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Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 3: Visual display requirements

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Exigences ergonomiques pour travail de bureau avec terminaux à écrans de visualisation (TEV)

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Partie 3: Exigences relatives aux écrans de visualisation

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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.

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.

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International Standard ISO 9241-3 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Sub-Committee SC 4, *Signals and controls*.

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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 3: Visual display requirements*

— *Part 4: Keyboard requirements*

— *Part 5: Workstation layout and postural requirements*

— *Part 6: Environmental requirements*

— *Part 7: Display requirements with reflections*

— *Part 8: Requirements for displayed colours*

— *Part 9: Requirements for non-keyboard input devices*

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— *Part 14: Menu dialogues*

— *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

— *Part 17: Form filling dialogues*

Annexes A, B, C and D of this part of ISO 9241 are for information only.

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Introduction

Task performance as well as the comfort of people in office work systems is affected by the presentation of information on the visual display terminal (VDT) and by the visual conditions at the workplace.

The satisfaction of individual human requirements is highly application-dependent. The recommendations and requirements defined here are based on established ergonomics principles, as described in ISO 6385.

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Ergonomic requirements for office work with visual display terminals (VDTs) —

Part 3:
Visual display requirements

1 Scope

This part of ISO 9241 establishes image quality requirements for the design and evaluation of single- and multi-colour VDTs. The requirements are stated as performance specifications, and the evaluations provide test methods and conformance measurements. It should be noted that, at present, the recommendations are based on Latin, Cyrillic, and Greek origin alphabetic characters, and Arabic numerals.

Other factors that affect performance and comfort are coding, format, and the style of presentation of information. With the exception of their visual aspects, they are not covered by this part of ISO 9241.

This part of ISO 9241 applies to the ergonomic design of electronic displays for office tasks. Office tasks include such activities as data entry, text processing, and interactive inquiry, but do not include recommendations for other specific applications such as computer-aided design or process control.

It is planned to issue recommendations on such applications separately.

2 Definitions

For the purposes of this part of ISO 9241, the following definitions apply.

2.1 angle of view: The angle between the line-of-sight angle and the line orthogonal to the surface of the display at the point where the line-of-sight intersects the image surface of the display.

2.2 anti-aliased font: Alphanumeric characters in which a technique has been utilized to smooth character edges.

2.3 between-character spacing: The distance between horizontally adjacent characters at their nearest point.

2.4 between-line spacing: The distance between vertically adjacent characters at their nearest point.

2.5 between-word spacing: The horizontal distance between adjacent words at their nearest point.

2.6 blink coding: Information presented by temporal luminance variations in images.

2.7 character format: The number of horizontal and vertical elements in the matrix used to form a single character.

2.8 character height: The distance between the top and bottom edges of a non-accented capital letter.

2.9 character size uniformity: The constancy in size of a particular character presented at different locations on the screen.

2.10 character width: The horizontal distance between the edges at the widest part of a capital letter (excluding serifs).

2.11 character width-to-height ratio: The ratio of character width to character height.

2.12 design viewing distance: The distance or range of distances (specified by the supplier) between the screen and the operator's eyes for which the images on the display meet the requirements of this part of ISO 9241, such as character size, raster

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modulation, fill factor, spatial instability (jitter) and temporal instability (flicker).

2.13 diacritic: A modifying mark near or through a character indicating a phonetic value different from that given the unmarked character.

2.14 display luminance: The luminance of the radiation emitted and reflected from the screen corresponding to the luminance of character symbols for bright images on a darker background, and the luminance of the background for dark images on a brighter background.

2.15 fill factor: The fraction of the total area geometrically available to a pixel that can be altered to display information.

2.16 image polarity: The relationship between background brightness and image brightness. The presentation of brighter images on a darker background is designated negative polarity, and darker images on a brighter background is designated positive polarity.

2.17 legibility: The visual properties of a character or symbol that determine the ease with which it can be recognized.

2.18 line-of-sight: The line connecting the point of fixation and the centre of the pupil.

2.19 linearity: The uniformity of the raster such that rows or columns appear straight and continuous.

2.20 luminance balance: The ratio between the luminances of the displayed image and its adjacent surround, or sequentially viewed surfaces.

2.21 luminance coding: Information presented by temporally independent differences in image luminances.

2.22 luminance contrast: The relationship between the higher (L_H) and lower (L_L) luminances that define the feature to be detected, expressed as either contrast modulation (C_m) defined as:

$$C_m = \frac{(L_H - L_L)}{(L_H + L_L)}$$

or contrast ratio (CR), defined as:

$$CR = \frac{L_H}{L_L}$$

2.23 luminance uniformity: The constancy in luminance between areas on the display that are intended to have the same luminance.

2.24 orthogonality: The appearance of geometric alignment or perpendicularity of rows and columns to each other.

2.25 pixel: The smallest addressable element of a display. In a multicolour display, the smallest addressable element capable of producing the full colour range.

2.26 raster modulation: The relative spatial variation in maximum to minimum luminance when all pixels are switched on.

2.27 readability: The characteristics of text which allow groups of characters to be easily discriminated, recognized, and interpreted.

2.28 spatial instability; jitter: The perception of unintended spatial variations in images.

2.29 stroke width: The edge-to-edge distance of a character stroke; for a multiple-pixel stroke, the exterior edge-to-edge width of the character stroke.

2.30 temporal instability; flicker: The perception of unintended temporal variations in luminance.

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3 Guiding principles

The office work system is an integrated whole, which includes the visual display work station, environment, task structure, organisational concerns, and sociological factors. The characteristics of a visual display terminal have to be considered in relation to the other elements of the work system and not as a collection of isolated visual requirements.

Design elements often interact such that optimising one degrades another. For example, for CRT displays there is a trade-off between character brightness and sharpness. Trade-offs should be made to achieve an acceptable balance.

A good work system should meet the needs of the individual. In a specific situation, this can be accomplished by custom design or by providing appropriate adjustability.

For viewing efficiency and comfort in office environments, the image quality should be significantly above the threshold values for the individual stimuli. The recommendations of this part of ISO 9241 take this into account.

4 Performance requirements

The objective of this part of ISO 9241 is to specify requirements for VDTs, compliance with which ensures that the VDTs are legible, readable and comfortable in use. (See clause 7 for compliance with this part of ISO 9241 and clause 2 for definitions.)

5 Design requirements and recommendations

5.1 Design viewing distance

For usual office tasks, the design viewing distance shall be no less than 400 mm.

For certain applications (e.g. soft key labels on touch screens) the minimum design viewing distance may be reduced to 300 mm.

Workstation parameters are the subject of ISO 9241-5. However, the workstation design should allow the display to be used within the design viewing distance. Preferably, if the task requires a significant amount of reading for context, the workstation design should permit the display to be used at a distance where the character height subtends approximately 20′ to 22′. Figure 1 gives a guide to the relationship between character height and viewing distance for character heights between approximately 2,0 mm and 5,0 mm.

The viewing distance requirement (and other requirements of this part of ISO 9241) are based on Latin, Cyrillic and Greek origin alphabetic characters and Arabic numerals. When the visual requirements for legibility and readability of more complex character sets, especially ideographic characters, are more fully understood, this part of ISO 9241 will be amended to include them.

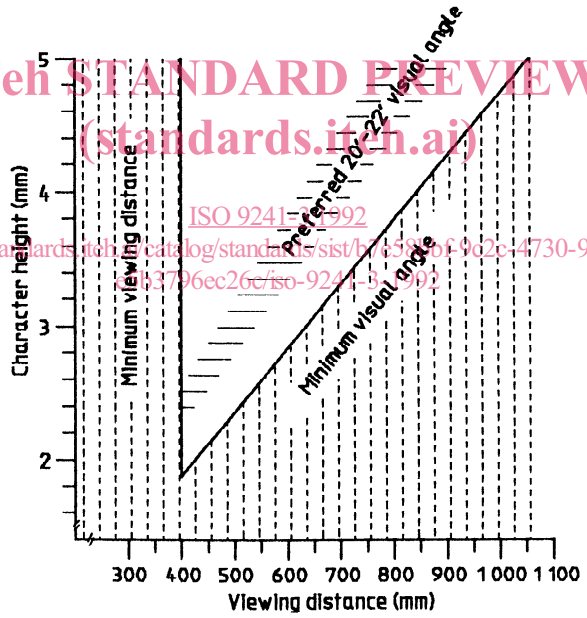

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Figure 1 — Relationship between design viewing distance and character height

5.2 Line-of-sight angle

It shall be possible to position the display so that those areas of it to be viewed continuously can be viewed with a line-of-sight angle between horizontal and 60° below the horizontal (see figure 2). This requirement applies to the entire workstation.

5.3 Angle of view

A display should be legible from any angle of view up to at least 40° from the normal to the surface of the display, measured in any plane. If this is not the case, the manufacturer shall specify the restricted angle of view, and the display shall be easy to reposition to an orientation in which it is legible (see figure 3).

5.4 Character height

Character heights subtending from 20′ to 22′ are preferred for most tasks. The minimum character height shall be 16′.

For applications where readability is incidental to the task, smaller characters may be used (e.g. for footnotes, superscripts, subscripts).

5.5 Stroke width

The stroke width shall be within the range of 1/6 to 1/12 of character height.

NOTE 1 In general, the wider stroke widths are preferred for a positive image polarity, and the narrower stroke widths for a negative image polarity.

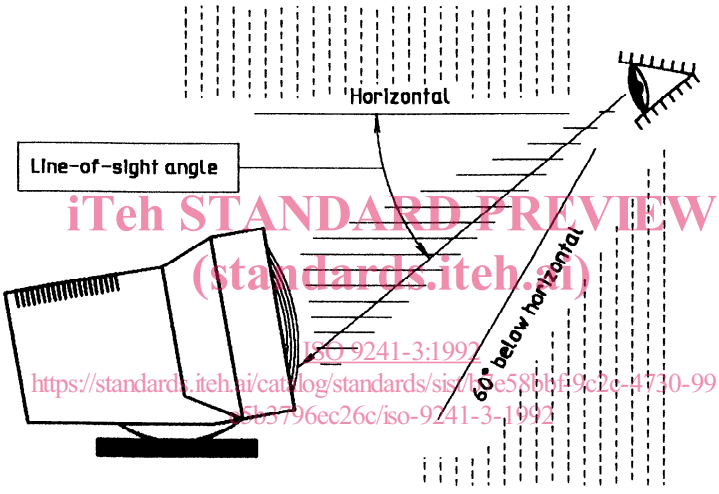

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Figure 2 — Line-of-sight angle

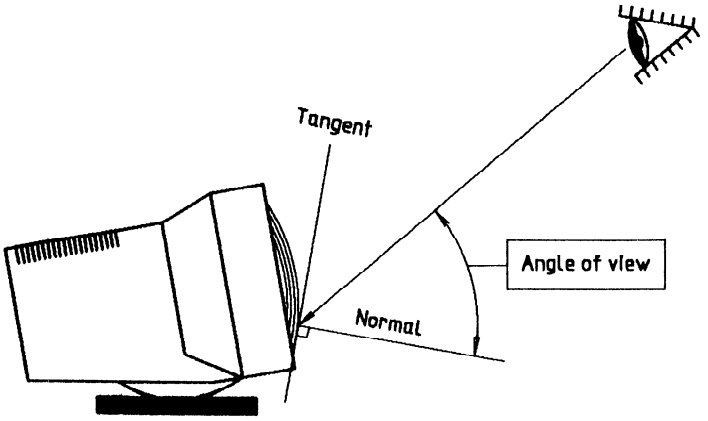

Figure 3 — Angle of view

5.6 Character width-to-height ratio

A width-to-height ratio between 0,7:1 and 0,9:1 is recommended for optimum legibility and readability. However, for other considerations (e.g. line length, proportional spacing) the ratio shall be between 0,5:1 and 1:1.

5.7 Raster modulation and fill factor

5.7.1 Raster modulation

For a CRT having a pixel density of less than 30 pixels per degree (perpendicular to the raster, 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, and $C_m = 0,7$ for multi-colour displays when all pixels are in their "on" state.

NOTE 2 For better legibility it is recommended that C_m should not exceed 0,2 for either type of display.

5.7.2 Fill factor

For non-CRT matrix displays having a pixel density of less than 30 pixels per degree at the design viewing distance, the fill factor shall be at least 0,3.

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5.8 Character format

A 5 pixels by 7 pixels (width × height) character matrix shall be the minimum used for numeric and upper-case-only presentations.

A 7 pixels by 9 pixels (width × height) character matrix shall be the minimum used for tasks that require continuous reading for context, or where individual alphabetic character legibility is important for the task, such as proofreading.

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, to accommodate the descenders of the lower case letters (see figure 4).

For higher density character matrices, the number of pixels used for diacritics should follow conventional designs for printed text.

A 4 pixels by 5 pixels (width × height) character matrix shall be the minimum used for subscripts and superscripts, and for numerators and denominators of fractions that are displayed in a single character position. It may also be used for alphanumeric information not related to the operator's task, such as copyright information.

For non-dot-matrix techniques, equivalent character shapes should be achieved.

5.9 Character size uniformity

The height and width of a specific character of a specific character font shall not vary by more than ± 5 % of the character height (see 6.6.1) of that character set, regardless of where it is presented on the display surface.

5.10 Between-character spacing

For character fonts without serifs, the between-character spacing shall be a minimum of one stroke width or one pixel (see figure 5). If characters have serifs, the between-character spacing shall be a minimum of one pixel between the serifs of adjacent characters.

5.11 Between-word spacing

A minimum of one character width (capital "N" for proportional spacing) shall be used between words.

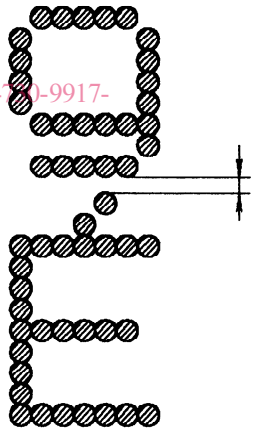

Figure 4 — Between-line spacing

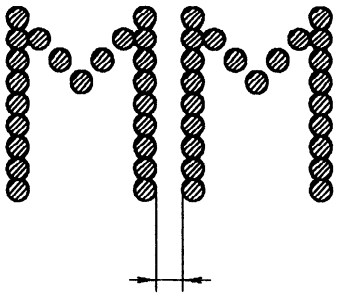

Figure 5 — Between-character spacing