
**Ergonomic requirements for work with
visual displays based on flat panels —**

**Part 2:
Ergonomic requirements for flat panel
displays**

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*Exigences ergonomiques pour travail sur écrans de visualisation
à panneau plat*

Partie 2: Exigences ergonomiques des écrans à panneau plat

ISO 13406-2:2001

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 13406 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13406-2 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 4, *Ergonomics of human-system interaction*.

ISO 13406 consists of the following parts, under the general title *Ergonomic requirements for work with visual displays based on flat panels*:

— *Part 1: Introduction*

— *Part 2: Ergonomic requirements for flat panel displays*

Annexes A, B and C of this part of ISO 13406 are for information only.

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Introduction

ISO 13406 extends its companion standard ISO 9241 to account for the significant differences in ergonomic trade offs present when flat panels are used.

The rationale for this part of ISO 13406 is presented in ISO 13406-1.

This part of ISO 13406 presents the requirements for visual display units (VDUs) based on flat panels as defined in ISO 13406-1. It is intended for evaluators and users of this technology. Some document users will find part of the material complex. Notes, figures and examples are provided to lessen the problem. The legibility of flat panels is a principal concern. The requirements are primarily based on the visual ergonomic research used in ISO 9241-3 and on new research referenced in this part of ISO 13406. Here, as in ISO 9241-3, some requirements are based on visual comfort, muscular comfort and user acceptability. This part of ISO 13406 includes requirements and recommendations that are based on legibility, comfort and acceptability that arise when multicolour displays are used, based on the visual ergonomic research described in ISO 9241-8, but modified and extended to consider the unique trade offs of flat panels. Legibility in the presence of ambient room light and the acceptability of unwanted reflected images are addressed covering the flat panel aspects covered in ISO 9241-7 for cathode ray tube (CRT) technology.

Clause 3 Definitions presents or recalls those terms needed to specify requirements and measurements. Where possible, definitions taken from other publications are quoted verbatim. If some change has been made, the definition is followed by a note stating "Adopted from ISO xxxx:date,x.x". Since this part of ISO 13406 often relies on mathematical models and physical measurements to ensure the fitness of purpose of flat panel VDUs, a clause 8 (Symbols) is presented as a convenient reference.

Guiding principles and performance requirements clauses modelled on ISO 9241-3 are presented to remind document users of the foundations of the work.

Design requirements and recommendations present the physical attributes that are to be strictly followed to conform (indicated by the word: shall) or preferred but not necessarily required (indicated by the word: should). The topics of design viewing distance, design viewing direction and design screen illumination depart somewhat from the precedents of ISO 9241-3. Two reasons exist:

- a) an important type of flat panel has viewing characteristics that require more careful control and consideration of viewing direction than considered in ISO 9241-3;
- b) there is no basis to assume that a flat panel VDU is tabletop mounted. These topics are presented as ergonomically constrained, supplier-specifications. This is not unprecedented, viewing distance was handled this way in ISO 9241-3. Once specified, these requirements become the conditions under which all other attributes are to be measured or decided.

A departure from ISO 9241-3 is the use of area-luminance. For CRT technology, the addressed locations are generally close together so that a *high-low-high-low-high-low*-pixel pattern will exhibit less contrast than a sparse pattern. Since the flat-panel pixel area is less than 100 % optically modulated (the fill factor is less than 1), the difference between sparse and dense pattern contrast is minor. The luminance determination has to be complicated by the need for viewing direction precision. The use of area-luminance simplification offsets that somewhat.

Some requirements are presented in categories. For example, some flat panels exhibit long image-formation times. For static images, such panels are ergonomically acceptable without reservation. Not all modern applications rely solely on such static images. Requirement categories are therefore established. If the supplied equipment has such a limitation, the supplier/evaluator is required to identify it. The system integrator, purchaser or user then can consider whether the category is consistent with intended applications.

Clause 8 covering measurements is intended for evaluators of flat panel VDUs. The panel surface is sampled for evaluation. Three evaluation sites are chosen and measured, and compliance decisions can be made from these measurements. Panels with large requirement margins do not require precision-evaluation equipment but panels with small margins can.

Clause 9 covering compliance is closely modelled on ISO 9241-3. The alternative test (Visual performance and comfort test) prepared as a normative annex in an amendment to ISO 9241-3, is cited as an alternative compliance route.

Annex A provides additional information on colour difference. Annex B extends the analytic flicker determination method of ISO 9241-3 to luminance-time modulation that is not CRT-like. Annex C informs the users of this International Standard of new work on an alternate modelling method for screens with reflection properties that cannot be adequately modelled with a simple combination of luminance coefficient (diffuse reflection) and luminance factor (specular or regular reflection) and standardized assumptions about the environment. This method develops the bidirectional reflection distribution function. When this work progresses further, it can possibly become a normative method and replace the method in clause 8. The bibliography cites references.

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Ergonomic requirements for work with visual displays based on flat panels —

Part 2: Ergonomic requirements for flat panel displays

1 Scope

This part of ISO 13406

- establishes ergonomic image-quality requirements for the design and evaluation of flat panel displays,
- defines terms needed to address image quality on flat panel displays,
- specifies methods of determining image quality on flat panel displays, and
- establishes ergonomic principles for guiding these requirements.

This part of ISO 13406 is applicable to

- flat panel display screens when used to perform office tasks,
- flat panel display screens that consist of a regular array of picture elements arranged in evenly spaced rows without built-in gaps,
- the presentation of fonts based on Latin-, Cyrillic- and Greek-origin alphabetic characters and Arabic numerals on flat panel display screens,
- the presentation of Asian characters, and
- flat panel display screens that are large enough to display at least 40 Latin-origin characters.

This part of ISO 13406 is not applicable to

- flat panel technology applied to a display that uses optics to form an image that is not the same size as the electro-optical transducer (projection applications of flat panel displays), or
- flat panel technology applied to a display limited to fixed-messages or segmented alphanumerics. [See 2.13 IEC SC 47C (Central Office) 3:1992].

NOTE Some of the measurement methods (e.g. contrast and luminance) in this part of ISO 13406 are not applicable for reflective flat panels. When technology has developed, appropriate measurement methods will be added to this part of ISO 13406.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13406. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13406 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

CIE Publication No. 15.2:1986, *Colorimetry*. (Central Bureau of the Commission International d'Éclairage CIE), Vienna, Austria.

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

ISO 9241-6, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 6: Guidance on the work environment*.

ISO 9241-7, *Ergonomic requirements for office work with visual display terminals (VDTs) — Part 7: Requirements for display with reflections*.

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

3 Definitions

For the purposes of this part of ISO 13406, the following definitions apply.

NOTE The symbols used in certain definitions are explained in clause 4.

3.1 Photometry

3.1.1

area-luminance

luminance of an area of the screen that has a diameter of at least 10 pixels, such that the state of an individual pixel has less than 2 % effect

NOTE Area-luminance is expressed in candelas per square metre (cd/m^2).

3.1.2

background luminance

luminance of an area of the screen with no graphic images present

NOTE Background luminance is expressed in candelas per square metre (cd/m^2).

3.1.3

contrast

(in a perceptual sense) assessment of the difference in appearance of two or more parts of a field seen simultaneously or successively (hence: brightness contrast, lightness contrast, colour contrast, etc.)

NOTE Adapted from IEC 60050 (845-02-47):1987.

3.1.4

EUT

Equipment Under Test

3.1.5**Lambert's (cosine) law**

for a surface element whose radiance or luminance is the same in all directions of the hemisphere above the surface:

$$I(\theta) = I_n \cos(\theta) \quad (1)$$

Where $I(\theta)$ and I_n are the radiant or luminous intensities of the surface element in a direction at an angle θ from the normal to the surface and in the direction of that normal, respectively

[IEC 60050 (845-04-56):1987]

3.1.6**Lambertian surface**

ideal surface for which the radiation coming from that surface is distributed angularly according to Lambert's cosine law

[IEC 60050 (845-04-57):1987]

For an ideal diffuse reflectance standard:

$$\rho_{\text{STD}} = \pi \cdot q_{\text{STD}} \quad (2)$$

3.1.7**luminance contrast**

ratio between the higher, L_H and lower, L_L , luminances that define the feature to be detected, measured by contrast modulation (C_m) defined as:

$$C_m = \frac{L_H - L_L}{L_H + L_L} \quad (3)$$

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or contrast ratio (CR), defined as:

$$CR = \frac{L_H}{L_L} \quad (4)$$

NOTE 1 For flat panels, area-luminance targets can be used to approximate the luminances that define the feature to be detected because pixels are discrete.

NOTE 2 Adapted from ISO 9241-3:1992, 2.22.

3.1.8**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

NOTE 1 The luminance coefficient is expressed in reciprocal steradians.

NOTE 2 Adapted from IEC 60050 (845-04-71):1987.

$$q = \frac{L}{E} \quad (5)$$

3.1.9

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

$$\beta = \frac{L_{\text{sample}}}{L_{\text{perfect diffuser}}} \quad (6)$$

NOTE 1 The luminance factor is expressed as unit: 1

NOTE 2 Adapted from IEC 60050 (845-04-69):1987.

3.1.10

optically anisotropic surface

optical surface for which the radiation deviates from that of a Lambertian surface by more than 10 % at any inclination angle, $\theta < 45^\circ$

3.2 Colorimetry

3.2.1

CIE 1976 $L^*u^*v^*$ colour space

CIELUV colour space

three-dimensional, approximately uniform colour space produced by plotting in rectangular coordinates L^*, u^*, v^* quantities defined by the three equations:

$$\left. \begin{aligned} L^* &= 116 (Y/Y_n)^{\frac{1}{3}} - 16, \text{ when } Y/Y_n > 0,008 856 \\ L^* &= 903,3 (Y/Y_n), \text{ when } Y/Y_n \leq 0,008 856 \\ u^* &= 13 L^* (u' - u'_n) \\ v^* &= 13 L^* (v' - v'_n) \end{aligned} \right\} \quad (7)$$

Y, u', v' describe the colour stimulus considered and Y_n, u'_n, v'_n describe a specified white achromatic stimulus.

NOTE Approximate correlates of lightness, saturation, chroma and hue may be calculated as follows:

$$\text{CIE 1976 } u, v \text{ saturation } s_{uv} = 13 \left[(u' - u'_n)^2 + (v' - v'_n)^2 \right]^{\frac{1}{2}} \quad (8)$$

$$\text{CIE 1976 } u, v \text{ chroma } C_{uv}^* = \left[u^{*2} + v^{*2} \right]^{\frac{1}{2}} = L^* s_{uv} \quad (9)$$

$$h_{uv} = \arctan \left(\frac{v' - v'_n}{u' - u'_n} \right) = \arctan \left(\frac{v^*}{u^*} \right), \text{ such that}$$

$$\begin{aligned} 0^\circ \leq h_{uv} < 90^\circ, & \text{ if } v^* \geq 0 \text{ and } u^* \geq 0 \\ 90^\circ \leq h_{uv} < 180^\circ, & \text{ if } v^* \geq 0 \text{ and } u^* < 0 \\ 180^\circ \leq h_{uv} < 270^\circ, & \text{ if } v^* < 0 \text{ and } u^* < 0 \\ 270^\circ \leq h_{uv} < 360^\circ, & \text{ if } v^* < 0 \text{ and } u^* \geq 0 \end{aligned} \quad (10)$$

[IEC 60050 (845-03-54)]

3.2.2

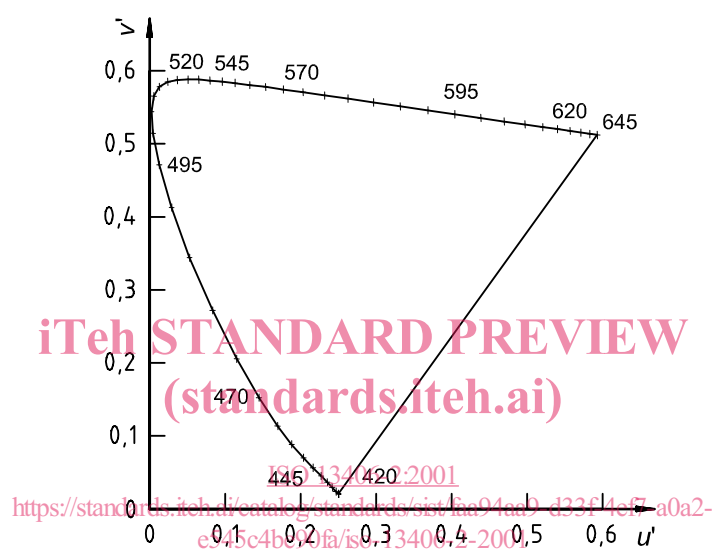
CIE 1976 uniform-chromaticity scale diagram

CIE 1976 UCS diagram

uniform-chromaticity-scale diagram produced by plotting in rectangular coordinates v' against u' , quantities defined by the equations (11):

$$\begin{aligned} u' &= \frac{4X}{X+15Y+3Z} = \frac{4x}{-2x+12y+3} \\ v' &= \frac{9Y}{X+15Y+3Z} = \frac{9y}{-2x+12y+3} \end{aligned} \quad (11)$$

See Figure 1 and IEC 60050 (845-03-53).



NOTE The curve annotations are wavelengths in nanometers.

Figure 1 — CIE 1976 UCS Diagram

3.2.3

CIE 1976 $L^*u^*v^*$ colour difference

CIELUV colour difference

difference between two colour stimuli, defined as the Euclidean distance between the points representing them in the $L^*u^*v^*$ space and calculated as equation:

$$\Delta E_{uv}^* = \left[(\Delta L^*)^2 + (\Delta u^*)^2 + (\Delta v^*)^2 \right]^{\frac{1}{2}} \quad (12)$$

The set $X_n Y_n Z_n$ and corresponding $u'_n v'_n$ define the colour of the nominally white object-colour stimulus.

(See CIE Publication No. 15.2.)

[IEC 60050 (845-03-55)]

3.2.4

chromaticity uniformity difference

distance on the CIE 1976 UCS diagram

$$\Delta u'v' = \sqrt{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2} \quad (13)$$

where

u'_1, v'_1 and u'_2, v'_2 are the coordinates of the same colour displayed at sites 1 and 2.

NOTE This is the appropriate measure of colour uniformity if luminance is not uniform or if the objects are not adjacent. (See 3.2.2.)

3.2.5

dominant wavelength of a colour stimulus, λ_d

wavelength of the monochromatic stimulus that, when additively mixed in suitable proportions with the specified achromatic stimulus, matches the colour stimulus considered

NOTE In the case of purple stimuli, the dominant wavelength is replaced by the complementary wavelength. See IEC 60050 (845-03-44).

3.2.6

same dominant wavelength

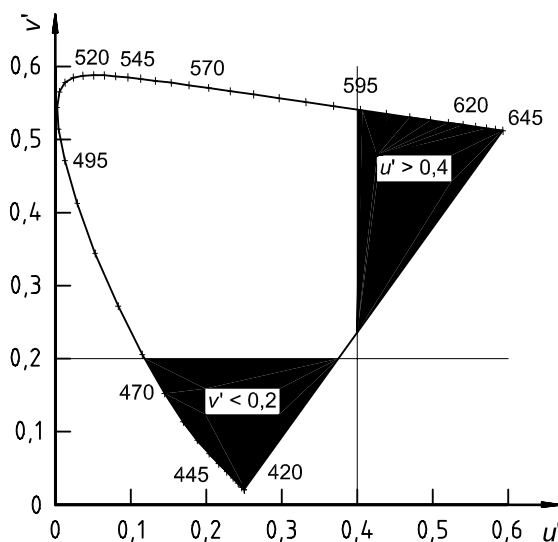
two colours have the same dominant wavelength if the difference between the hue angles of each colour is small

3.2.7

spectrally extreme colours

spectrally extreme colours are extreme blue and extreme red

NOTE Extreme blue is any colour with $v' < 0.2$. Extreme red is any colour with $u' > 0.4$. The extreme regions are illustrated in Figure 2.



NOTE The curve annotations are wavelengths in nanometers.

Figure 2 — Extreme red and extreme blue

3.2.8**uniform colour space**

colour space in which equal distances are intended to represent a threshold or suprathreshold perceived colour differences of equal size

[IEC 60050 (845-03-51):1987]

3.2.9**uniform-chromaticity-scale diagram**

UCS diagram

two-dimensional diagram in which the coordinates are defined with the intention of making equal distances represent as nearly as possible equal steps of colour discrimination for colour stimuli of the same luminance throughout the diagram

[IEC 60050 (845-03-52):1987]

3.3 Geometry**3.3.1****active area**

part of a display screen area delimited by picture elements [2.1, IEC SC 47C(Central Office) 3]

3.3.2**angular subtence**

size of a visual target at a specified viewing distance, e.g. at the design-viewing distance

$$\text{Angular subtence in degrees} = 2 \arctan \left(\frac{\text{target height}}{2 \times \text{viewing distance}} \right) \quad (14)$$

$$\begin{aligned} \text{Angular subtence in minutes of arc} &= 60 \times 2 \arctan \left(\frac{\text{target height}}{2 \times \text{viewing distance}} \right) \\ &\approx \frac{3\,438 \times \text{target height}}{\text{viewing distance}} \end{aligned} \quad (15)$$

NOTE The dimension for angular subtence is degrees (°), which is further divided into minutes of arc (') and seconds of arc (").

3.3.3**anisotropic display**

display (usually a liquid crystal display) with emitted luminance and/or luminance coefficient that meets the criterion in 3.1.10

3.3.4**coordinate system**

a normal spherical coordinate system (r, θ, ϕ)

See Figure 3.