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

Part 7:
Requirements for display with reflections

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

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Partie 7: Exigences d'affichage concernant les réflexions

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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 9241-7 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human system interaction*.

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: Requirements for display with reflections*

— *Part 8: Requirements for displayed colours*

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

— *Part 10: Dialogue principles*

— *Part 11: Guidance on usability*

— *Part 12: Presentation of information*

— *Part 13: User guidance*

— *Part 14: Menu dialogues*

— *Part 15: Command dialogues*

— *Part 16: Direct manipulation dialogues*

— *Part 17: Form-filling dialogues*

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

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Introduction

Visual display terminals (VDTs) are subject to reflections of environmental luminance and illuminance from the display device surfaces. Under some conditions, the reflections become disturbing to the user and affect both comfort and task performance. The objective of this part of ISO 9241 is to maintain usable and acceptable VDT image quality in luminous environments that can cause reflections from the screen.

The document is intended for evaluators and users of VDTs. It is intended to be used with ISO 8995, ISO 9241-3, ISO 9241-6 and ISO 9241-8 to provide guidance for the visual ergonomics of the VDT workplace. Compliance with this part of ISO 9241 is dependent on the hardware characteristics of the VDT, except for polarity that can be application-dependent.

This part of ISO 9241 contains requirements and methods for measurement of the image quality of VDTs used in luminous environments that can cause specular and diffuse reflections from the screen. ISO 9241-3 and ISO 9241-8 contain requirements that deal with luminance and luminance ratios for VDT images measured under conditions that exclude specular reflections. These parts of ISO 9241 interact with this part of ISO 9241. VDTs that meet the interacting requirements and recommendations of ISO 9241-3 and ISO 9241-8 do not necessarily meet those of this part ISO 9241 and vice versa.

ISO 9241-6 and ISO 8995 contain specific recommendations concerning design of the workplace luminous environment to minimize sources of glare. The luminous environment conditions used to determine compliance with this part of ISO 9241 are drawn from, or are consistent with recommendations and requirements of these International Standards. The luminous environment values used to determine compliance to this part of ISO 9241 do not constitute specific recommendations or requirements for workplace lighting.

The burden of a visually acceptable VDT workplace is a tradeoff between the display hardware and the VDT environment. To acknowledge that tradeoff, compliance with this part of ISO 9241 has been developed in three classes, each with rules for decision based on environmental assumptions.

Although the decision rules are not expected to be exactly duplicated in the workplace environment, they do correspond approximately to general types of workplace environment to which VDTs are expected to be suitable:

Class	Environment
I	suitable for general office use
II	suitable for most, but not all, office environments
III	requiring a specially controlled luminous environment for use

An alternative test method is provided for VDTs whose characteristics preclude use of the quantitative test method.

NOTE — ISO 13406 extends the definitions, requirements, and test method of this part of ISO 9241 for flat panels whose colour and/or luminance contrast is strongly dependent on the direction from which they are viewed, and whose reflection characteristics can vary with the logical state of the screen.

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

Part 7:
Requirements for display with reflections

1 Scope

This part of ISO 9241

— establishes image quality requirements for VDTs used in luminous environments that may cause reflections from the screen. The requirements are stated as performance or design specifications, and test methods are provided.

— applies to the ergonomic design of direct-view electronic displays for office tasks, including such activities as data entry, text processing and interactive inquiry. Office tasks are performed indoors, without exposure to direct sunlight. The recommendations can possibly be appropriate for other tasks, including process control, graphic design and computer-aided design, but their applicability has not been established.

— applies to monochrome and multicolour displays. The following displays and similar types are excluded from the scope of this part of ISO 9241: multi-user projection displays, transparent displays and virtual image displays.

— applies to VDTs for which its test method is suitable. The test method is limited to VDTs whose colour and/or luminance contrast does not vary strongly as a function of the viewing direction, and whose reflection properties do not vary as a function of the logical state of the screen. The test method is suitable for emissive VDT technologies, such as cathode ray tubes, and some flat panels.

NOTE — VDTs using display devices for which the test method of this part of ISO 9241 is not suitable (for example, liquid crystal displays) are directed to ISO 13406-2.

2 Normative references

The following standards contain provisions which, through reference in the text, constitute provisions of this part of ISO 9241. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9241 are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 9241-3:1992. *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 3: Visual display requirements.*

ISO 9241-8:1997, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 8: Requirements for displayed colours.*

CIE 17.4: 1989, *International Lighting Vocabulary.*

3 Definitions and symbols

3.1 Definitions

For purposes of this part of ISO 9241, the definitions given in ISO 9241-3 (except in 3.1.5) and the following definitions apply.

3.1.1 dark room: Room in which the only sources of light are the VDT under test and the prescribed sources of luminance or illuminance.

3.1.2 extended source of luminance: Area of uniform luminance, $L_{A(EXT)}$ with a width or diameter of at least 15° measured from the VDT screen centre.

3.1.3 luminance coefficient (at a surface element, in a given direction, under specified conditions of illumination)$[q_V, q]$: Quotient of the luminance of the surface element in the given direction by the illuminance of the medium. [see IEC (50) 845-04-71].

NOTE — It is expressed per steradian.

3.1.4 luminance factor (at a surface element of a non-self-radiating medium, in a given direction, under specified conditions of illumination)(β_V, β): Ratio of the luminance of the surface element in the given direction to that of a perfect reflecting or transmitting diffuser identically illuminated [based on IEC (50) 845-04-69 unit: 1] (unit: 1).

3.1.5 luminance ratio: Ratio between a higher and a lower area-average luminance, in which each luminance in the ratio is the sum of emitted and reflected luminance components, with one or more components common to both the numerator and the denominator.

NOTE — To reduce potential confusion, the terms *contrast* and *luminance contrast* are avoided in this part of ISO 9241. The luminance ratios of this part of ISO 9241 do not correspond to the luminance contrast within and between character details of ISO 9241-3.

3.1.6 negative polarity: Condition in which the foreground luminance L_F is the highest luminance level of the display, and the background luminance, L_B is the lowest luminance level of the display.

3.1.7 positive polarity: Condition in which the foreground luminance L_F is the lowest luminance level of the display, and the background luminance, L_B is the highest luminance level of the display.

3.1.8 reflectometer value: Value measured using the test method of this part of ISO 9241 for the diffuse luminance coefficient, R_D (an estimate of q) and the specular reflection factor, R_S (an estimate of β).

NOTE — The measured reflectometer value depends on the geometric characteristics of the test method, on the illuminant, on the spectral sensitivity of the detector (even when equipped with filters), and on the reference standard used.
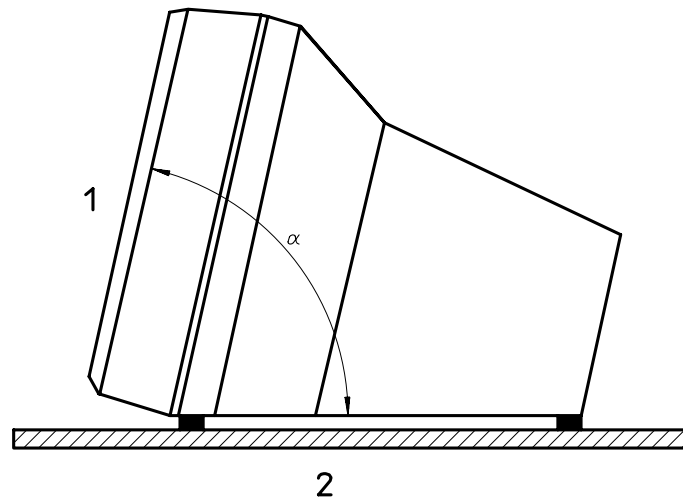
[Adapted from CIE 50(845): 1987].

3.1.9 screen tilt angle, α: Angle formed by the intersection of the plane tangent to the centre of the display and the horizontal plane.

NOTES
1   This is identical to the angle A in 6.1.2 of ISO 9241-3:1992.
2   Figure 1 shows the intended angle.
3   Screen tilt angle is expressed in degrees.

Key

1 Viewing side

2 Horizontal support surface

Figure 1 — Screen tilt angle

3.1.10 small source of luminance: Area with a diameter of 1° (measured from the screen) of uniform luminance ($L_{A(SML)}$), to be used in the measurement of specular reflections from screens with diffusing treatments.

3.2 Symbols

3.2.1 Primary symbols

The primary symbols used in this part of ISO 9241 are shown below. See figure 2.

E illuminance, expressed in lux (lx)

L luminance, expressed in candela per square metre (cd/m^2)

LR   luminance ratio. (Unit: 1)

R_D reflectometer value for the diffuse reflection characteristic of the screen, obtained following the procedure below. It is the ratio of diffusely reflected luminance of the screen to its illuminance, under the conditions specified by clause 7 of this part of ISO 9241 (see 3.1.8). It is expressed per steradian (sr^{-1}). The practical unit is candela per square metre per lux [cd/(m$^2 \cdot$ lx)].

R_S reflectometer value for the specular and partially diffuse reflection characteristic of the screen, determined following the procedure of clause 7 of this part of ISO 9241. It is the ratio of specular and partially diffuse reflected luminance of a defined part of the reflected virtual image to the luminance the source of reflections under the prescribed conditions of measurement (see 3.1.8). (Unit: 1)

3.2.2 Subscripting convention

This part of ISO 9241 uses luminances whose total is made up of contributions from several identifiable components. Luminance is identified by the symbol L followed by subscripts showing its components. For example L_{FSD} represents a total luminance composed of contributions from the Foreground emitted luminance, the Specular reflected luminance, and the Diffuse reflected luminance. The principal subscripts are:

B the emitted luminance from the display screen Background

F the emitted luminance from the display screen Foreground

D the Diffuse reflected component of a luminance.

S   the Specular reflected component of a luminance.

A   the luminance of an Area (whether extended or very small) that is the source of a specular reflection.

(0°) and (15°): the angle at which reflected and/or emitted luminances are measured, or the corresponding diffuse reflection factor or specular reflection coefficient applied. A measurement angle perpendicular or *normal* to the display screen surface is 0°. A measurement angle of 15° to the normal to the screen surface is 15°.

REF: the quantity is a reference value used in compliance calculations. Reference values are not intended to be reproduced during testing.

STD: the quantity is the calibrated value of a measurement standard.

Subscript modifiers:

(max): the maximum value of a quantity (usually the specular reflection source luminance $L_{A(max)}$) that will allow the VDT to just meet the requirements of this part of ISO 9241.

(EXT) and (SML): indicate specular reflected luminances and reflection characteristics determined using either an extended source or a small source of luminance. They are used only to modify the subscript S, as in $L_{S(F, SML, 15°)}$, the specular reflected luminance of an area of the screen set to the foreground state, from a small source, measured at 15°.

Composite luminances:

1 L_{FSD} = Luminance of image Foreground + Specular reflection + Diffuse reflection

2 L_{BSD} = Luminance of image Background + Specular reflection + Diffuse reflection

3 L_{FD} = Luminance of image Foreground + Diffuse reflection

4 L_{BD} = Luminance of image Background + Diffuse reflection

Reflected luminances:

L_S = Luminance of Specular reflection = $R_S L_A$

R_S = Specular reflectometer value (from test method)

L_A = Luminance of an Area causing the specular reflection

L_D = Luminance of Diffusion reflection = $R_D E$

R_D = Diffuse reflectometer value (from test method)
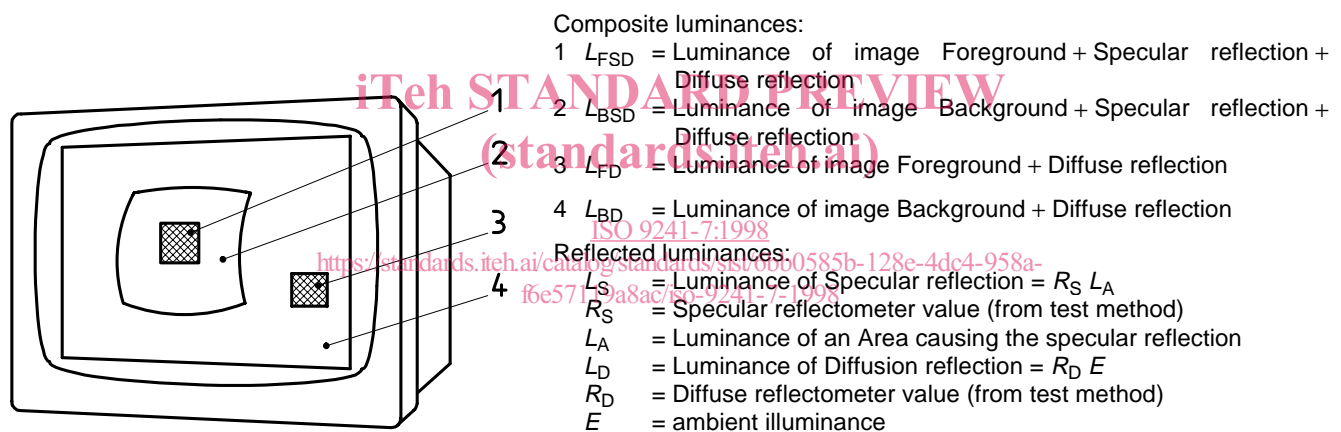
E = ambient illuminance

Figure 2 — Screen luminances

3.2.3 Secondary symbols

L_F, L_B: The area-average emitted luminances of a patch of pixels in the centre of the screen. The emitted luminances are to be measured in the lowest and highest luminance levels of the display that are available for text or its background, under program control.

L_D, L_S: Reflected luminances used to decide compliance with this part of ISO 9241 are approximated by a calculation based on the reflectometer values of the VDT screen and assumed lighting environment conditions.

$L_D \approx R_D \cdot E$ is the diffuse reflection luminance

where

R_D is the reflectometer value for the diffuse reflection characteristic of the screen;

E is the illuminance incident in the plane of the screen.

$L_S \approx R_S \cdot L_A$ is the specular reflected luminance

where

R_S is the reflectometer value for the specular and partially diffuse reflection characteristic of the screen;

L_A is the luminance of a uniform, extended or small luminous source positioned at the specular angle from the point of measurement. The values of L_A used for compliance with this part of ISO 9241 are specified in clause 6.

Specular reflected luminances and reflection factors are subdivided into those resulting from an extended-source and a small-source of luminance.

$L_{S(EXT)}$, $L_{S(SML)}$:   specular reflected luminances caused by extended and small sources, respectively.

$R_{S(EXT)}$, $R_{S(SML)}$:   specular and partially diffuse reflectometer values of the screen caused by extended and small sources of luminance, respectively.

$LR_{BDS/FDS}$:   luminance ratio of the screen image (foreground and background) with diffuse and specular reflections. It is the ratio between the higher and the lower area-average luminances of the image, when both specular and diffuse reflected luminances are superimposed on each. See figure 3. The definition of image luminance ratios is polarity-dependent.

$LR_{BDS/FDS}$ positive polarity:

$$LR_{BDS/FDS} \equiv \frac{L_B + L_D + L_S}{L_F + L_D + L_S}$$
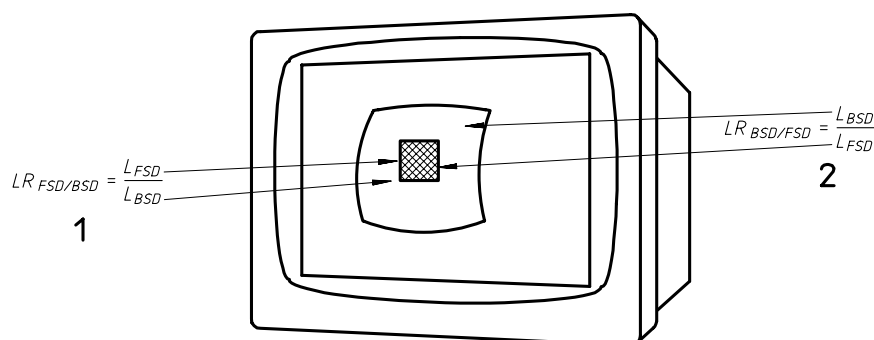
Expanded,

$$LR_{BDS/FDS} \equiv \frac{L_B + E \cdot R_D + L_A \cdot R_S}{L_F + E \cdot R_D + L_A \cdot R_S}$$

$(LR_{FDS/BDS})$ negative polarity:

$$LR_{FDS/BDS} \equiv \frac{L_F + L_D + L_S}{L_B + L_D + L_S}$$

Expanded,

$$LR_{FDS/BDS} \equiv \frac{L_F + E \cdot R_D + L_A \cdot R_S}{L_B + E \cdot R_D + L_A \cdot R_S}$$

$$LR_{FSD/BSD} = \frac{L_{FSD}}{L_{BSD}}$$

$$LR_{BSD/FSD} = \frac{L_{BSD}}{L_{FSD}}$$

1

2

1   in negative polarity

2   in positive polarity

Figure 3 — Image luminance ratio with both specular and diffuse reflections

$LR_{BDS/BD}$: specular reflection luminance ratio. It is the ratio between the luminance of an area of the screen set to the background state, with a specular reflection and diffuse reflection superimposed, and the luminance of the same area of the screen without the specular reflection. See figure 4. The definition is not polarity-dependent.

$$LR_{BDS/BD} \equiv \frac{L_B + L_{D(B)} + L_{S(B)}}{L_B + L_{D(B)}}$$

Expanded,

$$LR_{BDS/BD} \equiv \frac{L_B + E \cdot R_D + L_A \cdot R_S}{L_B + E \cdot R_D}$$

NOTES

1 Although mathematically the specular reflection luminance ratio is not polarity-dependent, practically and perceptually the polarity makes a very important difference. In negative polarity, the background is dark, causing much higher specular reflection luminance ratios. In positive polarity, the background is bright, which dramatically reduces the luminance ratio of specular reflections. This effect makes positive polarity VDTs far more resistant to the effects of reflections than negative polarity VDTs with the same highest and lowest luminance levels.

2 In negative polarity the specular reflection is the same polarity as the information displayed on the screen. This leads to some apparent perceptual competition between the reflection and the useful image. To maintain acceptable image quality, it is necessary to maintain the image luminance ratio $LR_{FDS/BDS}$ substantially greater than that of the specular reflection ratio $LR_{BDS/BD}$.
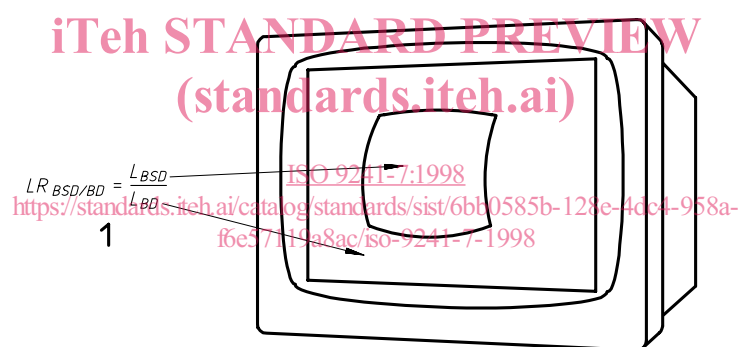
1 In either polarity.

Figure 4 — Luminance ratio of the specular reflection against the screen background

$LR_{FD/BD}$: luminance ratio of the screen foreground and background with diffuse reflected luminance only. It is the ratio between the higher and the lower area-average luminances of the image, when diffuse reflected luminance is superimposed on each. See figure 5. The maximum acceptable specular reflection luminance ratio is related to the luminance ratio of the image without specular reflection, in negative polarity. The definition is polarity-dependent. Only the definition in negative polarity is used for this part of ISO 9241.

Negative polarity

$$LR_{FD/BD} \equiv \frac{L_F + L_D}{L_B + L_D}$$

Expanded,

$$LR_{FD/BD} \equiv \frac{L_F + E \cdot R_D}{L_B + E \cdot R_D}$$