TECHNICAL SPECIFICATION

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Ergonomics of human-system interaction — Electronic paper display — Indoor use

Ergonomie de l'interaction homme-système — Affichage de papier électronique — Utilisation à l'intérieure

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Foreword

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The committee responsible for this document is ISO/TC 159, *Ergonomics*, Subcommittee SC4, *Ergonomics of human–system interaction*.

Introduction

The publication of the ISO 9241-300 series of International Standards addressed a wide range of visual display tasks and environments and provided the means for evaluating them. Not covered by those standards was the more recently developed electronic paper display (EPD) technology.

Owing to its unique optical characteristics, the current existing measuring methods may not be suitable for evaluating EPD.

Until measuring methods and compliance routes for EPD can be developed in the ISO 9241-300 series, this Technical Specification provides intermediate instruction and guidance. Using this Technical Specification together with ISO 9241-303 and ISO 9241-305 gives a good understanding of how to analyse an environment for which a specific analysis and compliance method does not yet exist.

Ergonomics of human-system interaction — Electronic paper display — Indoor use

1 Scope

This Technical Specification establishes test methods for evaluating electronic paper display (EPD) when used in indoor tasks and environments. It is intended to be applied together with the measurement procedures of ISO 9241-305 and the generic requirements of ISO 9241-303 to define compliance routes suitable for EPD.

2 Normative references

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

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

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*

3 Terms and definitions

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

3.1
electronic paper display
EPD
electronic display that shows information by diffuse reflection and holds the image with low power consumption

3.2
electronic reader
e-reader
electronic device which shows information using EPD

4 Electronic paper display for indoor use — Display laboratory method

4.1 Intended context of use

The attributes of the user, environment, tasks and the use of electronic readers based on electronic paper display (EPD) 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 1 Electronic readers with a diagonal of the active display area of up to approximately 7,1 inches (180 mm), corresponding to ISO A6 paper size, and up to 20,2 inches (514 mm), corresponding to ISO A3 paper size, are considered in this compliance route for typical visual display tasks for indoor use in work environments.

NOTE 2 Automotive environments, such as those of cars, trains and other vehicles, are not addressed here.

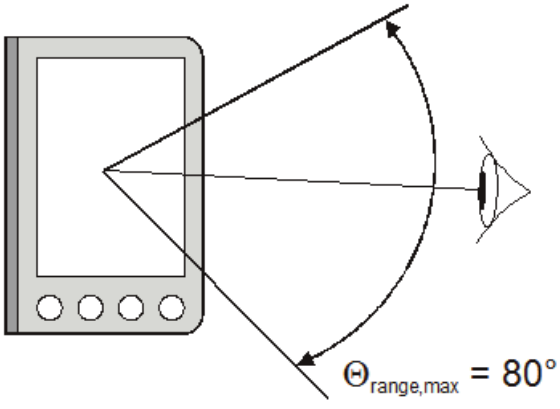
Table 1 — Intended context of use

Element	Attribute	Quantification
User	Age and vision	User with normal or to normal corrected vision of any age, 7 years or older (any literate user).
Environment	Design screen illuminance, E_S	At indoor locations: — minimum 20 lx — maximum 1 500 lx The supplier shall specify the design screen illuminance (or its range).
	Typical components of the illumination: large aperture source (15°) and small aperture source (1°) illumination.	N/A. There is no evaluation of unwanted reflections.
	Illuminant	For this compliance route CIE illuminant A, D50, D65, F11 and F12 are considered.[5] The supplier may specify the intended illuminant. 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. 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 approximate 15°C to 35°C is considered, if not otherwise specified by the supplier.

Table 1 *(continued)*

Element	Attribute	Quantification
Task	Content and perception	For this compliance route the following contexts for perception of information are considered, if not otherwise specified by the supplier. **Artificial information** Visualization of objects and scenes that do not have originals in our world, e.g. text (i.e. alphanumeric characters), graphical signs, symbols, etc. in monochrome (including achromatic) and/or multicolour (including full-colour) presentation. 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 require high performance in e.g. colour gamut, grey scale but also higher comfort regarding character attributes; **"Medium"** for general visual display tasks require sufficient performance to perceive colour and to read the information without discomfort by the user; **"Low"** for visual display tasks require low performance in e.g. colour gamut and grey scale, but with sufficient performance to read the information without discomfort by 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 and quasi-static images.
	Design viewing distance, $D_{\text{design,view}}$	The minimum design viewing distance, $D_{\text{design,view,min}}$, is > 200 mm. The supplier shall specify $D_{\text{design,view}}$.
	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 1 *(continued)*

Element	Attribute	Quantification
Task	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 (as shown below).  Therefore, the maximum angle of inclination, Θ, is 40°. The azimuth angle, Φ, is 0° to 360°
	Eye and head position	From fixed to moving.
	Number of users	Typically single.
Usage	Display handling	For this compliance route, stationary and portable display handling is considered, unless otherwise specified by the supplier.

4.2 Information about the technology

The basic physical attributes of electronic readers are given in Table 2.

The supplier shall submit a detailed technical specification which includes

— rated voltage,

— rated frequency,

— rated current,

— rated power consumption,

— panel specification,

— horizontal/vertical pixel size,

— original resolution,

— sub-pixel drawing,

— anti-reflection treatment,

— pixel fault declaration,

— prepared gamma-value, and

— factory setting of *brightness*, *contrast*, *colour* control.

The supplier shall also submit the test pattern, if required.

Table 2 — Basic physical attributes of the visual display

Basic physical attribute	Description
Optical mode of operation	Reflective
Mode of observation	Direct-view
Diagonal of the active display area	Approximately 7,1 inches (180 mm), corresponding to ISO-A6, and up to 20,2 inches (514 mm), corresponding to ISO-A3 paper sizes.
Aspect ratio	Depending on application
Resolution (addressable pixels)	Depending on application
Internal light source	None or built-in light source. If an electronic reader has supplement illumination, such as an integrated lighting unit on an EPD, either remove it or turn it off during testing.
Touch screen	None or built-in

4.3 Compliance assessment

The compliance assessment shall be given according to Tables 3 to 13.

Electronic paper displays for electronic readers are used in a wide variety of illumination conditions. The darkroom or laboratory illumination condition can vary greatly from actual usage conditions. The approach of this compliance route is to perform the measurements under 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.

Unless otherwise explicitly defined, a requirement is met only if it is met for all illuminance levels and illuminants defined in the intended context of use.

Table 3 — 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, a minimum of 200 mm; b) for adults, a minimum of 300 mm; c) for elderly people, a minimum of 450 mm. 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 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	Use supplier-specified values or values obtained from intended context of use. Report the resulting value.

Table 4 — Reflectance factor and illuminance

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. **b) Requirement level "Medium"** All requirements shall be met in all lighting conditions. **c) Requirement level "High"** All requirements shall be met in all lighting conditions.	Supplier specification, intended context of use	Use supplier-specified values or values obtained from the intended context of use. Report the resulting values.
Reflectance factor	The visual display shall fulfil the following requirements. **a) Requirement level "Low"** The visual display shall have a minimum reflectance factor of R = 20 % in order to get a minimum display luminance of $L = R \times E_S/\pi$. **b) Requirement level "Medium"** The visual display shall have a minimum reflectance factor of R = 38 % in order to get a minimum display luminance of $L = R \times E_S/\pi$. **c) Requirement level "High"** The visual display shall have a minimum reflectance factor of R = 55 % in order to obtain a minimum display luminance of $L = R \times E_S/\pi$, where L is the display luminance; R is the reflectance factor (reflectometer value) of the reflective visual display; E_S is the design screen illuminance. These luminance requirements need to be considered in conjunction with the contrast requirements.	ISO 9241-305:2008, P 16.1A The display shall be in its highest reflective state.	Determine the reflection coefficient according to the measuring method ISO 9241-305:2008, P16.5. Compare the minimum display reflectance factor for passed or failed as well as the fulfilled requirement level.

Table 5 — Special physical environments

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Excessive temperatures	When operation of visual display devices is required in environments where temperatures are approaching 0°C or +40°C, users should take precautions with equipment and personal precautions to ensure satisfactory and safe completion of their tasks. The following applies. **a) Requirement level "Low"** All requirements shall be met within the range 15°C to 30°C. **b) Requirement level "Medium"** All requirements shall be met within the range 0°C to 40°C. **c) Requirement level "High"** All requirements shall be met within the range −20°C to 40°C.	Supplier specification, intended context of use	Use a supplier-specified value or a value obtained from the intended context of use. Check whether the supplier has specified the use for extreme temperatures and report the resulting value.

Table 6 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Contrast uniformity	**a) Lateral uniformity criteria** For an intended uniform appearance, the contrast uniformity, $CR_{uniformity} = CR_{min}/CR_{max}$, shall exceed 50 % where CR is the luminance contrast. **b) Directional uniformity criteria** The visual display shall have a sufficient contrast uniformity over all relevant viewing directions (see design viewing direction). 1. CR shall exceed the limit CR_{min}. 2. There shall be no contrast inversion in the intended viewing direction range. See Table 9 for CR_{min}.	ISO 9241-305:2008, P 18.5 for a) P 18.8 for b)	Evaluate the contrast uniformity 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 11.	ISO 9241-305:2008, M 21.7 It is recommended that hemispherical illumination be used.	Report the supplier's declaration. Evaluate pixel and subpixel faults by direct observation. Determine and report the fault class. Rounding policy: round down: x,00 to x,49 → x round up: x,50 to x,99 → x + 1

Table 7 — Pixel fault classification

$Class_{Pixel}$	Type 1	Type 2	Type 3 (see table footnotes)		Cluster with more than one type 1 or type 2 faults	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

Table 7 *(continued)*

$Class_{Pixel}$	Type 1	Type 2	Type 3 (see table footnotes)		Cluster with more than one type 1 or type 2 faults	Cluster of type 3 faults
			Stuck high	Stuck low		
IV (for Type 3 = 1000 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

Type 1 = a hot pixel (always on, being colour white).

Type 2 = a dead pixel (always off, meaning black).

Faults that are below visibility threshold at the design viewing distance and design screen illuminance are not considered.

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

These fault classes consider the following.

a) Bright sub-pixel faults are perceived with more sensitivity than dark sub-pixel faults; therefore, pixel faults are weighted in perceived sensitivity units (PSU), where

— 1 Type 3 stuck high fault ≡ 2 PSU, and

— 1 Type 3 stuck low fault ≡ 1 PSU.

Therefore, different combinations of Type 3 faults in ClassPixel I, II, III and IV are possible.

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

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

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

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

3. $Class_{Pixel}$ II, for general user display tasks with a sensitivity to pixel faults, such as reading and processing text information, and perceiving objects and symbol information, with a reading performance sufficient for performing the task;

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

NOTE: Related ergonomics performance criteria with the threshold values of defects for visibility and different tasks are under investigation. See also Reference [4].

Type 3 faults are including 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 PSUs. The weighting of the PSU is indicated in front of the multiplier $n_{ClassPixel}$ of Type 3 faults.

The multiplier $n_{ClassPixel}$ 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, $Class_{Pixel}$ 0 or I the supplier shall specify the fault class, $Class_{Pixel}$ as well as the multiplier $n_{ClassPixel}$ depending on the specified distribution of PSUs.

The calculation of the maximum number of faults depends on the display size and the number of pixels of the display:

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

— for displays ≤ 9,1 inches (23,1 cm) with > 250 thousands pixels: per type per 250 000 pixels;

— for displays ≤ 9,1 inches (23,1 cm) with ≤ 250 thousands pixels: per type for the whole display.

Table 8 — Visual artefacts

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Moiré effects	The whole image area shall be free of moiré patterns to enable the user to perform the task in an effective and efficient way.	ISO 9241-305:2008, 5.3.15 5.3.16	Display, on the whole 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 whole 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 To be determined (TBD).	Evaluate other visual artefacts by visual inspection and report the resulting value for *passed* or *failed*.

Table 9 — Legibility and readability

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance contrast	Over all relevant viewing directions (see design viewing direction) the luminance contrast *CR* shall exceed the $CR_{\min}$ minimum luminance contrast of $\frac{L_{D,H}}{L_{D,L}} \geq 2,2 + 4,84 \times (L_{D,L})^{-0,65}$ where $L_{D,H}$ is the luminance component reflected from diffuse illumination while the display shows the high state; $L_{D,L}$ is the luminance component reflected from diffuse illumination while the display shows the low state.	ISO 9241-305:2008, M 12.2 P 12.4 P 18.2 For a reflective display, the emitted luminance in ISO 9241-305:2008, P 12.4 or P 18.2, is zero ("0").	Determine the reflection coefficient according to the measuring method ISO 9241-305:2008, M 12.2 for the low state as well as the high state. Based on the design screen illuminance, E_S, determine the resulting display luminance, $L_{D,L}$ and $L_{D,H}$, according to ISO 9241-305:2008, P 12.4. Determine the minimum luminance contrast by calculation of the right side of the Pass/Fail criteria formula. Determine the actual luminance contrast by calculation of the left side of the Pass/Fail criteria formula. Compare the minimum luminance contrast with the actual luminance contrast and report the resulting luminance contrast for *passed* or *failed*.

Table 10 — Legibility and readability

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image polarity	If the display provides positive and negative polarity, it shall meet all requirements of this compliance route for each image polarity. Both positive and negative polarity are accepted. The display shall meet all requirements in the polarities for which it is intended.	Not applicable.	Check requirements for character attributes for positive and negative polarity. If the visual display includes both hardware and software as one system, and this system provides only one polarity, then the requirements of this compliance route need be evaluated only for that polarity. Report the result.
Character height	**a) Requirement level "Low"** **For Latin-origin characters** the device shall have a character height within 16 min of arc to 22 min of arc at a defined fixed viewing distance within 300 mm to 600 mm. **For Japanese characters** the device shall have a character height within 20 min of arc to 35 min of arc at a defined fixed viewing distance within 300 mm to 600 mm. **b) Requirement level "Medium"** **For Latin-origin characters** the device shall have zoom supporting several viewing distances and character heights one of which is within 16 minutes of arc to 22 minutes of arc and 500 mm to 700 mm. **For Japanese characters** the device shall have zoom supporting several viewing distances and character heights one of which is within 20 min of arc to 35 min of arc and 500 mm to 700 mm. **c) Requirement level "High"** **For Latin-origin characters** the device shall have zoom enabling the user to select any character height 10 min of arc to 22 min of arc at any viewing distance 150 mm to 900 mm. **For Japanese characters** the device shall have zoom enabling the user to select any character height 20 min of arc to 35 min of arc at any viewing distance 150 mm to 900 mm.	ISO 9241-305:2008, 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* as well as the fulfilled requirement level. Report the font used as well as the number of pixels, $N_{H,Height}$, in the height of an unaccented, upper-case letter "H". Evaluate the default mode and report the character height in millimetres and in minutes of arc, the font used, and $N_{H,Height}$.
Text size constancy	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.	ISO 9241-305:2008, P 20.4	Not applicable.
Character stroke width	**For Latin-origin characters** The stroke width shall be within the range of 10 % to 17 % of character height. **For Japanese characters:** Not applicable.	ISO 9241-305:2008, P 20.7	Evaluate the character matrix and calculate the character stroke width. Report the resulting value for passed or failed.

Table 10 *(continued)*

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Character width-to-height ratio	**a) Requirement level "Medium/Low"** **For Latin-origin characters** the character width-to-height ratio shall be within the range from 0,5 : 1 to 1 : 1. **For Japanese characters:** Not applicable. **b) Requirement level "High"** **For Latin-origin characters** the character width-to-height ratio shall be within the range from 0,7 : 1 to 0,9 : 1. **For Japanese characters:** Not applicable.	ISO 9241-305:2008, P 20.8	Evaluate the character matrix and calculate the character width-to-height ratio. Report the resulting value for passed or failed, as well as the fulfilled requirement level.
Character format	**a) Requirement level "Medium/Low"** **For Latin-origin characters** — the minimum character matrix for continuous reading is 7 × 9 (width to height); — the minimum character matrix for numeric and upper-case-only presentations is 5 × 7 (width to height); — the character matrix shall be increased upward by at least two pixels if diacritics are used; — if lower case is used, the character matrix shall be increased downward by at least two pixels; — 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; — the 4 × 5 matrix may also be used for alphanumeric information not related to the operator's task, such as copyright information. **For Japanese characters** a minimum matrix of 11 × 11 shall be used. **b) Requirement level "High"** In addition to the medium/low requirements: **For Latin-origin characters and for higher density character matrices**, the number of pixels used for diacritics shall follow conventional designs for printed text. **For Japanese characters** a minimum matrix of 15 × 15 elements shall be used.	ISO 9241-305	Evaluate and report the character matrix. Report the resulting values for passed or failed, as well as the fulfilled requirement level.
Between-character spacing	**For Latin-origin characters** the minimum between-character spacing shall be one stroke width. **For Japanese characters:** Not applicable.	ISO 9241-305:2008, P 20.12	Evaluate the character matrix and report the between-character spacing. Report the resulting value for passed or failed.

Table 10 *(continued)*

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Between-word spacing	**For Latin-origin characters** the minimum number of pixels between words shall be the number of pixels in the width of an unaccented upper-case letter "N". **For Japanese characters:** 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	For Latin-origin characters: For tasks that require continuous reading of text, a minimum of one stroke width shall be used for spacing between lines of text. This area may not contain parts of characters or diacritics, but may contain underscores. For Japanese characters: For tasks that require continuous reading of text, the minimum between-line spacing should be within 1/2 to 3/4 of the horizontal or vertical stroke width.	ISO 9241-305:2008, P 20.14	Evaluate the character matrix and report the between-line spacing. Report the resulting value for *passed* or *failed*.
Characters per line of text	**For Latin-origin characters:** TBD **For Japanese characters**, for tasks that require continuous reading of text, the numbers of characters in horizontal/vertical direction should be around 30/40.	ISO 9241-305	Evaluate the characters per line of text and report the resulting value for *passed* or *failed*.
Margin of a page	TBD (to be determined). Planned for inclusion in ISO 9241-303.	TBD Planned for inclusion in ISO 9241-305	TBD

Table 11 — Legibility of information coding

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Luminance coding (For text and graphics, *not* for images)	Over all relevant viewing directions (see design viewing direction) the ratio between area-luminances of adjacent levels of a single area shall exceed $\frac{L_{\mathrm{D,Higherlevel}}}{L_{\mathrm{D,Lowerlevel}}} \geq 1,5$ where $L_{\mathrm{D,Higherlevel}}$ is the luminance component reflected from diffuse illumination, while the display shows the higher level; $L_{\mathrm{D,Lowerlevel}}$ is the luminance component reflected from diffuse illumination, while the display shows the lower level.	ISO 9241-305:2008, M 12.2 P 12.4 P 17.6	Determine the reflection coefficient according to the measuring method ISO 9241-305:2008, M 12.2 for the higher state as well as the lower state. Based on the design screen illuminance, E_S, determine the resulting display luminance, $L_{D,\mathrm{Higherstate}}$ and $L_{D,\mathrm{Lowerstate}}$, according to ISO 9241-305:2008, P 12.4. Determine the actual luminance coding ratio by calculation of the left side of the pass/fail criteria formula. Compare the result with the result with the set value and report the resulting value for *passed* or *failed*.

Table 12 — Fidelity

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting[a] [b]
Electro-optical transfer function (EOTF) and grey scale	**Requirement level "Low"** 1. Over all relevant viewing directions (see design viewing direction) the EOTF and its first derivative for each of the three primary colours should ascend 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 9241-305:2008, P 14.1 P 14.2 P 17.5 P 19.2 P 19.3	Measure and evaluate the electro-optical transfer function and the chromaticity uniformity difference. Report the resulting values for *passed* or *failed*.

[a] The chromatic fidelity of a visual display is evaluated on the basis of the additive colour mixing of the three primaries. In order to reduce the number of measurements required for assessment and reporting, the electro-optical transfer function (EOTF) is not measured for each primary colour individually, but only the achromatic states are evaluated.

This shall serve as a compact but significant measure for characterization of the chromatic fidelity of the visual display.

[b] If the R, G and B channels of the visual display have an unequal bit-depth, then the characterization and Pass/Fail determination may be a chromatic made for the individual channels instead of the state.

Table 13 — Fidelity

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Image formation time (IFT)	The IFT shall fulfil the following requirements. **a) Requirement level "Low"** **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. **Still images:** No requirement. **b) Requirement level "Medium"** **IFT ≤ 55 ms**: Contrast is stable for most applications. Motion artefacts can be distracting. **Still images:** No requirement. **c) Requirement level "High"** **IFT ≤ 10 ms:** 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. **Still images:** No requirement.	ISO 9241-305:2008, P 15.2 P 15.2A	Measure, using a minimum of 20 measurements, the image formation time between all combinations of the five different grey levels. The five grey levels are as follows: 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 %) Report the resulting values for — switching time t_{on} and t_{off} between grey levels, — IFT between grey levels, — minimum and maximum IFTs, and — mean value and standard deviation of IFT. Determine the capability for moving images.

Table 13 *(continued)*

Attribute	Pass/Fail criteria based on requirements and intended context of use	Measuring method	Assessment and reporting
Spatial resolution	**a) Requirement level "Low"** The resolution of the visual display should be sufficient for the tasks and images for which the display is intended. **b) Requirement level "Medium"** The resolution of the visual display should give a spatial resolution of approximately 0,75 min of arc to 1,5 min of arc at the design viewing distance so as to provide a good compromise between different requirements. **c) Requirement level "High"** 1. 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. 2. The visual display should have a spatial resolution of less than 1 min of arc at the design viewing distance.	Intended context of use/supplier specification ISO 9241-305:2008, 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: $\alpha = 60 \times 2 \times \arctan(b/2/D_{\text{design,view}})$ where b is the pixel size, in millimetres α is the spatial resolution, in minutes of arc; $D_{\text{design,view}}$ is the design viewing distance, in millimetres.
Pixel density	The supplier shall specify the pixel density.	Supplier specification	Report the resulting value.

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