

Ergonomics of design and use of visual display terminals (VDTs) in offices

Part 3. Specification for visual displays

Ergonomie de la conception et de l'utilisation
des claviers-écrans de bureau
Partie 3. Ecrans de visualisation —
Spécifications

Bildschirmarbeitsplätze in Büros; ergonomische
Anforderungen
Teil 3. Monitore

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Personal Safety Equipment Standards Policy Committee (PSM/-) to Technical Committee PSM/39, upon which the following bodies were represented:

AERC Institute of Engineering Research
 British Airways
 British Industrial Truck Association
 British Occupational Hygiene Society
 British Telecommunications plc
 Business Equipment and Information Technology Association
 Chartered Institution of Building Services Engineers
 Engineering Employers' Federation
 Ergonomics Society
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 Institute of Management Services
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 Loughborough University of Technology
 Ministry of Defence
 National Union of Mineworkers
 Society of Motor Manufacturers and Traders Limited
 Society of Occupational Medicine
 Trades Union Congress

This British Standard, having been prepared under the direction of the Personal Safety Equipment Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 30 November 1990

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The following BSI references relate to the work on this standard:
 Committee reference PSM/39
 Draft for comment 87/40676 DC

ISBN 0 580 18008 5

Amendments issued since publication

Amd. No.	Date	Text affected

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Foreword

This Part of BS 7179 has been prepared under the direction of the Personal Safety Equipment Standards Policy Committee.

This Part of BS 7179 specifies the ergonomics requirements for visual display terminals (VDTs) used for office tasks. Its purpose is to promote the health and safety of VDT users and to ensure that they can operate VDT equipment efficiently and comfortably. In practice, this can only be achieved by careful design of the VDTs themselves, the workstations and working environments in which they are used and the way the VDT work is designed, organized and managed.

This Part of this standard deals with ergonomics of the display itself.

Task performance and user comfort can be influenced by the characteristics of the visual display which determine its effectiveness in presenting an image to the user. The aim of this Part of BS 7179 is to ensure that the user should be able to detect and recognize the image accurately, quickly and without discomfort.

The display characteristics which influence detection and recognition performance are identified and where appropriate, design requirements for each characteristic presented.

The overall effect of these design characteristics can be assessed in a visual display performance test, details of which are given in appendix B.

User performance is specified in comparison with a reference display in terms of the accuracy and speed achieved by the test subjects in the detection and recognition tests and the maximum discomfort experienced.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared.

Other Parts of this standard are:

Part 1 Introduction

Part 2 Recommendations for the design of office VDT tasks

Part 4 Specification for keyboards

Part 5 Specification for VDT workstations

Part 6 Code of practice for the design of VDT work environments

Attention is drawn to the booklet 'Visual display units' published by HMSO and details of further sources of information on working with VDTs and on electrical safety are given in appendix H.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Specification

1 Scope

This Part of BS 7179 specifies image quality requirements as perceived by the user of the display for the design and evaluation of single and multicolour visual display terminals (VDTs) which satisfy the most basic aspects of visual perception. These aspects of visual perception are independent of specific display technologies. The image quality requirements are given in terms of design requirements and test methods. The requirements in this Part of BS 7179 apply to the design of electronic displays used in office tasks. It is concerned with people whose jobs include a significant proportion of office tasks using a VDT. It is assumed that such people will be seated while performing the VDT office task.

NOTE 1. General guiding principles are given in appendix A.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 7179, the definitions given in BS 7179 : Part 1 apply together with the following.

2.1 angle of incidence

The angle formed by the intersection of the line of sight and the line orthogonal to the surface of the display at the point where the line of sight intersects the surface of the display.

2.2 between-character spacing

The edge to edge distance between adjacent characters.

2.3 between-line spacing

The edge to edge distance between a vertically adjacent accented capital letter and a lower case letter with descender.

2.4 between-word spacing

The edge to edge distance between adjacent words.

2.5 blink coding

Alternating the luminance of the image, or a portion of the image, as a means of conveying information to the operator.

2.6 character format

The number of vertical and horizontal active elements in the matrix used to form a single upper case character.

2.7 character height

The distance between the top and bottom edges of a non-accented capital letter and stated in minutes of arc (the angle that the image would subtend on the retina from a given viewing distance).

2.8 character height-to-width ratio

The ratio of the distances between the top and the bottom edges and the widest part of the non-accented capital letters.

2.9 colour coding

A method to convey information by giving components of a screen image a predefined colour appearance.

2.10 colour difference

Perceived colour contrast or the total difference between two colours expressed in terms of recommended colour-difference equations.

2.11 colour notation

Specification of components of colour appearance according to an established colour notation system or a recommended perceptually uniform colour space.

2.12 contrast

The difference between two compared stimuli.

NOTE. See also 2.26.

2.13 cathode ray tube (CRT)

A device commonly used as a computer terminal/word processor display. It consists of a vacuum tube in which an electron beam is deflected onto a fluorescent screen producing visible spots of light.

2.14 design viewing distance

The distance or range of distances that should be specified by the manufacturer between the screen and the operator's eyes for which the images on the display meet the criteria for character size, resolution, spatial instability (jitter) and temporal instability (flicker).

2.15 diacritics

Signs used to indicate different sounds or values of a letter.

NOTE. An example of a diacritic is a cedilla.

2.16 display luminance

The luminance of the radiation emitted or reflected from the display 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. The spatial average luminance is the luminance per unit area of the light emitted or reflected from an area corresponding to not less than 1 % of the surface of the display.

2.17 dot matrix

Geometric segments within a specific area (cell) which, when illuminated, produce a visible image.

2.18 glare

Condition of vision in which there is discomfort or a reduction in the ability to see significant objects or both due to an unsuitable distribution or range of luminance or to extreme contrasts in space or time.

2.19 image persistence

The spatial blurring or maintenance of visibility of an image when the image is moved or deleted.

2.20 image polarity

Lighter images on a darker background are identified as negative polarity and darker images on a lighter background are identified as positive polarity.

2.21 legibility

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

2.22 legible display

A display on which single characters can be recognized quickly and accurately.

2.23 line of sight angle

The angle between a horizontal line and the visual axis of the eye (the line connecting the point of fixation and the centre of the pupil).

2.24 luminance balance

The ratio between the luminance of the displayed image and its adjacent surround, or sequentially viewed areas.

2.25 luminance coding

A method to convey information by causing an intentional difference in luminance between two or more screen images.

2.26 luminance contrast

The ratio between the higher L_h and lower L_l luminances that define the edge to be detected, measured by contrast modulation (C_m) defined as:

$$C_m = (L_h - L_l) / (L_h + L_l)$$

or contrast ration C_R defined as

$$C_R = L_h / L_l$$

2.27 luminance non-uniformity

The measurable difference in luminance between or within image areas on the screen that are intended to have the same luminance.

2.28 modulation transfer function area (MTFA)

A metric for measuring resolution (see 2.37).

NOTE. MTFA has been developed for monochrome CRT displays and allows display resolution to be defined and relates it to human performances. Increasing MTFA increases a viewer's ability to see detail. The relationship between MTFA and visual performance is non-linear. MTFA is a measure of a display's ability to present sine waves and the eye's ability to detect the presence of a sine wave pattern.

2.29 non-linearity

A discontinuity of rows or columns that are intended to appear straight or continuous.

2.30 orthogonality

The appearance of geometric alignment (or perpendicularity) of rows and columns to each other.

2.31 per cent active area

The percentage of the display image area that emits light when all active matrix elements are switched on.

2.32 percent raster modulation

The spatial variation in maximum to minimum luminance when all pixels are switched on.

2.33 raster

The pattern of horizontal scanning lines traced by the electron beam in CRTs.

2.34 readability

The characteristics of text which allows groups of characters to be easily discriminated, recognized and interpreted.

2.35 readable display

A display on which strings of characters can easily be discriminated and recognized as meaningful units, e.g. words, phrases, equations.

2.36 reference display

A display that is known to comply with this standard and its performance can be used as a baseline against which the performance of a new display can be assessed.

2.37 resolution

The capability of a display to present the smallest discernible details (see 2.28).

2.38 spatial instability (jitter)

Visual perception of vertical and/or horizontal movement of the picture elements composing an image that is supposed to be stable.

2.39 stroke width

The edge to edge width of a character stroke.

2.40 symbol non-uniformity

A measure of the variability in size and shape of a particular symbol presented in different locations on the screen.

2.41 temporal instability (flicker)

The visual perception of the non-intentional temporal variation in a lighted image (dimming/brightening) on a refreshed display screen.

3 Conformance

3.1 General

A display shall comply with this Part of BS 7179 if:

- (a) the design requirements of clause 4 are met; or
- (b) when the display is assessed in accordance with appendix B the test results comply with 3.2.

NOTE 1. The test method in appendix B is intended to be used when the design requirements are not applicable, for example where new and different technologies are being used.

NOTE 2. Appendix C illustrates routes by which a display is assessed for conformance.

3.2 User performance assessment

When tested in accordance with appendix B the display shall comply with the following.

- (a) The average error rate across all test characters for each test subject and the time per block averaged across all test subjects shall not be significantly lower (as assessed by a one-tailed t-test at a significance level α of 1.05) than that achieved on the reference display.

NOTE 1. Other levels of α are acceptable provided the rationale of appendix C is followed.

- (b) Comparative subjective assessment of comfort in use of the display under test shall not be statistically significantly worse than that of the reference display.

NOTE 2. Each test subject is tested on both displays. Therefore these are 'related' samples, i.e. each test subject acts as his/her control.

4 Design

4.1 General

Display characteristics which influence user performance, i.e. the detection and recognition of displayed images, shall comply with 4.2 to 4.15.

NOTE. Where appropriate, guidance on the minimum, maximum and optimum values of each characteristic is presented: the end result will be a display which can be read accurately with no discomfort to the user. Although these individual characteristics contribute to the clarity and stability of the display, they do interact and it is their combined effects which determine the ultimate quality of the display. For example, the clarity of a displayed image is influenced by its size, definition, contrast against the background and spacing from other images. In general terms the display will show a stable and clear image uniformly across all parts of the display surface.

4.2 Display polarity

Either display polarity, dark symbols on a lighter background (positive polarity) or light symbols on a darker background (negative polarity), shall be acceptable.

NOTE. When a positive polarity mode is used more attention should be given to the control of flicker; whereas for a negative polarity mode, more attention should be given to the control of specular glare and reflections.

If a display provides switchable polarity (as users vary in their preferences for display polarity), it shall comply with this Part of BS 7179 in each polarity.

4.3 Character size and shape

4.3.1 Character height

When measured in accordance with D.2 the minimum mean character height shall be 16' of arc.

NOTE. A mean character height of between 20' and 22' of arc is preferred for most tasks.

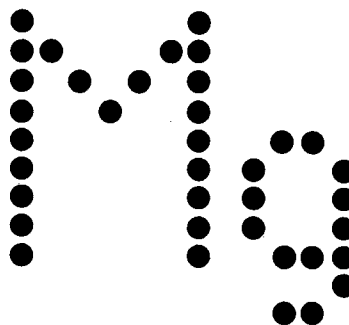


Figure 1. Character format

4.3.2 Character height to width ratio

When measured in accordance with D.3 the height to width ratio for character sets not proportionally spaced shall be between 1.07 and 1.09. For proportional spacing the height to width ratio shall be between 1.05 and 1.1.

4.3.3 Stroke width

When measured in accordance with D.4 the stroke width shall be within the range of 1/6 to 1/12 of character height.

NOTE. Wider stroke widths are preferred for positive polarity modes than for negative polarity modes.

4.3.4 Character format (see figure 1)

Displays which form characters using a dot matrix shall comply with the following.

- (a) A 7 x 9 (width to height) character matrix shall be the minimum used for tasks which require continuous reading for context, or where individual alpha character legibility is important for the task, such as proofreading.

NOTE 1. The vertical height should be increased upwards by two dot (pixel) positions if diacritics are to be used. If lower case is to be used, the vertical height should be increased downwards by at least two dot (pixel) positions, preferably by two or more, to accommodate the descenders of the lower case letters.

- (b) A 5 x 7 (width to height) character matrix shall be the minimum to be used for numeric and upper case only presentations.

NOTE 2. The vertical height should be increased upward by two dot positions if diacritics are to be used.

- (c) A 4 x 5 (width to height) character matrix shall be used for superscripts and for numerators and denominators of fractions that are to be displayed in a single character position.

NOTE 3. The 4 x 5 matrix may also be used for alphanumeric information not related to the operator's task, such as copyright identification.

4.4 Character spacing

4.4.1 Between-character spacing (see figure 2)

For character fonts without serifs the between-character spacing shall be a minimum of one stroke width or one pixel whichever is greater. If characters have serifs, the between-character spacing shall be a minimum of one pixel between the serifs of adjacent characters.

4.4.2 Between-line spacing (see figure 3)

A minimum of one stroke width or pixel, whichever is greater, shall be used for spacing between lines of text. This area shall not contain parts of characters such as diacritics but may contain underscores.

4.4.3 Between word spacing

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

4.5 Sharpness of display

For a CRT having a pixel density of less than 30 pixels per degree perpendicular to the raster (at the design viewing distance), the raster (luminance) modulation as measured in accordance with D.5 in the direction perpendicular to adjacent raster lines shall not exceed 20 % when all lines and all pixels are in their 'on' state.

This requirement shall be met when the pixel luminance is set at half the maximum luminance.

For non-CRT matrix displays, the per cent active area as calculated according to D.6 shall be at least 30 % for displays having a pixel density of less than 30 pixels per degree at the design viewing distance.

NOTE 1. It is recommended that the MTFA metric of a display should have a value of at least 5 for mono displays. As a minimum this value has to be achieved at the centre and the four corners of the active display area for the design viewing distance.

The value can be obtained directly from microphotometric measurements or for CRT displays it can be estimated using the formula given in appendix E.

NOTE 2. At the present time there is no accepted metric for displays other than monochrome CRTs, that adequately defines resolution and relates it to human performance.

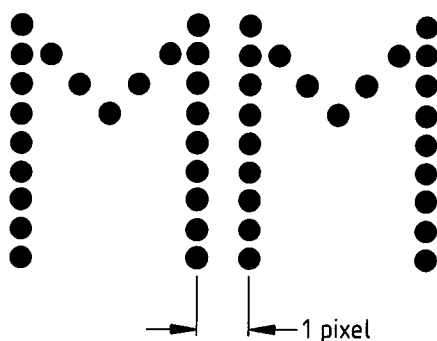


Figure 2. Between-character spacing