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Ergonomics of human-system interaction —

Part 306:
Field assessment methods for electronic visual displays

Ergonomie de l'interaction homme-système —

Partie 306: Méthodes d'appréciation sur le terrain des écrans de visualisation électroniques

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This second edition cancels and replaces the first edition (ISO 9241-306:2008), which has been technically revised. The main changes compared to the previous edition are as follows:

— cathode ray tubes (CRT) displays have been added to a new informative Annex E;

— definitions of five chromatic text charts for elementary or device hue output have been added to Annex D.

A list of all parts in the ISO 9241 series can be found on the ISO website.

Introduction

This document is part of the ISO 9241 series which establishes requirements for the ergonomic design of electronic visual displays. At the same time, this "300" subseries replaces either partially or fully certain previously published parts of ISO 9241 as well as several other International Standards (see the Forewords of the respective parts for the details).

— An introduction to the subseries is given by ISO 9241-300.

— Terms and definitions related to electronic visual displays have been transferred to, and collected in, ISO 9241-302.

— While the areas previously covered in ISO 9241 and by ISO 13406 remain essentially unchanged, test methods and requirements have been updated to account for advances in science and technology.

— All generic ergonomic requirements have been incorporated into ISO 9241-303.

— The application of those requirements to different display technologies, application areas and environmental conditions — including test methods and pass/fail criteria — are specified in ISO 9241-307.

— Methods for performing formal display measurements to determine display characteristics and verify technical specifications (tests that can be very costly and time-consuming and that are normally performed under rigorous test conditions with a new device) are given in ISO 9241-305 and ISO 9241-307.

— In addition, guidance on the design of SED (surface-conduction electron-emitter displays) and OLED (organic light-emitting diode) displays is given in ISO/TR 9241-308 and ISO/TR 9241-309.

The overall modular structure of the subseries facilitates its revision and amendment, as ongoing technological development enables new forms of display interaction.

This document is concerned with ergonomic workplace assessment and is aimed at providing a means of assessing whether or not the visual ergonomic requirements specified in ISO 9241-303 are satisfied within a specified task setting. The intention is not necessarily to produce a perfect display with optimum visual characteristics, but rather to ensure that the needed qualities to perform the visual task satisfactorily are indeed present.

During the lifetime of a display, the context in which it is used can often vary; "ageing" normally takes place as the display is used and, as a result, the performance of the display can be reduced over time. The lighting conditions under which a display is used also often vary.

In actual VDT workstation use, the main ergonomic concerns are the visual task being performed and the input devices being used to accomplish the task.

There are several factors that make the performance of a visual task using a VDT different from that in many other non-VDT or paper tasks. These factors are related to the positioning of the various elements needed for performing the visual task.

The ergonomic goal is to be able to read the information on the display comfortably, easily, accurately and quickly (where necessary) — as when a paper "hardcopy" placed on the work desk is read.

One consideration is what can be called the *positional sensitivity* of the screen. If positioned poorly, displays are susceptible to external light sources: these can be reflected back to the viewer and can contribute to reduced legibility of the information on the screen. In more compelling environments, these light sources can give rise to glare. They can come from either natural light from windows or from artificial lighting systems such as overhead mounted luminaries in offices.

Given the size and dimensions of most displays, a display is typically oriented in a vertical rather than horizontal position. This orientation and position of the information to be read is considerably different than that when a book or paper placed on the desk is read. The line of sight from the eye to the visual task is raised up to 45°, giving rise to a quite different visual background, often with a varying luminous background arising from walls and other objects in the environment. These factors can affect the working posture of a user trying to compensate between the line of sight angle to the display needed to be maintained and the distance to the visual task.

These, and other, considerations demonstrate that the positioning of a display is much more important than the mere positioning of paper or other hardcopy reading materials. They give rise to the need to be able to adjust the display for orientation and height and to have the flexibility to set up the workstation equipment so that the needs of a specific user can be met. The combination of display, lighting environment and workstation equipment are the basics for an ergonomically well-designed workplace.

Unlike most visual task materials, displays are intended to be used for several years. Many other kinds of work materials are used only once or a few times, or are renewed or refreshed when visibility is too low or possibly too uncertain (e.g. safety instructions or warnings), or else simply remain unchanged over time.

The display assessment methods presented in this document do not, in most cases, require expensive measuring equipment and can generally be carried out easily in a working field environment. In conducting these assessments, it ought to be possible to determine whether a problem is related to:

a) the display itself (or the display in combination with the graphic adapter);

b) the application software; or

c) physical environmental conditions.

In cases involving the display, it is beneficial that the workstation set-up be reviewed to determine whether it meets the supplier’s recommendations; if it does not, another assessment is performed to determine how it can be made to meet them. In cases involving the application software, it can be necessary to contact the software developers of the application product in order to ascertain possible corrective action. In cases involving conditions in the physical environment, simple re-orientations or the repositioning of the workstation and/or display can be a satisfactory solution; whereas, in more complex situations, it can be necessary to make arrangements with the relevant interested parties in order to ascertain appropriate actions and their feasibility. For details, see Annex B.

The ISO 9241 series was originally developed as a 17-part International Standard on the ergonomics requirements for office work with visual display terminals. As part of the standards review process, a major restructuring of the ISO 9241 series was agreed to broaden its scope, to incorporate other relevant standards and to make it more usable. The general title of the revised ISO 9241 series, (Ergonomics of human-system interaction) reflects these changes and aligns the series with the overall title and scope of Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*. The revised series is structured as a series of standards numbered in the “hundreds”: the 100 series deals with software interfaces, the 200 series with human centred design, the 300 series with visual displays, the 400 series with physical input devices and so on.

See Annex A for an overview of the entire ISO 9241 series.

Ergonomics of human-system interaction —

Part 306:
Field assessment methods for electronic visual displays

1 Scope

This document establishes optical, geometrical and visual inspection methods for the assessment of a display in various contexts of use according to ISO 9241-303.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 9241-302, *Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays*

ISO 9241-303:2011, *Ergonomics of human-system interaction — Part 303: Requirements for electronic visual displays*

ISO 9241-307, *Ergonomics of human-system interaction — Part 307: Analysis and compliance 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 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Preparation for assessment

4.1 Cleaning

Ensure that the visual display is clean; otherwise, clean it according to the manufacturer's instructions.

4.2 Set-up

The visual display shall be physically prepared for assessment. Drive the visual display with the following parameters:

— resolution: use the native resolution or the resolution recommended by the manufacturer;

— in case of CRT, see Annex E;

— image size: adjust to a specified size.

NOTE Use the factory-recommended (physical) resolution. Changing this native resolution to another can cause a degradation of the display image quality and character presentation, due to imperfect pixel interpolation (see Figure 1).

a) Physical   b) Reduced

Figure 1 — Comparison of letters displayed with physical and reduced resolutions

4.3 Display warm-up

Allow sufficient time (at least 20 min) for the display luminance to stabilize. When indicated by the manufacturer, it shall be warmed up for the specified time.

NOTE For some technologies, a specific warm-up sequence is sometimes recommended. For example, Electronic Paper Displays (EPD) can recommend that the test pattern be refreshed three times before taking measurements.

4.4 Control settings of the visual display

The manufacturer should deliver the visual display with a factory setting that helps the user to use the visual display in an ergonomic and efficient way within the intended context of use. If available, the user should follow the recommendations given by the manufacturer for the setup conditions.

Addressed controls are the brightness control, the contrast control and the gamma adjustment.

For visual displays that permit grey scale rendering, use the output of the 16-step equally spaced grey scale of test chart AE06 with samples between black and white, see Figure D.2.

In the intended environment, perform a visual check of the following display output properties:

1) The lowest two black levels should just be discriminated.

2) The lightest two white levels should just be discriminated.

3) All grey levels should be distinguishable.

4) The visual display should have an appropriate brightness level.

To achieve these conditions, apply the factory settings and recommendations of the display manufacturer for the setup conditions. If available, use the controls of the visual display to meet the above display output properties.

In a dark room, the 16-step grey scale should be approximately visually equally spaced, if the gamma is adjusted according to IEC 61966-2-1. For any ergonomic output in a non-dark environment, it is intended that the grey scale is approximately equally space. If this output setup stage is reached for the dark environment, then the reflection of the ambient light on the display surface changes the visual equal spacing. The changes increase with increasing ambient reflections on the screen. In the worst case, about 5 dark grey steps may not be distinguishable.

5 Assessment methods

5.1 Viewing conditions

5.1.1 Design viewing distance

The optimum distance between the visual display and the user's eyes depends on various factors, in particular character legibility (see Table 1) and in certain cases the possibility of viewing a full application without head movement (see Table 2). The design viewing distance, i.e. the distance specified by the manufacturer of the display is set to ≥300 mm (see ISO 9241-303). The optimum viewing distance for desktop office work in a seated position is about 600 mm. However, individual users tend to prefer settings between 400 mm and 750 mm. Viewing distances in this range for most people require character heights that subtend between 20′ to 22′ of arc (see ISO 9241-303).

Check whether the display is used within the specified viewing distance, *D*. Measure the distance from the user's eyes to the centre of the screen with a ruler. For desktop office work, the normal range is 400 mm to 750 mm: if the chosen distance is outside of this range, verify that there is not an underlying problem, such as bad image quality, incorrect font size or an uncorrected vision problem.

If the visual task requires that the entire application, i.e. its page or line width, is viewed at a glance, i.e. without head movements, the minimum viewing distances from Table 2 are recommended. They result from the maximum horizontal viewing angle of ±15° with respect to the normal on the screen surface, which allows such viewing at a glance and depends on screen size. Typical applications are to be found in control rooms. Figure 2 shows the relation between viewing angle, application width and viewing distance.

Table 1 — Optimum and maximum viewing distances for character legibility

Character height mm	Viewing distance of generally accepted legibility cm	Maximum viewing distance cm
1,4	23	30
2	33	43
3	49	65
4	66	86
4,6	75	99
9,2	150	197
18,3	300	394

NOTE 1 The maximum viewing distance is based on character height of 16′ of arc. Generally accepted legibility, i.e. one that is well accepted by most users, is calculated based on 21′ of arc. The optimum character height for task performance is a compromise between the legibility goal and the goal of "surveying at a glance" — presenting all information related to the same context on the same screen.

NOTE 2 The simplified rule of thumb for character legibility is: for optimum legibility, viewing distance ≈165 × character height:

— acceptable range ≈ ±30 % for most users;

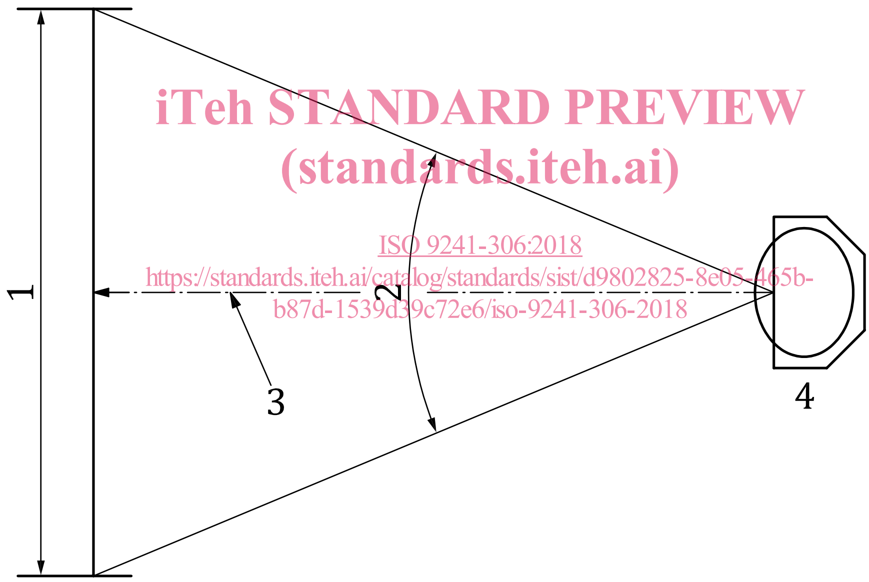
— acceptable range ≈ ±100 % for some users.

Table 2 — The smallest viewing distance at which the full application width can be used without need for head movement

Width of the application (or page or line) cm	Minimum viewing distance in order to avoid head movement cm
16	30
21	40
30	56
40	75
50	94
60	112
150	280
300	560

NOTE 1 The relationship is based on the ±15° requirement illustrated by Figure 2.

NOTE 2 In the field, it can be convenient to use the following approximation as a rule of thumb: viewing distance ≥1,9 × application width.



Key

1 screen width, *W*

2 viewing angle (±15°)

3 viewing distance, *D*

4 viewing location

Figure 2 — Viewing distance and viewing angle

5.1.2 Design viewing direction

If the display is a flat panel, check that it is used for the specified viewing direction class according to ISO 9241-303 and ISO 9241-307.

5.1.3 Gaze and head tilt angles

Verify that the work station and the visual display allow the user to view the screen with a gaze angle from 0° to 45° and a head tilt angle from 0° to 20°, using a device for measuring angles such as protractor or goniometer.

5.1.4 Virtual images

See ISO 9241-303:2011, Annex E.

5.2 Luminance

5.2.1 Illuminance

Measure the screen illuminance using a lux meter. Place the lux meter's sensor directly in the centre of the screen at the same tilt angle as applied by the user. Check that no shadows are falling onto the sensor.

Verify that the measured illuminance corresponds to the value specified by the supplier.

5.2.2 Display luminance

Measure the area luminance with a luminance meter in the centre of the visual display. Use:

a) full screen white at maximum grey level;

b) a white box at maximum grey level with a size of 4 % of the active display area, as per Formula (1).

$$A = H_{\text{view}} / 5 \times W_{\text{view}} / 5 \quad (1)$$

where

A is the active display area;

H_{view} is the height of the active display area, measured in meters;

W_{view} is the width of the active display area, measured in meters.

Place the luminance meter perpendicular to the display surface on the target. Verify that the measurement area of the luminance meter is smaller than the target.

Verify that the measured luminance values are in accordance with ISO 9241-307.

In case of interest, e.g. for determination of the lowest and highest luminance, repeat the measurement in measurement locations as defined by ISO 9241-307 for the individual technology.

5.2.3 Luminance balance and glare

Measure the luminance of the display (e.g. full screen white), of a frequently viewed task area (e.g. a document on the desk) and of a selected surround (e.g. a room wall). Calculate the luminance ratio between the screen and the frequently viewed area. Perform the same calculation for the luminance ratio between the screen and selected surround. Verify that the ratios are in accordance with the value range specified in ISO 9241-303.

A possible method of controlling the avoidance of glare is to check whether the surface of the housing is matte or glossy. Glossy surfaces can produce glare; the gloss value can be measured with a gloss meter or gloss reference samples.

5.2.4 Luminance adjustment

Verify that the luminance of the display and the contrast between characters and character background on the display are adjustable by the user to the ambient environmental conditions of the workplace.

5.3 Special physical environments

5.3.1 Vibration

See ISO 9241-303:2011, 5.3.2.

5.3.2 Wind and rain

See ISO 9241-303:2011, 5.3.3.

5.3.3 Excessive temperatures

See ISO 9241-303:2011, 5.3.4.

5.4 Visual artefacts

5.4.1 Luminance non-uniformity

Estimate the luminance non-uniformity by sequentially viewing different areas on the screen to determine the degree of non-uniformity. If it is determined that a noticeable amount of luminance non-uniformity is present, then the measurement of luminance with a luminance meter is recommended.

The measurement locations are the positions on the screen with the lowest and highest luminance (see 5.2.2). Determine the luminance non-uniform ratio using Formula (2):

$$L_{NU} = 100\ \% \left(\frac{L_{max} - L_{min}}{L_{max}} \right) \quad (2)$$

where

L_{NU} is the luminance non-uniformity;

L_{min} is the lowest luminance in cd/m^2;

L_{max} is the highest luminance in cd/m^2.

Verify that the luminance uniformity value is according to ISO 9241-307.

5.4.2 Colour non-uniformity

Display the full screen with only one colour and estimate the colour non-uniformity by sequentially viewing different areas on the screen. Repeat with different colours.

The subjective impression of colour is not only determined by the colour itself (chromaticity) but also by the luminance. For applications requiring exact colour distinction, use a colorimeter or a spectrophotometer. For further details, see ISO 9241-305.

5.4.3 Contrast non-uniformity

Calculate the contrast non-uniformity from the values measured in 5.2.2 using Formula (3):

$$C_{NU} = 100\,\% \left(\frac{C_{max} - C_{min}}{C_{max}} \right) \tag{3}$$

where

C_{NU} is the contrast non-uniformity;

C_{min} is the lowest contrast;

C_{max} is the highest contrast.

5.4.4 Geometric distortions

Disturbing changes of character form or character location due to image stability or geometry faults should not occur. Such geometrical faults can be ascertained, for example, by placing a rectangular sheet of paper on the horizontal or vertical lines in the intended area of the display.

Most of these faults can be corrected using the screen display controls.

5.4.5 Pixel faults

5.4.5.1 Pixel/subpixel stuck on

These pixels/subpixels always appear as bright on a black background. Use a black screen to observe.

5.4.5.2 Pixel/subpixel stuck dim

These pixels/subpixels can appear as grey, independent of white or black background. To observe, first use a white and then a black screen.

5.4.5.3 Pixel/subpixel stuck off

These pixels/subpixels always appear as dark on a white screen. Use a white screen to observe.

NOTE For a complete analysis, refer to Reference [7]. To determine the pixel fault class, see ISO 9241-307.

5.4.6 Temporal instability (flicker)

See ISO 9241-303:2011, 5.4.7.

5.4.7 Spatial instability (jitter)

A strong jitter can be simply observed by the user without a measurement device. Jitter measurements can be performed using a magnifying glass with a built-in scale.

For measurement methods, see ISO 9241-305.

5.4.8 Moiré effects

Moiré effects can be detected by visual inspection or appropriate monitor test programs.

Some visual displays have a built-in correction function that should be used to eliminate Moiré effects.