPixel}}$, depending on the specified distribution of PSU.

NOTE 7 The calculation of the maximum number of faults depends on the display size and the number of pixels of the display, as follows:

a) for displays > 9,1 in (23,1cm): per type per million pixels;

b) for displays ⩽ 9,1 in (23,1 cm) with > 250 000 pixels: per type per 250 000 pixels;

c) for displays ⩽ 9,1 in (23,1 cm) with ⩽ 250 000 pixels: per type for the whole display.

Table 64 — 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. NOTE 1 Monochrome visual display: full-screen test pattern at maximum grey level. NOTE 2 Multicolour visual display: combination R=G=B = 100 %.
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 millimetre 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.

Table 64 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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.	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.
Unwanted reflections	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 following requirements shall be fulfilled: 1) $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 2{,}2 + 4{,}84 \times (L_L + L_D + L_S)^{-0{,}65}$ 2) For visual displays using positive polarity: $\frac{L_H + L_D + L_S}{L_H + L_D} \leqslant 1{,}25$ 3) For visual displays using negative polarity: $\frac{L_L + L_D + L_S}{L_L + L_D} \leqslant 1{,}2 + \frac{1}{15} \times \frac{L_H + L_D}{L_L + L_D}$ **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: $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 6{,}7 + 44{,}89 \times (L_L + L_D + L_S)^{-0{,}65}$ 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 and isotropic visual displays, see Table 65. For artificial information and anisotropic visual displays, see Table 66. For reality information and isotropic visual displays, see Table 67. For reality information and anisotropic visual displays, see Table 68.

Table 65 — Assessment and reporting for unwanted reflections — Artificial information — Isotropic visual displays

According to Table 64	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 location: 5 (see Figure 12); — measurement direction: Θ = 15°. 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 Table 64, a) 1), 2) and 3), and report the resulting values for passed or failed.

Table 66 — Assessment and reporting for unwanted reflections — Artificial information — Anisotropic visual displays

According to Table 64	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 location: CL (see Figure 11); — measurement direction: 1 to 6. 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 Table 64, a) 1), 2) and 3), and report the resulting values for passed or failed.

Table 67 — Assessment and reporting for unwanted reflections — Reality information— Isotropic visual displays

According to Table 64	Assessment and reporting
b)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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 12); — measurement direction: Θ = 15°. 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 68 — Assessment and reporting for unwanted reflections — Reality information — Anisotropic visual displays

According to Table 64	Assessment and reporting
b)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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 12); — measurement direction: A, C, E and G. 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, $L_{S,SML}$, which is the luminance component 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 69 — 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 70 — 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: $\mathrm{CR}_{\mathrm{min}} = \frac{L_{\mathrm{H}} + L_{\mathrm{D}} + L_{\mathrm{S}}}{L_{\mathrm{L}} + L_{\mathrm{D}} + L_{\mathrm{S}}}$ $\mathrm{CR}_{\mathrm{min}} = 2{,}2 + 4{,}84 \times (L_1)^{-0{,}65}$ with $L_1 = L_{\mathrm{L}} + L_{\mathrm{D}} + L_{\mathrm{S}}$ 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. **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]: $\mathrm{CR}_{\mathrm{min}} = \frac{L_{\mathrm{H}} + L_{\mathrm{D}} + L_{\mathrm{S}}}{L_{\mathrm{L}} + L_{\mathrm{D}} + L_{\mathrm{S}}}$ $\mathrm{CR}_{\mathrm{min}} = 6{,}7 + 44{,}89 \times (L_1)^{-0{,}65}$ with $L_1 = L_{\mathrm{L}} + L_{\mathrm{D}} + L_{\mathrm{S}}$ 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 and isotropic visual displays, see Table 71. For artificial information and anisotropic visual displays, see Table 72. For reality information and isotropic visual displays, see Table 73. For reality information and anisotropic visual displays, see Table 74.

Table 71 — Assessment and reporting for luminance contrast — Artificial information — Isotropic visual displays

According to Table 70	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: 1 to 9 (see Figure 12); — 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 72 — Assessment and reporting for luminance contrast — Artificial information — Anisotropic visual displays

According to Table 70	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: CL, HL and LL (see Figure 11); — measurement direction: 1 to 7. 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 73 — Assessment and reporting for luminance contrast — Reality information — Isotropic visual displays

According to Table 70	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 12); — 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, $R_{\text{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\text{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\text{S,EXT}}$, 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 74 — Assessment and reporting for luminance contrast — Reality information — Anisotropic visual displays

According to Table 70	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, 3, 5, 7 and 9 (see Figure 12); — measurement direction: A to I. 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, $R_{\text{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\text{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\text{S,EXT}}$, 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 75 — 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.
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 by 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 20.5	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 the number of pixels, $N_{\text{H,Height}}$, in the height of an unaccented, uppercase letter H. Evaluate the default mode and report the character height in millimetres, character height in minutes of arc, the font used and the character height number, $N_{\text{H,Height}}$.
Text size constancy	Depending on the type of information shown, the visual display shall fulfil the following requirement. **a) Artificial information** The height and width of a specific character of a specific character font shall not vary by more than ± 3 % of the character height of that character set. **b) Reality information** Not applicable.	ISO 9241-305: P 20.4	Not applicable.
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 20.7	Evaluate the character matrix and calculate the character stroke width. Report the resulting value for passed or failed.

Table 75 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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	Evaluate the character matrix and calculate 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. 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.	ISO 9241-305	Evaluate and report the character matrix. Report the resulting values for passed or failed.

Table 75 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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	Evaluate the character matrix and report 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 requirements. **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	Evaluate the character matrix and report 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 requirements. **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 shall not contain parts of characters or diacritics, but may contain underscores. **b) Reality information** Not applicable.	ISO 9241-305 P 20.14	Evaluate the character matrix and report the between-line spacing. Report the resulting value for passed or failed.

Table 76 — 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	For artificial information and isotropic visual displays, see Table 77. For artificial information and anisotropic visual displays, see Table 78.

Table 77 — Assessment and reporting for luminance coding — Artificial information — Isotropic visual displays

According to Table 76	Assessment and reporting
a)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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: 5 (see Figure 12); — 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 78 — Assessment and reporting for luminance coding — Artificial information — Anisotropic visual displays

According to Table 76	Assessment and reporting
a)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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 11); — measurement direction: 0 to 7. 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 79 — 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 should meet the following recommendations. **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 0,33 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 $\Delta E^*_{uv} \geqslant 20$ under ambient illumination. **b) Reality information** Not applicable.	ISO 9241-305 P 17.4	See Table 80.

Table 80 — Assessment and reporting for colour coding — Artificial information

According to Table 79	Assessment and reporting
a)	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 with combinations R,G,B = 100 %, combination R=G=B = 75 % and combinations R,G,B = 50 %; — measurement locations: 5 for isotropic visual displays (see Figure 12) and CL for anisotropic visual displays (see Figure 11); — measurement direction: 0 (perpendicular) for isotropic visual displays and 7 (design viewing direction) for anisotropic visual displays. 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 81 — 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 should meet the following recommendation. **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 82 — Legibility of graphics

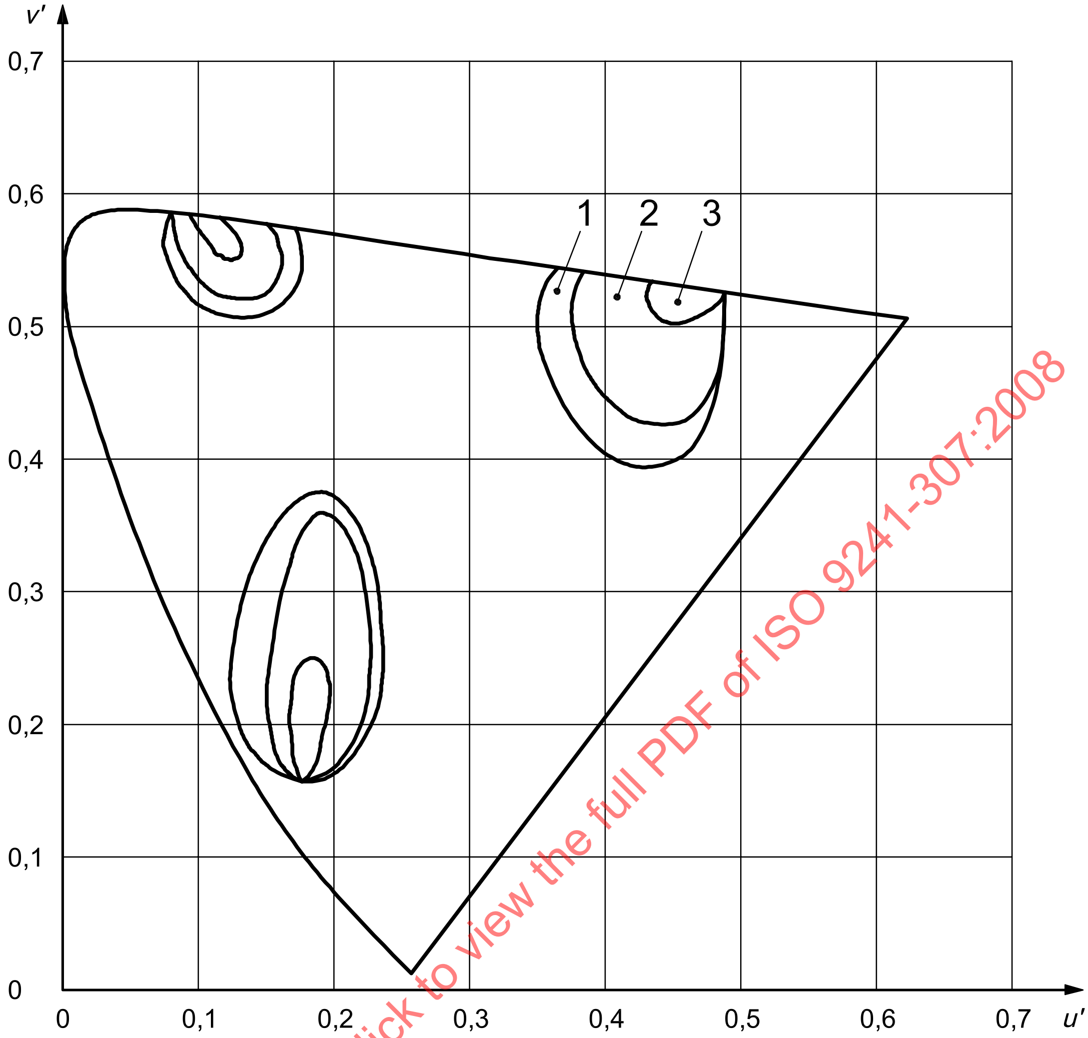
Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Monochrome and multicolour object size	Depending on the type of information shown, the visual display shall fulfil the following requirements. **a) Artificial information** 1) Critical 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 *luminance contrast*. 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	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 82 (*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 should meet the following recommendation. **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 should meet the following recommendations. **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 83 — 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 colour gamut 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 13) [37], [44]. NOTE 1 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 2 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 ± 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 $\Delta u', v' = [(0{,}222\,1 - u')^2 + (0{,}488\,1 - v')^2]^{0{,}5} = 0{,}02$. NOTE 3 If the visual display offers sufficient colour gamut and electro-optical transfer function (gamma value) according to the regional regulations as defined by the ITU, sufficient colour rendering can be assumed (additivity law of colour stimuli).	ISO 9241-305 P 19.5 P 19.7	For artificial information, see Table 84. For reality information, see Table 85.



Key

1 acceptable (50 %)

2 acceptable (75 %)

3 optimal

Figure 13 — Optimal and acceptable chromaticity ranges — Emissive flat-panel LCD

Table 84 — Assessment and reporting for colour gamut and reference white — Artificial information

According to Table 83	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: 5 for isotropic visual displays (see Figure 12) and CL for anisotropic visual displays (see Figure 11); — measurement direction: 0 (perpendicular) for isotropic visual displays and 1 to 7 for anisotropic visual displays. 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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 for isotropic visual displays (see Figure 12) and CL for anisotropic visual displays (see Figure 11); — measurement direction: 0 (perpendicular) for isotropic visual displays and 7 for anisotropic visual displays. Step 2 Report the resulting values, 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 85 — Assessment and reporting for colour gamut and reference white — Reality information

According to Table 83	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 for both isotropic and anisotropic visual displays (see Figure 12); — measurement direction: 0 (perpendicular) for isotropic visual displays and A to I for anisotropic visual displays. 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, 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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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 % and acceptable to 50 % of the population (see also Annex B for the boundaries).
b) 2)	Step 1 Measure the chromaticity coordinates, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 for both isotropic and anisotropic visual displays (see Figure 12); — measurement direction: 0 (perpendicular) for isotropic visual displays and I for anisotropic visual displays. Step 2 Report the resulting values, 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 the chromaticity coordinates, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 to the regional regulations as defined by the ITU; — measurement location: 5 for both isotropic and anisotropic visual displays (see Figure 12); — measurement direction: 0 (perpendicular) for isotropic visual displays and A to I for anisotropic visual displays. 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 85 (*continued*)

According to Table 83	Assessment and reporting
	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 for both isotropic and anisotropic visual displays (see Figure 12); — measurement direction: 0 (perpendicular) for isotropic visual displays and A to I for anisotropic visual displays. Report the resulting values. Step 4 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 5 Based on the luminance of the large aperture source, determine the (reflectometer) tristimulus values, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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 6 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 86 — 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 0,04.	ISO 9241-305 P 14.1 P 14.2 P 17.5 P 19.2 P 19.3	For artificial information and isotropic visual displays, see Table 87. For artificial information and anisotropic visual displays, see Table 88. For reality information and isotropic visual displays, see Table 89. For reality information and anisotropic visual displays, see Table 90. 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 86 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	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 ± 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.		

Table 87 — Assessment and reporting for electro-optical transfer functions and grey scale — Artificial information — Isotropic visual displays

According to Table 86	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 % (equidistant spaced in 2,5 % steps) for monochrome or multicolour visual displays; — measurement location: 5 (see Figure 12); — 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: 5 (see Figure 12); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 88 — Assessment and reporting for electro-optical transfer functions and grey scale — Artificial information — Anisotropic visual displays

According to Table 86	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 11); — measurement direction: 7 (design viewing direction). 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 11); — measurement direction: 7 (design viewing direction). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 89 — Assessment and reporting for electro-optical transfer functions and grey scale — Reality information — Isotropic visual displays

According to Table 86	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 12); — 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].
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 %, 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 12); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 90 — Assessment and reporting for electro-optical transfer functions and grey scale — Reality information — Anisotropic visual displays

According to Table 86	Assessment and reporting
b) 1)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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 12); — measurement direction: I (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].
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 12); — measurement direction: I (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 91 — 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	Display a wheel on the screen. The wheel and the spokes shall be displayed with a 0 % to 100 % grey level on a background of 50 % grey level for monochrome visual displays or combination R=G=B = 0 % to 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 and 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	Not applicable.

Table 91 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image formation time (IFT)	Depending on the image type, the IFT shall fulfil the following requirements. **a) Still images** Not applicable. **b) Quasi-static images** — IFT > 200 ms: Noticeable loss of contrast observed during key entry, scrolling, animation and blink coding. Pointing devices with rapid cursor positioning can be used only with special techniques. — 55 ms < IFT ⩽ 200 ms: Applications using scrolling, animation and pointing devices lose detectable contrast. Blink coding from 0,33 Hz to 5 Hz is operable. — 10 ms < IFT ⩽ 55 ms: Contrast is stable for most applications. Motion artefacts can be distracting. **c) Moving images** — IFT ⩽ 10 ms: However, for displays that keep displaying each part of the image over a large part of the frame period, the duration of the frame period is also a limiting factor. If the IFT or frame period duration is too long while the display produces the image during a large part of the frame period, then blurred or jerky images result, and contrast may be reduced.	ISO 9241-305 P 15.2 P 15.2A	Definition of five grey levels: Combination R=G=B = 0 % Combination R=G=B = 25 % Combination R=G=B = 50 % Combination R=G=B = 75 % Combination R=G=B = 100 %

Table 91 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Spatial resolution	a) Resolution of the visual display should enable a satisfying reproduction of the original image. The minimum resolution of the display should be (horizontal × vertical): — for VGA: ⩾ 640 × 480; — for PAL: 768 × 576; — for NTSC: 720 × 480. b) The visual display should have a spatial resolution of less than 1 minute of arc at the design viewing distance.	Intended context of use/supplier specification ISO 9241-305 P 20.10	Report the resolution of the visual display. Use the pixel size as a basis for evaluation of the spatial resolution. Calculate and report the resulting value: $\alpha = 60 \times 2 \times \arctan(b/2/D_{\text{design,view}})$ where b is the pixel size, in millimetres (mm); α is the spatial resolution, in minutes of arc (′); $D_{\text{design,view}}$ is the design viewing distance, in millimetres (mm).
Raster modulation	For visual displays having a pixel density of less than 30 pixels per degree at the design viewing distance, the luminance modulation in the direction perpendicular to adjacent raster lines shall not exceed C_m = 0,4 for monochrome displays or C_m = 0,7 for multicolour displays, when all pixels are in their high state.	ISO 9241-305 P 21.9	Not applicable.
Fill factor	For a visual display having a pixel density of less than 30 pixels per degree at the design viewing distance, the fill factor shall exceed 0,3. The supplier shall submit the subpixel drawing or specify the fill factor.	Supplier specification ISO 9241-305 M 21.10	Evaluate the subpixel drawing and calculate the fill factor. Alternatively, use the fill factor as specified by the supplier. Report the resulting value for passed or failed.
Pixel density	The supplier shall specify the pixel density.	Supplier specification	Report the resulting value.

5.3 PDP for indoor use — Display laboratory method

5.3.1 Intended context of use

The attributes of the user, environment, tasks and the use of PDP (plasma display panels) are summarized in Table 92. 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 PDP are considered in this compliance route for typical visual display tasks for indoor use.

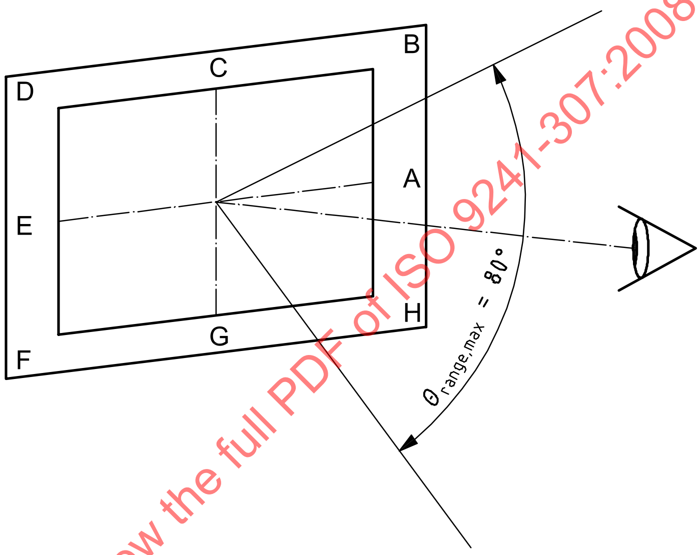
Table 92 — Intended context of use — PDP

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 lx + 250 lx × cos(α) 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 80°, 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]): — $L_{REF,EXT}$ = 500 cd/m^2, $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 300 cd/m^2, $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 200 cd/m^2, $L_{REF,SML}$ = 2 000 cd/m^2 (suitable for general office use); — $L_{REF,EXT}$ = 125 cd/m^2, $L_{REF,SML}$ = 200 cd/m^2 (requires a specially controlled luminous environment); where $L_{REF,EXT}$ is the luminance of the large aperture source (15°); $L_{REF,SML}$ 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 92 (*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, $D_{design,view}$	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 on optimum position for the most important visual display that is within ± 15° in the vertical and horizontal directions from the line-of-sight [11]. — If $W_{view} > H_{view}$: $D_{design,view} = W_{view}/2 \times \tan(15°) = W_{view}/0{,}536$ — If $H_{view} > W_{view}$: $D_{design,view} = H_{view}/2 \times \tan(15°) = H_{view}/0{,}536$ 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, $D_{design,view}$, is as follows. — For aspect ratio 4:3 (from ITU-R BT.500): If $H_{view} \leqslant 1{,}53$ m: $D_{design,view} = 1\ \text{m} + 4 \times H_{view}$ If $H_{view} > 1{,}53$ m: $D_{design,view} = 4{,}7 \times H_{view}$ — For aspect ratio 16:9 (from ITU-R BT.710): $D_{design,view} = 3 \times H_{view}$

Table 92 (*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 14). Therefore, the maximum angle of inclination, Θ, is 40°. The azimuth angle, Φ, is 0° to 360°.  **Figure 14 — Design viewing direction for PDP**
	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.

5.3.2 Information about the technology

The basic physical attributes of PDP technology are given in Table 93. The supplier shall submit a detailed technical specification — rated voltage, rated frequency, rated current, rated power consumption, panel, panel specification, horizontal/vertical pixel size, original resolution, anti-reflection treatment, pixel fault declaration, 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, etc.

Table 93 — Basic physical attributes of PDP

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

5.3.3 Compliance assessment method

The compliance assessment for PDP shall be made in accordance with Tables 94 to 129.

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.

Table 94 — 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 ± 15° in the vertical and horizontal directions from the line-of-sight. — If $W_{\text{view}} > H_{\text{view}}$: $D_{\text{design,view}} = W_{\text{view}}/2 \times \tan(15°) = W_{\text{view}}/0{,}536$ — If $H_{\text{view}} > W_{\text{view}}$: $D_{\text{design,view}} = H_{\text{view}}/2 \times \tan(15°) = H_{\text{view}}/0{,}536$ 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 $H_{\text{view}} \leqslant 1{,}53$ m: $D_{\text{design,view}} = 1\text{ m} + 4 \times H_{\text{view}}$ If $H_{\text{view}} > 1{,}53$ 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, (Θ_D, Φ_D), as well as the design viewing direction range shall be specified.	Supplier specification, intended context of use.	See Table 95.

Table 95 — Assessment and reporting for design viewing direction

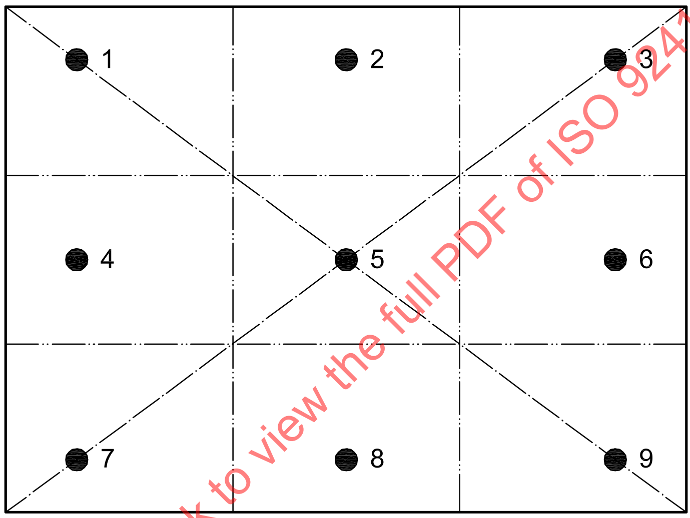
According to Table 94	Assessment and reporting
	Step 1 Examine the isotropy of the visual display and report the result. NOTE 1 For isotropic visual displays, only lateral optical measurements are performed. NOTE 2 For anisotropic visual displays, lateral and directional optical measurements are performed. NOTE 3 PDP 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 intended context of use or supplier-specified values. Report the resulting values. Step 3 Carry out optical measurements at measurement locations 1 to 9 as shown in Figure 15. Throughout the measurements, align the measuring instrument perpendicular to the screen if not otherwise stated.  **Figure 15 — Measurement locations on PDP**

Table 96 — 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.

Table 97 — Luminance

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Illuminance	The supplier shall specify the minimum and maximum design screen illuminance, E_S, as well as the illuminant.	Intended context of use/supplier specification	Use supplier-specified value or value obtained from intended context of use. Report the resulting value.
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/m^2 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/m^2 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/m^2 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/m^2 over all relevant viewing directions (see design viewing direction) [30]. NOTE The display luminance under ambient illumination is explicitly considered in the attribute *luminance contrast*.	ISO 9241-305 P 12.5 M 12.1	For artificial information, see Table 98. For reality information, see Table 99.

Table 98 — Assessment and reporting for display luminance — Artificial information

According to Table 97	Assessment and reporting
a)	Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, 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 locations: 1 to 9 (see Figure 15); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 99 — Assessment and reporting for display luminance — Reality information

According to able 97	Assessment and reporting
b)	Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, 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 locations: 1 to 9 (see Figure 15); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 100 — 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 $0{,}1 \times L_{\text{task,area}} \leqslant L_{\text{Ea,HS}} \leqslant 10 \times L_{\text{task,area}}$ 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 do 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 is thus 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 100 (*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 states 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 states 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 101.

Table 101 — Assessment and reporting for luminance and contrast adjustment

According to Table 100	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. 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, $L_{\text{ill,object(mloc-mdir)}}$, 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: 5 (see Figure 15); — 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, $L_{\text{ill,object(mloc-mdir)}}$, 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: 5 (see Figure 15); — measurement direction: 0 (perpendicular). Step 3 Report the resulting values for passed or failed.
a) 4), b) 4) a) 5), b) 5)	Step 1 Display a full screen grey scale (equidistantly spaced in 5 % steps). Step 2 Adjust the control responsible for the display luminance of the high state to the middle position. Adjust the control responsible for the display luminance of the low state between minimum and maximum. Perform a visual inspection of the whole grey scale as well as the 0 %, 5 % and 10 % areas of the grey scale. Step 3 Adjust the control responsible for the display luminance of the low state to the middle position. Adjust the control responsible for the display luminance of the high state between minimum and maximum. Perform a visual inspection of the whole grey scale as well as the 90 %, 95 % and 100 % areas of the grey scale. Step 4 Observe the visual display for independency between adjustments of the display luminance of the low and high state. Step 5 Observe the visual display for discrimination between the grey levels. Step 6 Report the resulting values for passed or failed.

Table 102 — 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.
Excessive 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 excessive temperatures and report the resulting value.

Table 103 — 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°: 1,1:1 ⩾ 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.	ISO 9241-305 P 14.1 P 14.2	See Table 104.

Table 103 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	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 $\geqslant$ 2° to < 4°: 1,2:1 $\geqslant$ 4° to < 5°: 1,3:1 $\geqslant$ 5° to <7°: 1,35:1 $\geqslant$ 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.		

Table 104 — Assessment and reporting for luminance non-uniformity

According to Table 103	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: 1 to 9 (see Figure 15); — 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 105 — 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 $\Delta u',v' = 0{,}02$ for $D_{active}/D_{design,view} < 0{,}75$ $\Delta u',v' = 0{,}03$ for $D_{active}/D_{design,view} \geqslant 0{,}75$ where D_{active} is the diagonal of the active display area; $D_{design,view}$ 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 106.

Table 106 — Assessment and reporting for colour non-uniformity

According to Table 105	Assessment and reporting
a) 1), b) 1)	Step 1 Measure the chromaticity coordinates, $u',v'_{ill,object(mloc\text{-}mdir)}$, 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: 1 to 9 (see Figure 15); — 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 107 — 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, $CR_{nonuniformity} = 1 - CR_{min}/CR_{max}$, 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.
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 should be in the fault class $Class_{Pixel}$ 0, with a recommended maximum of $Class_{Pixel}$ I. If not in $Class_{Pixel}$ 0, the supplier shall specify the $Class_{Pixel}$ of the visual display in accordance with Table 108.	ISO 9241-305 M 21.6	Report supplier's declaration. Evaluate pixel and subpixel faults by direct observation. Determine and report the fault class. NOTE Rounding policy: round down: x,00 to x,49 → x; round up: x,50 to x,99 → x + 1.

Table 108 — Pixel fault classification

Class pixel	Type 1	Type 2	Type 3 (See Notes 1 to 7)		Cluster with more than one type 1 or type 2 fault	Cluster of type 3 faults
			Stuck high	Stuck low		
0	0	0	0	0	0	0
I (for type 3 = 5 PSU)	1	1	2	1	0	0
	1	1	1	3	0	0
	1	1	0	5	0	0
II (for type 3 = 10 PSU)	2	2	5	0	0	1
	2	2	$5 - 1 \times n_{II}$	$2 \times n_{II}$	0	1
	2	2	0	10	0	1
III (for type 3 = 100 PSU)	5	15	50	0	0	5
	5	15	$50 - 1 \times n_{III}$	$2 \times n_{III}$	0	5
	5	15	0	100	0	5
IV (for type 3 = 1 000 PSU)	50	150	500	0	5	50
	50	150	$500 - 1 \times n_{IV}$	$2 \times n_{IV}$	5	50
	50	150	0	1 000	5	50

NOTE 1 Faults that are below the visibility threshold at the design viewing distance and design luminance level are not considered.

NOTE 2 For ergonomics performance, the number, size and contrast of defects and pixel faults shall not exceed the threshold for performance decrease.

NOTE 3 These fault classes consider the following.

a) Bright subpixel faults are perceived as more sensitive than dark subpixel faults. Therefore, pixel faults are weighted in perceived sensitivity units (PSU), where type 3 stuck high fault ≡ 2 PSU and type 3 stuck low fault ≡ 1 PSU. Therefore, different combinations of type 3 faults in $\text{Class}_{\text{Pixel}}$ I, II, III and IV are possible.

b) For smaller displays < 9,1 in (23,1 cm) in predominant, the pixel density is higher and less sensitive than for bigger displays > 9,1 in (23,1 cm) with less pixel density.

c) A class definition that addresses primarily the acceptance levels of the users and their related tasks and where, for example, the classes can reflect the following contexts:

1) $\text{Class}_{\text{Pixel}}$ 0, for special video display unit tasks with a very high sensitivity and importance in minimizing risks in the information perception, such as inspection of critical information in processes or critical process indicators with a high risk of wrong decisions and process-inherent errors;

2) $\text{Class}_{\text{Pixel}}$ I, for specific video display tasks with high sensitivity and special importance to pixel faults, such as observation, surveillance, image quality inspection tasks with less risk of inherent faults in the case of reading and observation errors;

3) $\text{Class}_{\text{Pixel}}$ II, for general user display tasks with a sensitivity to pixel faults, such as reading and processing text information, perceiving object and symbol information with sufficient reading performance to operate the task.

4) $\text{Class}_{\text{Pixel}}$ III and $\text{Class}_{\text{Pixel}}$ IV, for display tasks with less sensitivity to pixel faults, such as processing public information and advertisements, text book reading, and reading of fast-moving images, with sufficient performance to perceive the information without discomfort to the user.

NOTE 4 Related ergonomics performance criteria with threshold values of defects for visibility and different tasks are under investigation.

NOTE 5 Type 3 faults include dim pixels of 25 % < L_x < 50 % (dark), 50 % ⩽ L_x < 75 % (bright), where L_x is the average pixel response to a maximum luminance command (e.g. white). Intermittent pixels or blinking pixels are rated with 2 PSU. The weighting of the PSU is indicated in front of the multiplier $n_{\text{ClassPixel}}$ of type 3 faults.

NOTE 6 The multiplier, $n_{\text{ClassPixel}}$, can vary with the PSU and can take n_{II} = 1 to 4, n_{III} = 1 to 49, n_{IV} = 1 to 499. If not fault class, $\text{Class}_{\text{Pixel}}$ 0 or I, the supplier shall specify the fault class, $\text{Class}_{\text{Pixel}}$, as well as $n_{\text{ClassPixel}}$, depending on the specified distribution of PSU.

NOTE 7 The calculation of the maximum number of faults depends on the display size and the number of pixels of the display, as follows:

a) for displays > 9,1 in (23,1cm): per type per million pixels;

b) for displays ⩽ 9,1 in (23,1 cm) with > 250 000 pixels: per type per 250 000 pixels;

c) for displays ⩽ 9,1 in (23,1 cm) with ⩽ 250 000 pixels: per type for the whole display.

Table 109 — 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. NOTE Multicolour visual display: combination R=G=B = 100 %.
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 millimetre 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.	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 109 (*continued*)

Attribute	Pass/Fail criteria 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 requirements. **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) $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 2{,}2 + 4{,}84 \times (L_L + L_D + L_S)^{-0{,}65}$ 2) For visual displays using positive polarity: $\frac{L_H + L_D + L_S}{L_H + L_D} \leqslant 1{,}25$ 3) For visual displays using negative polarity: $\frac{L_L + L_D + L_S}{L_L + L_D} \leqslant 1{,}2 + \frac{1}{15} \times \frac{L_H + L_D}{L_L + L_D}$ **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: $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 6{,}7 + 44{,}89 \times (L_L + L_D + L_S)^{-0{,}65}$ 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 110. For reality information, see Table 111.

Table 110 — Assessment and reporting for unwanted reflections — Artificial information

According to Table 109	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 location: 5 (see Figure 15); — measurement direction: Θ = 15°. 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 Table 109, a) 1), 2) and 3), and report the resulting values for passed or failed.

Table 111 — Assessment and reporting for unwanted reflections — Reality information

According to Table 109	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 15); — measurement direction: Θ = 15°. 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 112 — 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 113 — 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: $CR_{min} = \frac{L_H + L_D + L_S}{L_L + L_D + L_S}$ $CR_{min} = 2,2 + 4,84 \times (L_1)^{-0,65}$ with $L_1 = L_L + L_D + L_S$ 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. **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]: $CR_{min} = \frac{L_H + L_D + L_S}{L_L + L_D + L_S}$ $CR_{min} = 6,7 + 44,89 \times (L_1)^{-0,65}$ with $L_1 = L_L + L_D + L_S$ 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 114. For reality information, see Table 115.

Table 114 — Assessment and reporting for luminance contrast — Artificial information

According to Table 113	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: 1 to 9 (see Figure 15); — 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, $R_{\text{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\text{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\text{S,EXT}}$, 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 115 — Assessment and reporting for luminance contrast — Reality information

According to Table 113	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 15); — 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, $R_{\text{S,EXT}}$, for the specular reflection characteristic of the visual display and the luminance, $L_{\text{REF,EXT}}$, of the large aperture source, determine the luminance component, $L_{\text{S,EXT}}$, 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 116 — 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.	Not applicable.
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 by 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 20.5	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 the number of pixels, $N_{\mathrm{H,Height}}$, in the height of an unaccented, upper-case letter H. Evaluate the default mode and report the character height in millimetres, character height in minutes of arc, the font used and the character height number, $N_{\mathrm{H,Height}}$.
Text size constancy	Depending on the type of information shown, the visual display shall fulfil the following requirement. **a) Artificial information** The height and width of a specific character of a specific character font shall not vary by more than ± 3 % of the character height of that character set. **b) Reality information** Not applicable.	ISO 9241-305: P 20.4	Not applicable.
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 20.7	Evaluate the character matrix and calculate the character stroke width. Report the resulting value for passed or failed.

Table 116 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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	Evaluate the character matrix and calculate 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. 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.	ISO 9241-305	Evaluate and report the character matrix. Report the resulting values for passed or failed.

Table 116 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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	Evaluate the character matrix and report 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 requirements. **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	Evaluate the character matrix and report 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 requirements. **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 shall not contain parts of characters or diacritics, but may contain underscores. **b) Reality information** Not applicable.	ISO 9241-305 P 20.14	Evaluate the character matrix and report the between-line spacing. Report the resulting value for passed or failed.

Table 117 — 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 118.

Table 118 — Assessment and reporting for luminance coding — Artificial information

According to Table 117	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: 5 (see Figure 15); — 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 119 — 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 should meet the following recommendations. **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 0,33 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 $\Delta E^*_{uv} \geqslant 20$ under ambient illumination. **b) Reality information** Not applicable.	ISO 9241-305 P 17.4	See Table 120.

Table 120 — Assessment and reporting for colour coding — Artificial information

According to Table 119	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: 5 (see Figure 15); — measurement direction: 0 (perpendicular) for isotropic visual displays and 7 (design viewing direction) for anisotropic visual displays. 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 121 — 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 should meet the following recommendation. **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.	Not applicable.

Table 122 — Legibility of graphics

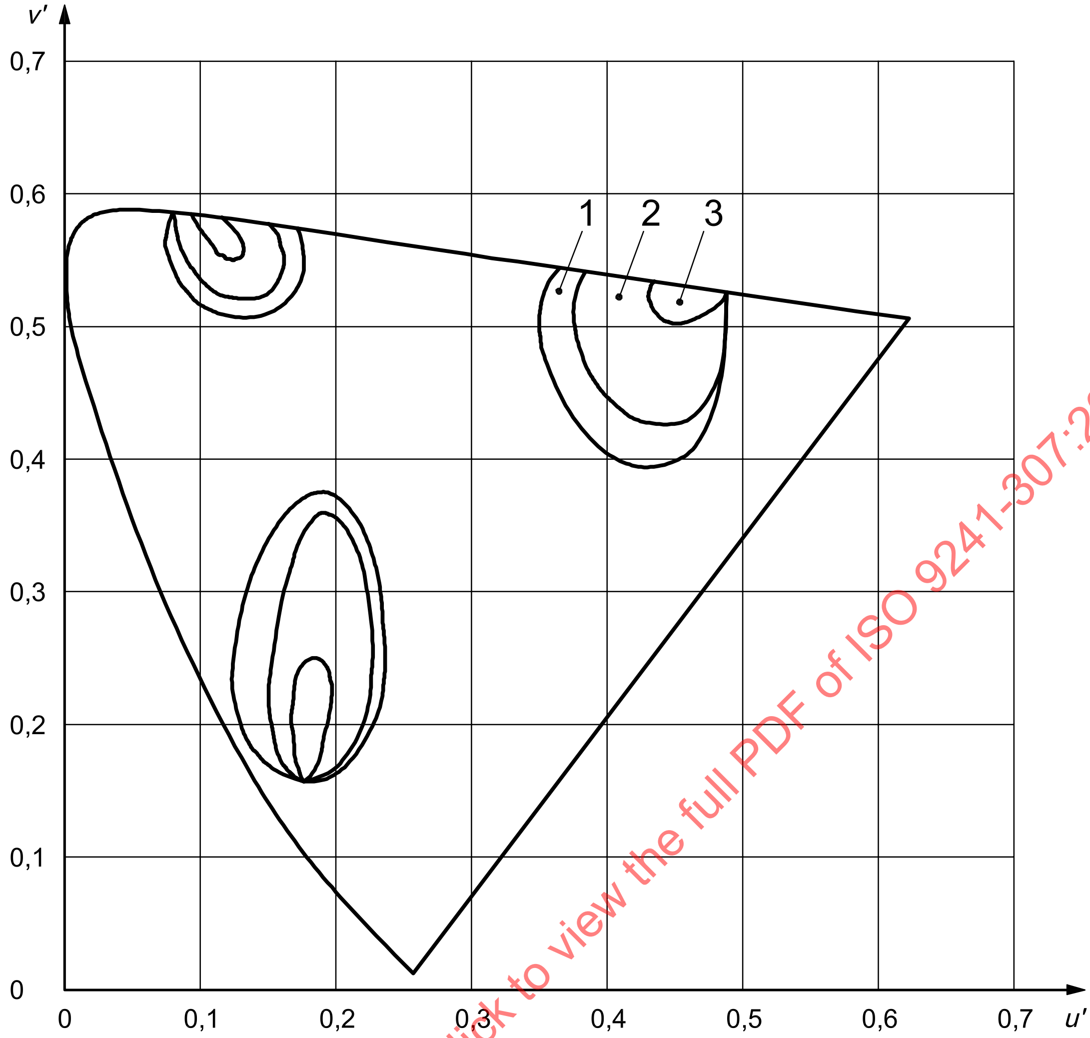
Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Monochrome and multicolour object size	Depending on the type of information shown, the visual display shall fulfil the following requirements. **a) Artificial information** 1) Critical 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 *luminance contrast*. 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	Applicable only in software applications.
Contrast for object legibility	Depending on the type of information shown, the visual display shall fulfil the following requirements. **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.
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 $\Delta E^*_{uv} > 20$.	See character height, colour coding. ISO 9241-305 P 19.1	Applicable only in software applications.

Table 122 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	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.		
Background and surrounding image effects	Depending on the type of information shown, the visual display should meet the following recommendation. **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 should meet the following recommendations. **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 123 — 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 colour gamut 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 16) [37], [44]. NOTE 1 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 2 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' = 0,4884 and shall be within a circle of radius 0,01 from this point with a luminance of Y = 0,440 4 ± 10 %, normalised 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 $\Delta u', v' = [(0{,}222\,1 - u')^2 + (0{,}488\,1 - v')^2]^{0{,}5} = 0{,}02$. NOTE 3 If the visual display offers sufficient colour gamut and electro-optical transfer function (gamma value) according to the regional regulations as defined by the ITU, sufficient colour rendering can be assumed (additivity law of colour stimuli).	ISO 9241-305 P 19.5 P 19.7	For artificial information, see Table 124. For reality information, see Table 125.



Key

1 acceptable (50 %)

2 acceptable (75 %)

3 optimal

Figure 16 — Optimal and acceptable chromaticity ranges — PDP

Table 124 — Assessment and reporting for colour gamut and reference white — Artificial information

According to Table 123	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: 5 (see Figure 15); — measurement direction: 0 (perpendicular) for isotropic visual displays and 1 to 7 for anisotropic visual displays. 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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 15); — measurement direction: 0 (perpendicular) for isotropic visual displays and 7 for anisotropic visual displays. Step 2 Report the resulting values, 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 125 — Assessment and reporting for colour gamut and reference white — Reality information

According to Table 123	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 15); — 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, 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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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 % and acceptable to 50 % of the population (see also Annex B for the boundaries).
b) 2)	Step 1 Measure the chromaticity coordinates, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 15); — measurement direction: 0 (perpendicular). Step 2 Report the resulting values, 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 the chromaticity coordinates, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 15); — 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 125 (*continued*)

According to Table 123	Assessment and reporting
	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 15); — measurement direction: 0 (perpendicular). Report the resulting values. Step 4 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 5 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 6 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 126 — 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.	ISO 9241-305 P 14.1 P 14.2 P 17.5 P 19.2 P 19.3	For artificial information, see Table 127. For reality information, see Table 128. 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 126 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	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 ± 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.		

Table 127 — Assessment and reporting for electro-optical transfer functions and grey scale — Artificial information

According to Table 126	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: 5 (see Figure 15); — 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: 5 (see Figure 15); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 128 — Assessment and reporting for electro-optical transfer functions and grey scale — Reality information

According to Table 126	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 % (equidistant spaced in 2,5 % steps) for monochrome or multicolour visual displays; — measurement location: 5 (see Figure 15); — 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].
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 %, 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 15); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.

Table 129 — 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	Display a wheel on the screen. The wheel and the spokes shall be displayed with a 0 % to 100 % grey level on a background of 50 % grey level for monochrome visual displays or combination R=G=B = 0 % to 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 and 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	Not applicable.

Table 129 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image formation time (IFT)	Depending on the image type, the IFT shall fulfil the following requirements. **a) Still images** Not applicable. **b) Quasi-static images** — IFT > 200 ms: Noticeable loss of contrast observed during key entry, scrolling, animation and blink coding. Pointing devices with rapid cursor positioning can be used only with special techniques. — 55 ms < IFT ⩽ 200 ms: Applications using scrolling, animation and pointing devices lose detectable contrast. Blink coding from 0,33 Hz to 5 Hz is operable. — 10 ms < IFT ⩽ 55 ms: Contrast is stable for most applications. Motion artefacts can be distracting. **c) Moving images** — IFT ⩽ 10 ms: However, for displays that keep displaying each part of the image over a large part of the frame period, the duration of the frame period is also a limiting factor. If the IFT or frame period duration is too long while the display produces the image during a large part of the frame period, then blurred or jerky images result, and contrast may be reduced.	ISO 9241-305 P 15.2 P 15.2A	Not applicable.

Table 129 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Spatial resolution	a) Resolution of the visual display should enable a satisfying reproduction of the original image. The minimum resolution of the display should be (horizontal × vertical): — for VGA: ⩾ 640 × 480; — for PAL: 768 × 576; — for NTSC: 720 × 480. b) The visual display should have a spatial resolution of less than 1′ of arc at the design viewing distance.	Intended context of use/supplier specification ISO 9241-305 P 20.10	Report the resolution of the visual display. Use the pixel size as a basis for evaluation of the spatial resolution. Calculate and report the resulting value: $\alpha = 60 \times 2 \times \arctan(b/2/D_{design,view})$ where b is the pixel size, in millimetres (mm); α is the spatial resolution, in minutes of arc (′); $D_{design,view}$ is the design viewing distance, in millimetres (mm).
Raster modulation	For visual displays having a pixel density of less than 30 pixels per degree at the design viewing distance, the luminance modulation in the direction perpendicular to adjacent raster lines shall not exceed C_m = 0,4 for monochrome displays or C_m = 0,7 for multicolour displays, when all pixels are in their high state.	ISO 9241-305 P 21.9	Not applicable.
Fill factor	For a visual display having a pixel density of less than 30 pixels per degree at the design viewing distance, the fill factor shall exceed 0,3. The supplier shall submit the subpixel drawing or specify the fill factor.	Supplier specification ISO 9241-305 M 21.10	Evaluate the subpixel drawing and calculate the fill factor. Alternatively, use the fill factor as specified by the supplier. Report the resulting value for passed or failed.
Pixel density	The supplier shall specify the pixel density.	Supplier specification	Report the resulting value.

5.4 Front-screen projection visual displays with fixed resolution for indoor use — Display laboratory method

5.4.1 Intended context of use

The attributes of the user, environment, tasks and the use of front-screen projection visual displays with fixed resolution are summarized in Table 130. Attributes are derived by an 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 Devices that produce an image projected on the audience side of a light-reflecting screen are considered in this compliance route for typical visual display tasks for indoor use. The screen is separate and not an integral part of the product but an integral part of the display.

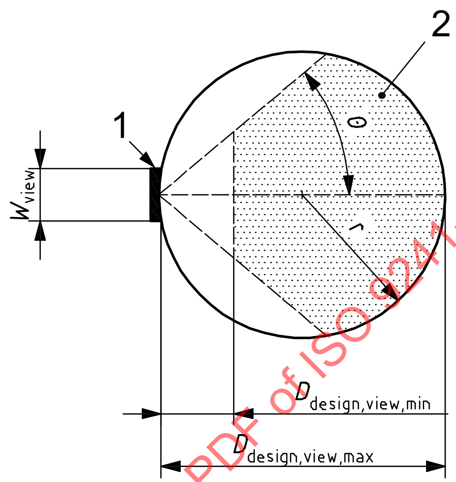
Table 130 — Intended context of use — Front-screen projection visual displays with fixed resolution

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 lx + 250 lx × cos(α) 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 80°, 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]): — $L_{REF,EXT}$ = 500 cd/m^2, $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 300 cd/m^2, $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 200 cd/m^2, $L_{REF,SML}$ = 2 000 cd/m^2 (suitable for general office use); — $L_{REF,EXT}$ = 125 cd/m^2, $L_{REF,SML}$ = 200 cd/m^2 (requires a specially controlled luminous environment); where $L_{REF,EXT}$ is the luminance of the large aperture source (15°); $L_{REF,SML}$ 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 130 (*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.
	Screen	For this compliance route, a screen with a Lambertine surface and a diffuse reflectance, ρ, of 0,8 is considered.
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, $D_{design,view}$	The minimum design viewing distance, $D_{design,view,min}$, is calculated from the width, W_{view}, of the projected image, as follows [26]: $D_{design,view,min} = 1,5 \times W_{view}$ The maximum design viewing distance, $D_{design,view,max}$, is calculated from the width, W_{view}, of the projected image, as follows: $D_{design,view,max} = 6 \times W_{view}$
	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°, –).

Table 130 (*continued*)

Element	Attribute	Quantification
	Design viewing direction range (angle of inclination and azimuth)	Figure 17 shows a typical application. For this compliance route, a design viewing direction range of up to 80° is considered, if not otherwise specified by the supplier. Therefore, the maximum angle of inclination, Θ, is 40°. The azimuth angle, Φ, is 0° to 360°.  **Key** 1 screen 2 observation area W_{view} width of projected image $D_{design,view,min}$ minimum design viewing distance $D_{design,view,max}$ maximum design viewing distance Θ azimuth r radius **Figure 17 — Design viewing direction — Front-screen projection visual displays**
	Eye and head movement	From fixed to moving.
	Number of users	Typical multiple.
Usage	Display handling	For this compliance route, stationary and portable display handling is considered, if not otherwise specified by the supplier.

5.4.2 Information about the technology

The basic physical attributes of the technology of front-screen projection visual displays with fixed resolution are given in Table 131. The supplier shall submit a detailed technical specification — rated voltage, rated frequency, rated current, rated power consumption, projection system and number of panels, projection lamp, relationship between the throwing distance, d, in metres, and the screen size, A, in square metres [$A = f(d)$], lens and zoom, light output, original and interpolated resolutions, displayable formats, pixel fault declaration, 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, etc.

Table 131 — Basic physical attributes of front-screen projection visual displays with fixed resolution

Basic physical attributes	Description
Optical mode of operation	Depending on technology
Mode of observation	Front projection (via reflective screen)
Diagonal of the projected image	Depending on application and throwing distance
Resolution (addressable pixels)	Depending on application
Projector type	Fixed resolution projector
Light output (luminous flux in lumen)	Depending on application
Aspect ratio	Depending on application, e.g. 4:3, 5:4 or 16:9
Typical throwing distance	Depending on application. [a]
NOTE An estimate of the typical throwing distance is given by the following investigation. Determine screen size A in square metres: A = light output/400 (based on design screen illuminance E_S = 50 lx and contrast ratio CR = 5:1).	
[a] Determine the typical throwing distance, d, using the technical specification, $A = f(d)$, obtained from the supplier.	

5.4.3 Compliance assessment

The compliance assessment for front-screen projection visual displays with fixed resolution shall be made in accordance with Tables 132 to 166.

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.

Table 132 — Viewing conditions

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Design viewing distance	The minimum design viewing distance, $D_{\text{design,view,min}}$, is $D_{\text{design,view,min}} = 1{,}5 \times W_{\text{view}}$ The maximum design viewing distance, $D_{\text{design,view,max}}$, is $D_{\text{design,view,max}} = 6 \times W_{\text{view}}$	Supplier specification, intended context of use	Use supplier-specified values or values obtained from intended context of use. Report the resulting values.
Design viewing direction	The visual display shall conform to all optical requirements over a relevant range of viewing directions. The design viewing direction, (Θ_D, Φ_D), as well as the design viewing direction range shall be specified.	Supplier specification, intended context of use	See Table 133.

Table 133 — Assessment and reporting for design viewing direction

According to Table 132	Assessment and reporting
	Step 1 Examine the 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 Owing to the use of a diffuse reflective screen, isotropy is given. 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 supplier-specified values. Report the resulting values. Step 3 Carry out optical measurements at measurement locations 1 to 13 as shown in Figure 18. Throughout the measurements, align the measuring instrument perpendicular to the screen if not otherwise stated.

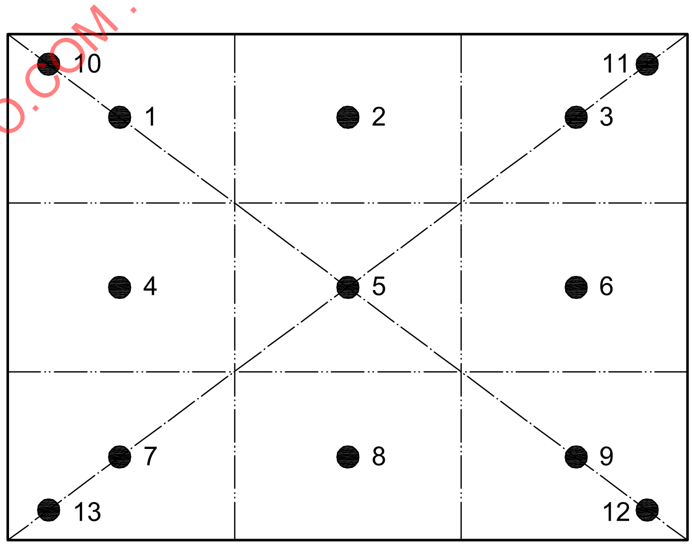


Figure 18 — Measurement locations on front-screen projection visual displays

Table 134 — 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.

Table 135 — Luminance

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Illuminance	The supplier shall specify the maximum design screen illuminance, E_S, as well as the illuminant.	Intended context of use/supplier specification	Use supplier-specified value or value obtained from intended context of use. Report the resulting value.
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 50 cd/m^2 over all relevant viewing directions (see design viewing direction) [16]. 2) Under darkroom conditions, the visual display should have a minimum display luminance of 100 cd/m^2 over all relevant viewing directions (see design viewing direction) [3]. **b) Reality information** 3) Under darkroom conditions, the visual display shall have a minimum display luminance of 80 cd/m^2 over all relevant viewing directions (see design viewing direction) [21]. 4) Under darkroom conditions, the visual display should have a minimum display luminance of 200 cd/m^2 over all relevant viewing directions (see design viewing direction) [30]. NOTE The display luminance under ambient illumination is explicitly considered in the attribute *luminance contrast*.	ISO 9241-305 P 12.5 M 12.1	For artificial information, see Table 136. For reality information, see Table 137.

Table 136 — Assessment and reporting for display luminance — Artificial information

According to Table 135	Assessment and reporting
a)	Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, 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: 1 to 9 (see Figure 18); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 137 — Assessment and reporting for display luminance — Reality information

According to Table 135	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 18); — measurement direction: 0 (perpendicular). Report the resulting values for passed or failed.

Table 138 — 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, $L_{task,area}$, that are frequently viewed in sequence while using the visual display (document, covers, etc.) should be between $0{,}1 \times L_{task,area} \leqslant L_{Ea,HS} \leqslant 10 \times L_{task,area}$ where $L_{Ea,HS}$ 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 138 (*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 states 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 states 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 12.3	See Table 139.

Table 139 — Assessment and reporting for luminance and contrast adjustment

According to Table 138	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. 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, $L_{\text{ill,object(mloc-mdir)}}$, 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: 5 (see Figure 18); — 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, $L_{\text{ill,object(mloc-mdir)}}$, 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: 5 (see Figure 18); — measurement direction: 0 (perpendicular). Step 3 Report the resulting values for passed or failed.
a) 4), b) 4) a) 5), b) 5)	Step 1 Display a full screen grey scale (equidistantly spaced in 5 % steps). Step 2 Adjust the control responsible for the display luminance of the high state to the middle position. Adjust the control responsible for the display luminance of the low state between minimum and maximum. Perform a visual inspection of the whole grey scale as well as the 0 %, 5 % and 10 % areas of the grey scale. Step 3 Adjust the control responsible for the display luminance of the low state to the middle position. Adjust the control responsible for the display luminance of the high state between minimum and maximum. Perform a visual inspection of the whole grey scale as well as the 90 %, 95 % and 100 % areas of the grey scale. Step 4 Observe the visual display for independency between adjustments of the display luminance of the low and high state. Step 5 Observe the visual display for discrimination between the grey levels. Step 6 Report the resulting values for passed or failed.

Table 140 — 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.
Excessive 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 excessive temperatures and report the resulting value.

Table 141 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance non-uniformity	**Artificial and reality information** a) Lateral uniformity criterion For an intended uniform display luminance, the following requirements shall be fulfilled [47]: $\frac{L_{max(1-13)}}{L_{mean(1-9)}} \times 100\ \% \leqslant 20\ \%$ $\frac{L_{max(1-13)}}{L_{mean(1-9)}} \times 100\ \% \leqslant 45\ \%$ $g_1 = \frac{L_{min(1-9)}}{L_{mean(1-9)}} \times 100\ \% \geqslant 80\ \%$ $g_2 = \frac{L_{min(1-9)}}{L_{max(1-9)}} \times 100\ \% \geqslant 65\ \%$ where $L_{max(1-13)}$ is the maximum luminance of measuring locations 1 to 13; $L_{mean(1-9)}$ is the mean value of the luminance of measuring locations 1 to 9; $L_{min(1-9)}$ is the minimum luminance of measuring locations 1 to 9; $L_{max(1-9)}$ is the maximum luminance of measuring locations 1 to 9; g_1 is the ratio of the minimum illuminance to the average illuminance; g_2 is the ratio of the minimum illuminance to the maximum illuminance;	ISO 9241-305 M 12.9	See Table 142.

Table 141 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	b) Directional uniformity criterion The visual display shall have sufficient luminance uniformity over all relevant viewing directions (see design viewing direction). The luminance uniformity shall not exceed the following values: 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		

Table 142 — Assessment and reporting for luminance non-uniformity

According to Table 141	Assessment and reporting
a)	Step 1 Measure the display luminance, $L_{\text{ill,object(mloc-mdir)}}$, or illuminance, $E_{\text{ill,object(mloc-mdir)}}$, 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: 1 to 13 (see Figure 18); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Evaluate the lateral uniformity criterion. Determine the angular distance of the measurement locations, using the centre location as the reference, and calculate the corresponding ratios. Report the resulting value for passed or failed.
b)	Not applicable.

Table 143 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Colour non-uniformity	**Artificial and reality information** a) 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. b) 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 144.

Table 144 — Assessment and reporting for colour non-uniformity

According to Table 143	Assessment and reporting
a)	Step 1 Measure the chromaticity coordinates, $u',v'_{\text{ill,object(mloc-mdir)}}$, where: — illumination condition: darkroom; — object: full-screen test pattern with half and maximum grey level for monochrome visual displays or combinations R,G,B = 100 %, combination R=G=B = 75 % and combinations R,G,B = 50 % for multicolour visual displays; — measurement locations: 5 (CL), 10, 11, 12 and 13 (see Figure 18); — 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.
b)	Not applicable.

Table 145 — 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, $CR_{nonuniformity} = 1 - CR_{min}/CR_{max}$, 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.
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	Not applicable.
Screen and faceplate defects	The visual display should be in the fault class, $Class_{Pixel}$ 0, with a recommended maximum of $Class_{Pixel}$ I. If not in $Class_{Pixel}$ 0, the supplier shall specify the $Class_{Pixel}$ of the visual display in accordance with Table 146.	ISO 9241-305 M 21.6	Report the supplier's declaration. Evaluate pixel and subpixel faults by direct observation. Determine and report the fault class. NOTE Rounding policy: round down: x,00 to x,49 $\rightarrow x$; round up: x,50 to x,99 $\rightarrow x + 1$.

Table 146 — Pixel fault classification

Class pixel	Type 1	Type 2	Type 3 (See Notes 1 to 7)		Cluster with more than one type 1 or type 2 fault	Cluster of type 3 faults
			Stuck high	Stuck low		
0	0	0	0	0	0	0
I (for type 3 = 5 PSU)	1	1	2	1	0	0
	1	1	1	3	0	0
	1	1	0	5	0	0
II (for type 3 = 10 PSU)	2	2	5	0	0	1
	2	2	$5 - 1 \times n_{II}$	$2 \times n_{II}$	0	1
	2	2	0	10	0	1
III (for type 3 = 100 PSU)	5	15	50	0	0	5
	5	15	$50 - 1 \times n_{III}$	$2 \times n_{III}$	0	5
	5	15	0	100	0	5
IV (for type 3 = 1 000 PSU)	50	150	500	0	5	50
	50	150	$500 - 1 \times n_{IV}$	$2 \times n_{IV}$	5	50
	50	150	0	1 000	5	50

NOTE 1 Faults that are below the visibility threshold at the design viewing distance and design luminance level are not considered.

NOTE 2 For ergonomics performance, the number, size and contrast of defects and pixel faults shall not exceed the threshold for performance decrease.

NOTE 3 These fault classes consider the following.

a) Bright subpixel faults are perceived as more sensitive than dark subpixel faults. Therefore, pixel faults are weighted in pixel shader units (PSU), where type 3 stuck high fault ≡ 2 PSU and type 3 stuck low fault ≡ 1 PSU. Therefore, different combinations of type 3 faults in $\text{Class}_{\text{Pixel}}$ I, II, III and IV are possible.

b) For smaller displays < 9,1 in (23,1 cm) predominant, the pixel density is higher and less sensitive than for bigger displays > 9,1 in (23,1 cm) with less pixel density.

c) A class definition that addresses primarily the acceptance levels of the users and their related tasks and where, for example, the classes can reflect the following contexts:

1) $\text{Class}_{\text{Pixel}}$ 0, for special video display unit tasks with a very high sensitivity and importance in minimizing risks in the information perception, such as inspection of critical information in processes or critical process indicators with a high risk of wrong decisions and process-inherent errors;

2) $\text{Class}_{\text{Pixel}}$ I, for specific video display tasks with high sensitivity and special importance to pixel faults, such as observation, surveillance, image quality inspection tasks with less risk of inherent faults in the case of reading and observation errors;

3) $\text{Class}_{\text{Pixel}}$ II, for general user display tasks with a sensitivity to pixel faults, such as reading and processing text information, perceiving object and symbol information with sufficient reading performance to operate the task;

4) $\text{Class}_{\text{Pixel}}$ III and $\text{Class}_{\text{Pixel}}$ IV, for display tasks with less sensitivity to pixel faults, such as processing public information and advertisements, text book reading, and reading of fast-moving images, with a sufficient performance to perceive the information without discomfort to the user.

NOTE 4 Related ergonomics performance criteria with threshold values of defects for visibility and different tasks are under investigation.

NOTE 5 Type 3 faults include dim pixels of 25 % < L_x < 50 % (dark), 50 % ⩽ L_x < 75 % (bright), where L_x is the average pixel response to a maximum luminance command (e.g. white). Intermittent pixels or blinking pixels are rated with 2 PSU. The weighting of the PSU is indicated in front of the multiplier $n_{\text{ClassPixel}}$ of type 3 faults.

NOTE 6 The multiplier, $n_{\text{ClassPixel}}$, can vary with the PSU and can take n_{II} = 1 to 4, n_{III} = 1 to 49, n_{IV} = 1 to 499. If not fault class $\text{Class}_{\text{Pixel}}$ 0 or I, the supplier shall specify the fault class, $\text{Class}_{\text{Pixel}}$, as well as $n_{\text{ClassPixel}}$, depending on the specified distribution of PSU.

NOTE 7 The calculation of the maximum number of faults depends on the display size and the number of pixels of the display, as follows:

d) for displays > 9,1 in (23,1cm): per type per million pixels;

e) for displays ⩽ 9,1 in (23,1 cm) with > 250 000 pixels: per type per 250 000 pixels;

f) for displays ⩽ 9,1 in (23,1 cm) with ⩽ 250 000 pixels: per type for the whole display.

Table 147 — 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. NOTE Multicolour visual display: combination R=G=B = 100 %.
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 millimetre 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.	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 147 (*continued*)

Attribute	Pass/Fail criteria 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 requirements. **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) $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 2{,}2 + 4{,}84 \times (L_L + L_D + L_S)^{-0{,}65}$ 2) For visual displays using positive polarity: $\frac{L_H + L_D + L_S}{L_H + L_D} \leqslant 1{,}25$ 3) For visual displays using negative polarity: $\frac{L_L + L_D + L_S}{L_L + L_D} \leqslant 1{,}2 + \frac{1}{15} \times \frac{L_H + L_D}{L_L + L_D}$ **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: $\frac{L_H + L_D + L_S}{L_L + L_D + L_S} \geqslant 6{,}7 + 44{,}89 \times (L_L + L_D + L_S)^{-0{,}65}$ 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 148. For reality information, see Table 149.

Table 148 — Assessment and reporting for unwanted reflections — Artificial information

According to Table 147	Assessment and reporting
a)	Step 1 Measure the display luminance, $L_{ill,object(mloc-mdir)}$, 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 18); — measurement direction: $\Theta = 15°$. Report the resulting values. Step 2 Determine the reflectometer value, R_D, for the diffuse reflection characteristic of the screen, expressed in steradian. Based on a diffuse reflectance, ρ, of the screen of $\rho = 0{,}8$ as given in the intended context, R_D is calculated as follows: $R_D = \frac{\rho}{\pi} = \frac{0{,}8}{\pi} = 0{,}254\,7\ \text{sr}^{-1}$ Step 3 Based on the reflectometer value, R_D, for the diffuse reflection characteristic of the screen and the design screen illuminance, E_S, determine the luminance component, L_D, reflected from diffuse illumination. Report the resulting values. Step 4 Determine the reflectometer value, $R_{S,EXT}$, for the specular reflection characteristic of the screen. Report the resulting value. $R_{S,EXT} = \frac{L_{screen}}{L_{EXT}} = \frac{\rho \cdot \Omega_{EXT} \cdot \cos\Theta}{\pi}$ where L_{screen} is the luminance of the screen caused by a large source of illumination; L_{EXT} is the luminance of the large source of illumination; Ω_{EXT} is the solid angle of the large source of illumination (15°), equal to 0,0537 5 sr^{-1}; Θ is the azimuth of the large source of illumination, equal to 15°. Therefore, $R_{S,EXT} = 0{,}0132\,2$ for $\rho = 0{,}8$. Step 5 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 6 Determine the reflectometer value, $R_{S,\ SML}$, for the specular reflection characteristic of the screen. Report the resulting value. $R_{S,SML} = \frac{L_{screen}}{L_{EXT}} = \frac{\rho \cdot \Omega_{SML} \cdot \cos\Theta}{\pi}$ where Ω_{SML} is the solid angle of the small source of illumination (1°), equal to $2{,}392 \times 10^{-4}\ \text{sr}^{-1}$ Therefore, $R_{S,SML} = 5{,}885 \times 10^{-5}$ for $\rho = 0{,}8$. Step 7 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 8 Evaluate the requirements of Table 147 a) 1), 2) and 3) and report the resulting values for passed or failed.

Table 149 — Assessment and reporting for unwanted reflections — Reality information

According to Table 147	Assessment and reporting
	Step 1 Use the results from Table 148, Steps 1 to 7. Step 2 Evaluate the requirement of Table 147 b) and report the resulting value for passed or failed.

Table 150 — 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 depth (chromostereopsis) effects shall be avoided. **b) Reality information** Not applicable.	ISO 9241-305 P 19.1	Applicable only in software applications.

Table 151 — 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: $$CR_{min} = \frac{L_H + L_D + L_S}{L_L + L_D + L_S}$$ $$CR_{min} = 2{,}2 + 4{,}84 \times (L_1)^{-0{,}65}$$ with $L_1 = L_L + L_D + L_S$ 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. **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]: $$CR_{min} = \frac{L_H + L_D + L_S}{L_L + L_D + L_S}$$ $$CR_{min} = 6{,}7 + 44{,}89 \times (L_1)^{-0{,}65}$$ with $L_1 = L_L + L_D + L_S$ 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	See Table 152.

Table 152 — Assessment and reporting for luminance contrast

According to Table 151	Assessment and reporting
a), 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 18); — measurement direction: 0 (perpendicular). Step 2 Use the results from Table 148, Steps 2 to 5. Step 3 Evaluate the requirements and report the resulting values for passed or failed.

Table 153 — 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 check character attributes for positive and negative polarity.
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 20.5	Measure the character height in millimetres at the throwing distance of the projector 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 the number of pixels, $N_{\text{H,Height}}$, in the height of an unaccented, upper-case letter H. Evaluate the default mode and report the character height in millimetres, character height in minutes of arc, the font used and the character height number, $N_{\text{H,Height}}$

Table 153 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Text size constancy	Depending on the type of information shown, the visual display shall fulfil the following requirement. **a) Artificial information** The height and width of a specific character of a specific character font shall not vary by more than ± 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	Not applicable.
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 20.7	Evaluate the character matrix and calculate 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	Evaluate the character matrix and calculate the character width-to-height ratio. Report the resulting value for passed or failed.

Table 153 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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. 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.	ISO 9241-305	Evaluate and report the character matrix. Report the resulting values for passed or failed.

Table 153 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
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	Evaluate the character matrix and report 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 requirements. **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	Evaluate the character matrix and report 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 requirements. **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 shall not contain parts of characters or diacritics, but may contain underscores. **b) Reality information** Not applicable.	ISO 9241-305 P 20.14	Evaluate the character matrix and report the between-line spacing. Report the resulting value for passed or failed.

Table 154 — 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 155.

Table 155 — Assessment and reporting for luminance coding — Artificial information

According to Table 154	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: 5 (see Figure 18); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Use the results from Table 148, Steps 2 to 5. Step 3 Determine the display luminances under ambient illumination. Determine the ratios between adjacent levels and report the resulting values for passed or failed.

Table 156 — 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 should meet the following recommendations. **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 0,33 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 $\Delta E^*_{uv} \geqslant 20$ under ambient illumination. **b) Reality information** Not applicable.	ISO 9241-305 P 17.4	See Table 157.

Table 157 — Assessment and reporting for colour coding — Artificial information

According to Table 156	Assessment and reporting
a)	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 with combinations R,G,B = 100 %, combination R=G=B = 75 % and combinations R,G,B = 50 %; — measurement location: 5 (see Figure 18); — 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 158 — 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 159 — Legibility of graphics

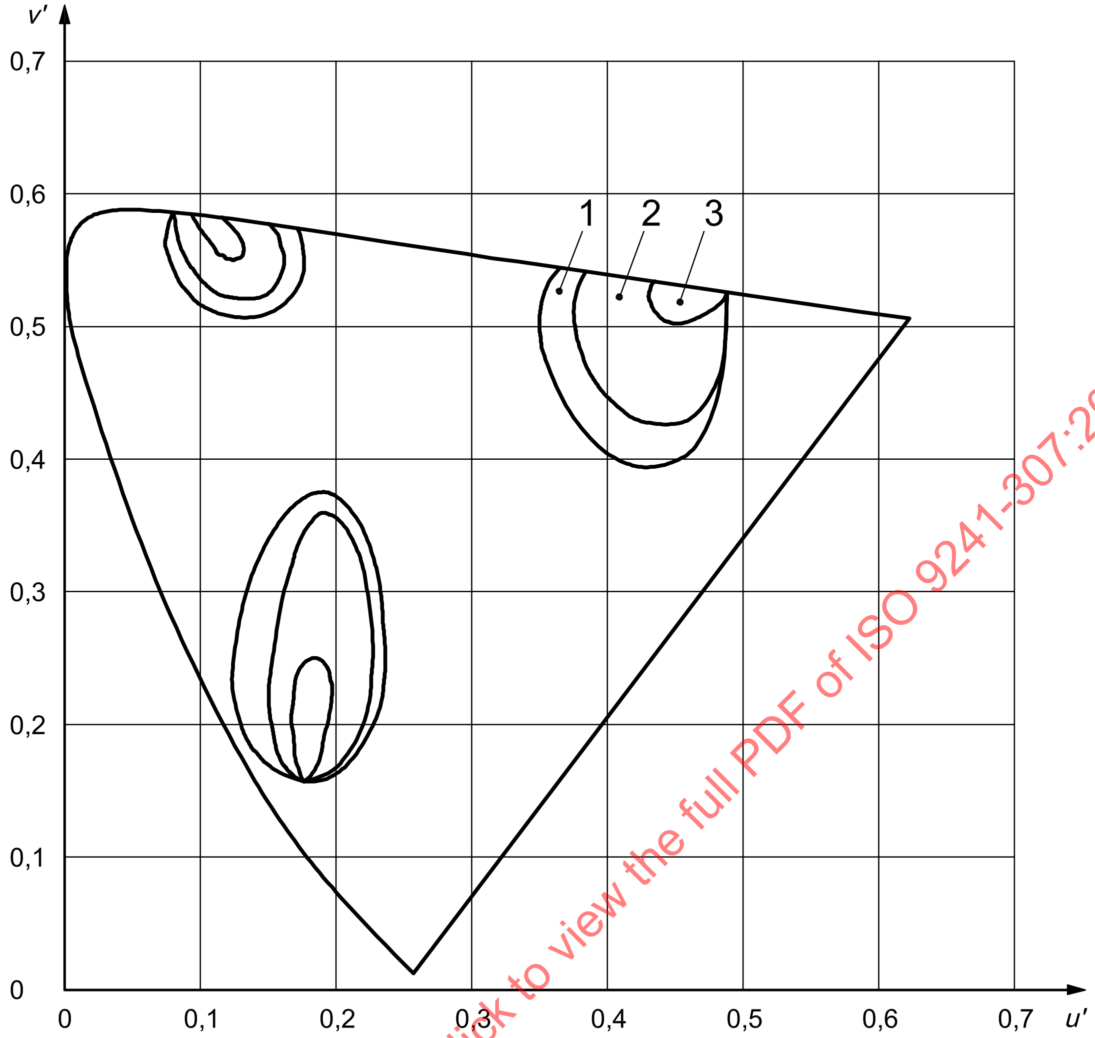
Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Monochrome and multicolour object size	Depending on the type of information shown, the visual display shall fulfil the following requirements. **a) Artificial information** 1) Critical 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 *luminance contrast*. 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.	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 as for display luminance and luminance contrast shall apply. **b) Reality information** Not applicable.	See display luminance, luminance contrast.	Applicable only in software applications.

Table 159 (*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 should meet the following recommendation. **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 should meet the following recommendations. **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 160 — 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 colour gamut under ambient illumination should be optimal for more than 90 % of the population and shall be optimal for more than 75 % of the population (see Figure 19) [37], [44]. NOTE 1 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 2 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 $u' = 0{,}222\,1$, $v' = 0{,}4884$ 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 161. For reality information, see Table 162.



Key

1 acceptable (50 %)

2 acceptable (75 %)

3 optimal

Figure 19 — Optimal and acceptable chromaticity ranges — Front-screen projection visual displays

Table 161 — Assessment and reporting for colour gamut and reference white — Artificial information

According to Table 160	Assessment and reporting
a) 1)	Step 1 Measure the tristimulus values, $X_{\mathrm{ill,object(mloc\text{-}mdir)}}$, $Y_{\mathrm{ill,object(mloc\text{-}mdir)}}$, $Z_{\mathrm{ill,object(mloc\text{-}mdir)}}$, 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 18); — 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, $X_{\mathrm{S,EXT}}$, $Y_{\mathrm{S,EXT}}$, $Z_{\mathrm{S,EXT}}$, 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, $u'_{\mathrm{ill,object(mloc\text{-}mdir)}}$, $v'_{\mathrm{ill,object(mloc\text{-}mdir)}}$, 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 18); — measurement direction: 0 (perpendicular). Step 2 Report the resulting values, 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 162 — Assessment and reporting for colour gamut and reference white — Reality information

According to Table 160	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 18); — 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, $X_{\text{S,EXT}}$, $Y_{\text{S,EXT}}$, $Z_{\text{S,EXT}}$, 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, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 18); — measurement direction: 0 (perpendicular). Step 2 Report the resulting values, 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 the chromaticity coordinates, $u'_{\text{ill,object(mloc-mdir)}}$, $v'_{\text{ill,object(mloc-mdir)}}$, 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 18); — 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 162 (*continued*)

According to Table 160	Assessment and reporting
	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 18); — measurement direction: 0 (perpendicular). Report the resulting values. Step 4 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 5 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 6 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 163 — 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. 3) The gamma value of the visual display should be adjustable to establish an approximately uniform colour space in ambient illumination.	ISO 9241-305 P 14.1 P 14.2 P 17.5 P 19.2 P 19.3	For artificial information, see Table 164. For reality information, see Table 165. 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 163 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
	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 ± 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. 3) The gamma value of the visual display should be adjustable to establish an approximately uniform colour space in ambient illumination.		

Table 164 — Assessment and reporting for electro-optical transfer functions and grey scale — Artificial information

According to Table 163	Assessment and reporting
a) 1)	Step 1 Measure the illuminance, $E_{\text{ill,object(mloc-mdir)}}$, 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 18); — 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: 5 (see Figure 18); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.
a) 3)	Report whether this feature is available.

Table 165 — Assessment and reporting for electro-optical transfer functions and grey scale — Reality information

According to Table 163	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 18); — 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].
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 %, 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 18); — measurement direction: 0 (perpendicular). Report the resulting values. Step 2 Calculate the chromaticity uniformity differences. Report the resulting value for passed or failed.
b) 3)	Report whether this feature is available.

Table 166 — 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 1 pixel in the horizontal or vertical directions over the entire screen.	ISO 9241-305 M 21.8	Measure the misconvergence by direct observation and report the resulting value for passed or failed.

Table 166 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image formation time (IFT)	Depending on the image type, the IFT shall fulfil the following requirements. **a) Still images** Not applicable. **b) Quasi-static images** — IFT > 200 ms Noticeable loss of contrast observed during key entry, scrolling, animation, and blink coding. Pointing devices with rapid cursor positioning can be used only with special techniques. — 55 ms < IFT ⩽ 200 ms Applications using scrolling, animation and pointing devices lose detectable contrast. Blink coding from 0,33 Hz to 5 Hz is operable. — 10 ms < IFT ⩽ 55 ms Contrast is stable for most applications. Motion artefacts can be distracting. **c) Moving images** — IFT ⩽ 10 ms However, for displays that keep displaying each part of the image over a large part of the frame period, the duration of the frame period is also a limiting factor. If the IFT or frame period duration is too long while the display produces the image during a large part of the frame period, then blurred or jerky images result, and contrast may be reduced.	ISO 9241-305 P 15.2 P 15.2A	**Projectors using modulators from liquid crystal devices** Measure the image formation time between all combinations of the five different grey levels. Use a minimum of 20 measurements. Report the following result values: — switching times, t_{on} and t_{off}, between grey levels; — IFT between grey levels; — minimum and maximum IFT; — mean value and standard deviation of IFT. Determine the capability for moving images. NOTE Definition of five grey levels: combination R=G=B = 0 %; combination R=G=B = 25 %; combination R=G=B = 50 %; combination R=G=B = 75 %; combination R=G=B = 100 % **Projectors using modulators other than liquid crystal devices** (e.g. digital micro-mirror) Not applicable.
Spatial resolution	a) Resolution of the visual display should enable a satisfying reproduction of the original image. The minimum resolution of the display should be (horizontal × vertical): — VGA: ⩾ 640 × 480 — PAL: 768 × 576 — NTSC: 720 × 480 b) The visual display should have a spatial resolution of less than 1′ of arc at the design viewing distance.	Intended context of use/supplier specification ISO 9241-305 P 20.10	Report the resolution of the visual display. Use the projected pixel size as a basis for evaluation of the spatial resolution, α, expressed in minutes of arc. Calculate and report the resulting value: $\alpha = 60 \times 2 \times \arctan (b/2/D_{design,view})$ where b is the pixel size, in millimetres; $D_{design,view}$ is the design viewing distance, in millimetres.

Table 166 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Raster modulation	For visual displays having a pixel density of less than 30 pixels per degree at the design viewing distance, the luminance modulation in the direction perpendicular to adjacent raster lines shall not exceed $C_m = 0{,}4$ for monochrome displays or $C_m = 0{,}7$ for multicolour displays when all pixels are in their high state.	ISO 9241-305 P 21.9	Measure the luminance modulation and report the resulting value for passed or failed.
Fill factor	a) For a visual display having a pixel density of less than 30 pixels per degree at the design viewing distance, the fill factor shall exceed 0,3. b) The supplier shall submit the subpixel drawing or specify the fill factor.	Supplier specification ISO 9241-305 M 21.10	Not applicable.
Pixel density	The supplier shall specify the pixel density.	Supplier specification	Report the resulting value.

5.5 Emissive, reflective or transflective LCD for handheld devices for indoor use — Display laboratory method

5.5.1 Intended context of use

The attributes of the user, environment, tasks and the use of emissive, reflective or transflective LCD (liquid crystal displays) for handheld devices are summarized in Table 167. 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 1 Handheld device LCD displays — as used for example in a pocket-PC that includes a keyboard or in a PDA (personal digital assistant) with a diagonal of the active display area of up to 9,1 in (23,1 cm) and a design viewing inclination of $\Theta_D = 0° \pm 20°$ — are considered in this compliance route for typical visual display tasks for indoor use in work environments with a design screen illuminance in a range of 50 lx up to 5 000 lx.

NOTE 2 The scope of this compliance route is limited to the intended context of use given in 5.5.1. The supplier may specify a subset of the described intended context of use given in 5.5.1.

NOTE 3 Automotive environments (cars, trains and other vehicles) are not addressed here.

Table 167 — Intended context of use — Emissive, reflective or transflective LCD for handheld devices

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]): — minimum 50 lx [5]; — 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 lx + 250 lx × cos(α) 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; — maximum 5 000 lx. The supplier shall specify the maximum design screen illuminance as well as the intended environment. The screen tilt angle is defined by the position of the handheld device in its cradle or is considered to be 45° if not otherwise specified by the supplier. NOTE The minimum illumination level to consider is 50 lx and the maximum illumination level to consider is 5 000 lx. The intended illumination levels are all illumination levels between minimum and maximum (all indoors environments except those that are too dark for walking, including sunlit indoors areas). The compliance calculations are made for the following illuminance levels: 50 lx, 200 lx, 500 lx, 750 lx, 1 500 lx and 5 000 lx. The compliance calculations shall be repeated for every specified illuminant.

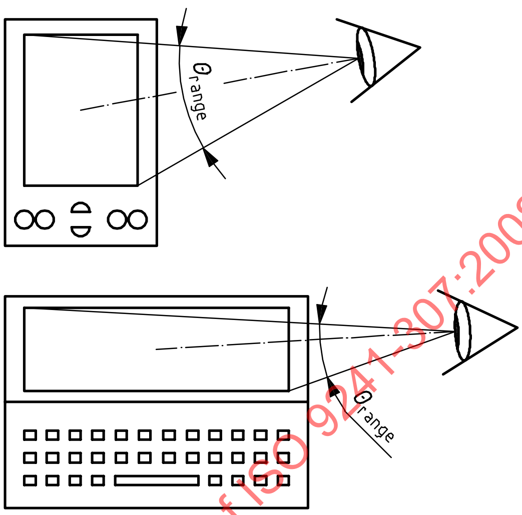
Table 167 (*continued*)

Element	Attribute	Quantification
Environment	Typical components of the illumination: large aperture source (15°) and small aperture source (1°) illumination	At indoor locations (see References [13], [19]): — $L_{REF,EXT}$ = 500 cd/m², $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 300 cd/m², $L_{REF,SML}$ = not applicable; — $L_{REF,EXT}$ = 200 cd/m², $L_{REF,SML}$ = 2 000 cd/m² (suitable for general office use); — $L_{REF,EXT}$ = 125 cd/m², $L_{REF,SML}$ = 200 cd/m² (requires a specially controlled luminous environment). where $L_{REF,EXT}$ is the luminance of the large aperture source (15°); $L_{REF,SML}$ 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. For the purpose of evaluating the performance of a reflective or transflective handheld display device, it is assumed that the above-mentioned luminances are present in every intended environment and that the user can tilt and turn his/her device to make optimum usage of the light source. The calculations shall be repeated for every specified illuminant.
	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.
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.

Table 167 (*continued*)

Element	Attribute	Quantification
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. The Pass/Fail criteria may contain three different requirement levels: "High", "Medium" and "Low", which determine the degree to which a criterion is fulfilled: — "High" for visual display tasks including video display tasks with high performance in e.g. colour gamut, grey scale; — "Medium" for general visual display tasks with sufficient performance to perceive colour and to read the information without discomfort by the user; — "Low" for visual display tasks with low performance in e.g. colour gamut and grey scale, but with sufficient performance to read the information without discomfort to the user.
	Amount of information	Preferred screen size for sufficient amount of information with appropriate object size and resolution.
	Image type	For this compliance route, the visual display shall be capable of displaying still, quasi-static or moving images.
	Design viewing distance, $D_{design,view}$	The minimum design viewing distance, $D_{design,view,min}$, is > 200 mm. The supplier shall specify $D_{design,view}$.
	Design viewing direction (Θ_D, Φ_D)	**For handheld display devices with emissive display** 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°, –). **For handheld display devices with reflective and transflective display** The design viewing direction is: — the angle at which the emitted luminance has its maximum for cases where the emissive properties of the display are dominating; — the angle of the incident light plus the beam shift angle for cases where the reflection of direct light are dominating; — the beam shift angle for cases where the reflection of diffuse light are dominating.

Table 167 (*continued*)

Element	Attribute	Quantification
Task	Design viewing direction range (angle of inclination and azimuth)	The supplier shall specify the design viewing direction range (see Figure 20).  The maximum inclination angle range, Θ_{range}, is: $\Theta_{range} = 2 \times \arctan(D_{active}/2 \times D_{design,view})$ where D_{active} is the diagonal of the active display area; $D_{design,view}$ is the design viewing distance. The design inclination angle is within: $0° \leqslant \Theta_D \leqslant 40° - \Theta_{range}/2$. The azimuth angle, Φ, is 0° to 360°. NOTE This definition corresponds to viewing direction range class $\text{Class}_{viewing}$ III, see Reference [19]. **Figure 20 — Design viewing direction — Handheld device LCD**
	Eye and head movement	From fixed to moving.
	Number of users	Typically single, but might be multiple.
Usage	Display handling	For this compliance route, stationary and portable display handling is considered, if not otherwise specified by the supplier.

5.5.2 Information about the technology

The basic physical attributes of emissive, reflective or transflective LCD technology for handheld devices are given in Table 168. The supplier shall submit a detailed technical specification — rated voltage, rated frequency, rated current, rated power consumption, panel specification, LCD, LCD panel specification, horizontal/vertical pixel size, original resolution, subpixel drawing, anti-reflection treatment, pixel fault declaration, LCD mode, LCD effect, prepared gamma value, factory setting of “brightness”, “contrast”, “colour” control, reference colour gamut, e.g. as defined by the ITU if colour processing is used, etc. In addition, the supplier shall submit the test pattern, if required.

Table 168 — Basic physical attributes of emissive, reflective or transflective handheld device LCD

Basic physical attributes	Description
Optical mode of operation	Emissive, reflective or both emissive and reflective. NOTE A visual display which is both emissive and reflective can consist of a transflective display panel with a backlight, a reflective display panel with a transparent frontlight, a reflective display panel with a sidelight or be inherently both reflective and emissive.
Mode of observation	Direct-view
Diagonal of the active display area	Approximately 1,4 in (35 mm) up to 9,1 in (231 mm)
Aspect ratio	Depending on application
Resolution (addressable pixels)	Depending on application
Light source	Built-in as frontlight, backlight or sidelight
Touch screen	None or built-in

5.5.3 Compliance assessment

The compliance assessment for the handheld device LCD visual displays shall be made in accordance with Tables 170 to 197.

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.

Handheld display devices are used in a wide variety of illumination conditions. The darkroom or laboratory illumination condition can be far removed from actual usage conditions. The approach of this compliance route is to make the measurements in stable laboratory conditions with darkroom and laboratory light source illumination and then convert by calculation to the contexts of use prescribed by the compliance route. For every type of technology, including emissive technologies, the compliance determination shall always be made with the total reflected and emitted light. Except if not explicitly defined differently, this requirement is met only if met for all illuminance levels and illuminants defined in the intended context of use. The assessment is further complicated by the many different illumination conditions available. In this part of ISO 9241, three illumination conditions are considered: small aperture source direct illumination, large aperture source direct illumination and (approximately) diffuse illumination. For compliance purposes related to the illumination of a handheld display device, it is sufficient that the visual display meets the requirements related to luminance under one of these three conditions, because all three illumination geometries are usually available and the user will unconsciously select the appropriate illumination by tilting, turning and moving the handheld display device in his/her hand.

This means precalculation of many combinations of illuminance levels 50 lx, 200 lx, 500 lx, 750 lx, 1 500 lx and 5 000 lx, illuminants A, D65, F11 and F12 and the three different illumination conditions.

As a consequence, it is not practical to report all individually calculated values in the test report, but it is sufficient to report the key technical data on a general level and “pass”, “fail” or “compliance uncertain” for the individual requirements. If the handheld display device fails the test, the report shall include a statement of which illuminance levels and illuminants the handheld display device failed to meet. A test agency shall, on request, report the detailed values including uncertainties to the customer that ordered the test.

To aid the user in understanding the performance and limitations of the handheld display device, the test agency shall issue an overview table and the supplier shall publish that table in the user’s manual. The minimum requirements of the overview table shall be in accordance with Table 169.

Table 169 — Sample compliance overview table

Description of covered ambient condition		**Statement of Pass or Fail**			
Illumination level lx	**Representative environment**	**Illuminant A** (halogen and incandescent)	**Illuminant D65** (daylight)	**Illuminant F11** (4 000 K fluorescent light bulb)	**Illuminant F12** (3 000 K fluorescent light bulb)
50	Homes and general building areas	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]
200		[Pass/Fail]	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]
500	Offices, medium assembly and decorative work, simple inspection, counters, libraries, (mostly) educational areas, control rooms	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]
750		[Pass/Fail]	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]
1 500	Precision work, special workplaces, areas with large windows	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]
5 000		[Pass/Fail]	[Pass/Fail]	[Pass/Fail]	[Pass/Fail]
[General explanation of the compliance cases that the visual display failed to meet]		[Free-form description giving the main reasons for not passing one or more of the compliance cases in the table]			

Table 170 — Viewing conditions

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Design viewing distance	The design viewing distance is: a) for children: minimum 200 mm; b) for adults: minimum 300 mm; c) for elderly people: minimum 450 mm. NOTE These requirements need to be considered in conjunction with the character height requirements.	Supplier specification, intended context of use	Use supplier-specified values or values obtained from the 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, (Θ_D, Φ_D), as well as the design viewing direction range shall be specified. In addition, the following applies. **a) Requirement level "Low"** There shall be at least one design viewing direction at which all requirements are met. **b) Requirement level "Medium"** All requirements shall be met within the design viewing direction range. **c) Requirement level "High"** In addition to the low/medium level requirements, the visual display may be tilted at least ± 5° in any angle and still meet all requirements. NOTE These requirements need to be considered in conjunction with those for luminance non-uniformity, colour non-uniformity and contrast non-uniformity.	Supplier specification, intended context of use	See Table 171.

Table 171 — Assessment and reporting for design viewing direction

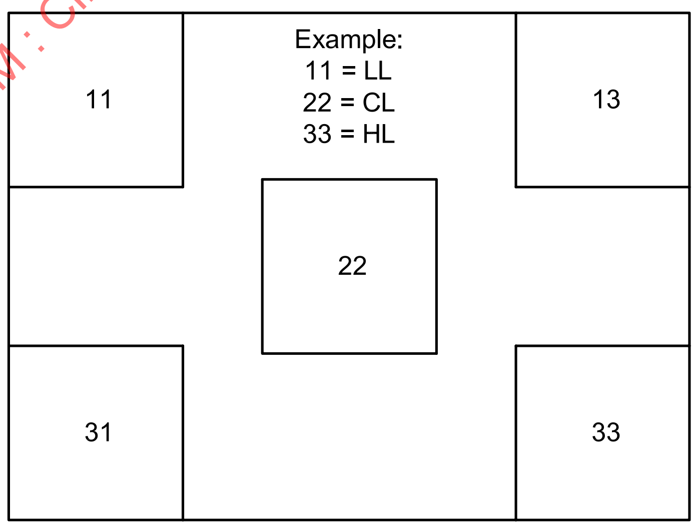
According to Table 170	Assessment and reporting
	Step 1 Use supplier-specified values or values obtained from the intended context of use. Report the resulting value. Step 2 Determine the measurement locations. Normal photometric practice is to use a target that is at least 60 % larger than the luminance meter image to guarantee that edge effects are eliminated. When possible, 85 % or more is preferred. With noted exceptions, make all measurements with 1° targets imaged in the luminance meter focused in the centre of the target (see ISO 9241-305). Depending on the diagonal of the active display area, choose three final measurement locations from an odd number of initial locations. The number of initial locations is from 5 up to a maximum of 11. The initial locations should not overlap. Display the initial locations with maximum grey level for monochrome visual displays or combination R=G=B = 100 % for multicolour visual displays. The locations are screened for their darkroom area-luminance or their selected luminance coefficient under perpendicular measurement direction. Select the site that has the lowest measured luminance (LL, low location) and the site that has the highest measured luminance (HL, high location). The centre site (CL, centre location) is always selected. If there are locations on the screen, outside the assessed initial locations, which in typical ambient lighting user conditions are visibly worse than the LL or HL, then the measurements shall be performed in those locations in addition to the LL and HL locations. The judgement of "visibly worse" shall be made in darkroom conditions and by a trained person. NOTE 1 The "visibly worse" definition is not unambiguous. The aim is to find the locations that are visible to an average user in ambient lighting. When the judgement is made in darkroom conditions and by a trained person, the detection threshold is significantly lower than for the average user. Therefore, the risk that an average user would detect a worse location not detected by the test laboratory can be neglected. NOTE 2 Most flat panels that currently meet the conditions of this part of ISO 9421 do not have such "visibly worse" locations. NOTE 3 With an automatic test device, the visibly worst location can be found, for example, by scanning the whole screen in steps of 1° (subtended angle). Carry out optical measurements at measurement locations HL, LL and CL as shown in Figure 21.  **Figure 21 — Typical measurement locations on handheld device LCD display**

Table 171 (*continued*)

According to Table 170	Assessment and reporting
	Step 3 Determine the measurement directions. **a) Requirement level “Low”** One measurement direction is defined as: — measurement direction 7: $\Theta = \Theta_D$, $\Phi = \Phi_D$ (design viewing direction) **b) Requirement level “Medium”** Eight measurement directions are defined as follows: — measurement direction 0: $\Theta = 0°$, Φ = not applicable (perpendicular); — measurement direction 1: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D + 2 \times \Phi_C$; — measurement direction 2: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D + \Phi_C$; — measurement direction 3: $\Theta = 0{,}5 \times \Theta_{range} - \Theta_D$, $\Phi = \Phi_D - 180°$; — measurement direction 4: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D$; — measurement direction 5: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D - \Phi_C$; — measurement direction 6: $\Theta = 0{,}5 \times \Theta_{range}$, $\Phi = \Phi_D - 2 \times \Phi_C$; — measurement direction 7: $\Theta = \Theta_D$, $\Phi = \Phi_D$ (design viewing direction). **c) Requirement level “High”** Eight measurement directions are defined as follows: — measurement direction 0: $\Theta = 0°$, Φ = not applicable (perpendicular) — measurement direction 1: $\Theta = 0{,}5 \times \Theta_{range} + 5°$, $\Phi = \Phi_D + 2 \times \Phi_C$; — measurement direction 2: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range} + 5°$, $\Phi = \Phi_D + \Phi_C$; — measurement direction 3: $\Theta = 0{,}5 \times \Theta_{range} - \Theta_D + 5°$, $\Phi = \Phi_D - 180°$; — measurement direction 4: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range} + 5°$, $\Phi = \Phi_D$; — measurement direction 5: $\Theta = \Theta_D + 0{,}5 \times \Theta_{range} + 5°$, $\Phi = \Phi_D - \Phi_C$; — measurement direction 6: $\Theta = 0{,}5 \times \Theta_{range} + 5°$, $\Phi = \Phi_D - 2 \times \Phi_C$; — measurement direction 7: $\Theta = \Theta_D$, $\Phi = \Phi_D$ (design viewing direction); where $\Phi_C = 90° - 0{,}5 \times \arctan(W_{view}/H_{view})$, when $W_{view}/H_{view} > 0{,}727$; $\Phi_C = 72°$, when $W_{view}/H_{view} \leqslant 0{,}727$; where H_{view} is the height of the active display area; W_{view} is the width of the active display area.

Table 172 — 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 shall permit the user to view the screen with a gaze angle from 0° to 45° and a head tilt angle from 0° to 20°.	Not applicable.	Not applicable.
Virtual images	Outside the scope of this part of ISO 9241.	Not applicable.	Not applicable.

Table 173 — Luminance

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Illuminance	The supplier shall specify the minimum and maximum design screen illuminance, E_S, as well as the illuminant. The following applies. **a) Requirement level "Low"** All requirements shall be met in at least one specified but not all lighting conditions with either artificial or reality information. **b) Requirement level "Medium"** All requirements shall be met in all lighting conditions with either artificial or reality information. **c) Requirement level "High"** All requirements shall be met in all lighting conditions with either artificial or reality information.	Supplier specification, intended context of use	Use supplier-specified values or values obtained from intended context of use. Report the resulting values.
Display luminance	Depending on the type of information shown, the visual display shall fulfil the following requirements. **Artificial information** **a) Requirement level "Low"** Emissive visual displays shall have a minimum display luminance of 20 cd/m^2 over all relevant viewing directions (see design viewing direction). Reflective visual displays shall have a minimum display luminance of $L = R \times E_S/\pi$ over all relevant viewing directions (see design viewing direction) for R = 20 %. **b) Requirement level "Medium"** Emissive visual displays shall have a minimum display luminance of 35 cd/m^2 over all relevant viewing directions (see design viewing direction). Reflective visual displays shall have a minimum display luminance of $L = R \times 5\ 000$ lx/π over all relevant viewing directions (see design viewing direction) for R = 20 %.	ISO 9241-305 P 12.5 M 12.1	See Table 174.

Table 173 (*continued*)

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Display luminance	**c) Requirement level "High"** Emissive visual displays shall have a minimum display luminance of 100 cd/m^2 over all relevant viewing directions (see design viewing direction). Reflective visual displays shall have a minimum display luminance of $L = R \times 5\,000$ lx/π over all relevant viewing directions (see design viewing direction), R = 55 %. **Reality information** **a) Requirement level "Low"** Emissive visual displays shall have a minimum display luminance of 20 cd/m^2 over all relevant viewing directions (see design viewing direction). Reflective visual displays shall have a minimum display luminance of $L = R \times E_{max}/\pi$ over all relevant viewing directions (see design viewing direction), R = 50 %. **b) Requirement level "Medium"** Emissive visual displays shall have a minimum display luminance of 35 cd/m^2 over all relevant viewing directions (see design viewing direction). Reflective visual displays shall have a minimum display luminance of $L = R \times 5\,000$ lx/π over all relevant viewing directions (see design viewing direction), R = 50 %. **c) Requirement level "High"** Emissive visual displays shall have a minimum display luminance of 100 cd/m^2 over all relevant viewing directions (see design viewing direction). Reflective visual displays shall have a minimum display luminance of $L = R \times 5\,000$ lx/π over all relevant viewing directions (see design viewing direction), R = 100 %. where L is the display luminance; R is the reflectance of the reflective visual display; E_S is the design screen illuminance; E_{max} is the maximum illuminance. NOTE 1 These luminance requirements need to be considered in conjunction with the contrast requirements. NOTE 2 Display luminance is always the sum of the emitted and the reflected light.	ISO 9241-305 P 12.5 M 12.1	See Table 174.