INTERNATIONAL STANDARD

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

Part 8
Requirements for displayed colours

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

Partie 8: Exigences relatives aux couleurs affichées

Reference number
ISO 9241-8:1997(E)

Contents

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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 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 of an International Standard requires approval by at least 75% of the member bodies casting a vote.

International Standard ISO 9241-8 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Sub-committee 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: Display requirements with reflections*
- *Part 8: Requirements for displayed colours*
- *Part 9: Requirements for nonkeyboard 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 and C of this part of ISO 9241 are for information only.

Introduction

The purpose of this part of ISO 9241 is to prescribe basic specifications for colours on computer display terminals to ensure their visibility, identification and discrimination.

The specifications in this part address colour images (visual "stimuli"), their appearance (visual "perception") and identification (colour "naming"). The specifications thus address both the perceptual components of colour (such as detection of saturation and lightness) and some cognitive components (such as naming of specific colours). Other cognitive components will be addressed in ISO 9241-12.

The ability to detect, identify and discriminate colours on display terminals determines the usefulness of colour in the perception and interpretation of the computer-generated image. Colour perception of displayed images depends on a number of factors such as:

- hardware and software components of the *display* system,
- physical characteristics of the display *image,*
- the ability of the *viewer* to perceive the colours,
- the lighting in the viewing *environment.*

The primary characteristics of these factors (that is display, image, viewer and environment) that affect colour appearance are shown in table 1.

Table 1 - Examples of factors affecting colour appearance

Source	Factor affecting colour appearance
Display	Luminance
	Spectral distribution and range
	Phosphor type
	Screen treatment for reflection control
	Resolution
Image	Adjacent colours
	Size
	Spatial frequency content
Viewer	State of visual adaptation
	Colour-perception ability
Room	Illumination level
	Colour temperature of the illumination

Colour interpretation depends on the ability of the viewer to associate a colour with a specific meaning, function, or action. It is thus important that colours assigned to images on displays be carefully chosen to achieve intended effects or convey intended meaning. However, the appearance of colours may vary among different suppliers' displays. For example, the blue on one display may appear darker and more purple than on another, and red may appear more orange.

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

Part 8:
Requirements for displayed colours

1 Scope

This part of ISO 9241 describes minimum ergonomic requirements and recommendations to be applied to colours assigned to text and graphic applications and images in which colours are discretely assigned. The specifications in this part thus exclude photorealistic images and graphics.

This part of ISO 9241 applies to both hardware and software for visual display terminals, because both these sources control the presentation and appearance of colour on the display screen.

The specifications, measurements and test procedures described in this part of ISO 9241 are for displays that produce colour images and are intended to be independent of display technologies unless otherwise specified.

The specifications in this part of ISO 9241 are for images on computer displays that meet minimum requirements for users with normal colour vision. Displays conforming to this part will be suboptimal for persons with colour vision deficiencies.

This part of ISO 9241 is complementary to ISO 9241-3. The tasks and conditions of use in this part are similar to those described in ISO 9241-3, unless otherwise specified. This part of ISO 9241 is not intended to be a specification on colour coding.

Although the primary users of this part of ISO 9241 are intended to be hardware and software user-interface designers and manufacturers, it will also be useful to those persons responsible for procuring colour displays and those evaluating the use of colour in the user-interface of the computer system.

2 Normative references

The following standards contain provisions which, through reference in this 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 editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

ISO 9241-5:—[1], *Ergonomic requirements for office tasks with visual display terminals* (VDTs) – *Part 5: Workplace requirements.*

3 Definitions

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

3.1 achromatic (perceived) colour:
(1) <perceptual sense> Perceived colour devoid of hue.

The colour names white, gray and black are commonly used or, for transmitting objects, colourless and neutral.

(2) <psychophysical sense> See achromatic stimulus 845-03-06. [CIE 17.4 / IEC 50, 845-02-26]

3.2 adaptation (visual): Process by which the state of the visual system is modified by previous and present exposure to stimuli that may have various luminances, spectral distributions and angular subtenses. [CIE 17.4 / IEC 50, 845-02-07]

3.3 additive mixing: Stimulation that combines on the retina the actions of various colour stimuli in such a manner that they cannot be perceived individually. [CIE 17.4 / IEC 50, 845-03-15]

3.4 brightness: Attribute of a visual sensation according to which an area appears to emit more or less light. [CIE 17.4 / IEC 50, 845-02-28]

3.5 chroma: Chromaticness, or colourfulness, of an area judged as a proportion of the brightness of a similarly illuminated area that appears white or highly transmitting. [CIE 17.4 / IEC 50, 845-02-42]

3.6 chromaticity: Property of a colour stimulus defined by its chromaticity coordinates, or by its dominant or complementary wavelength and purity taken together. [CIE 17.4 / IEC 50, 845-03-34]

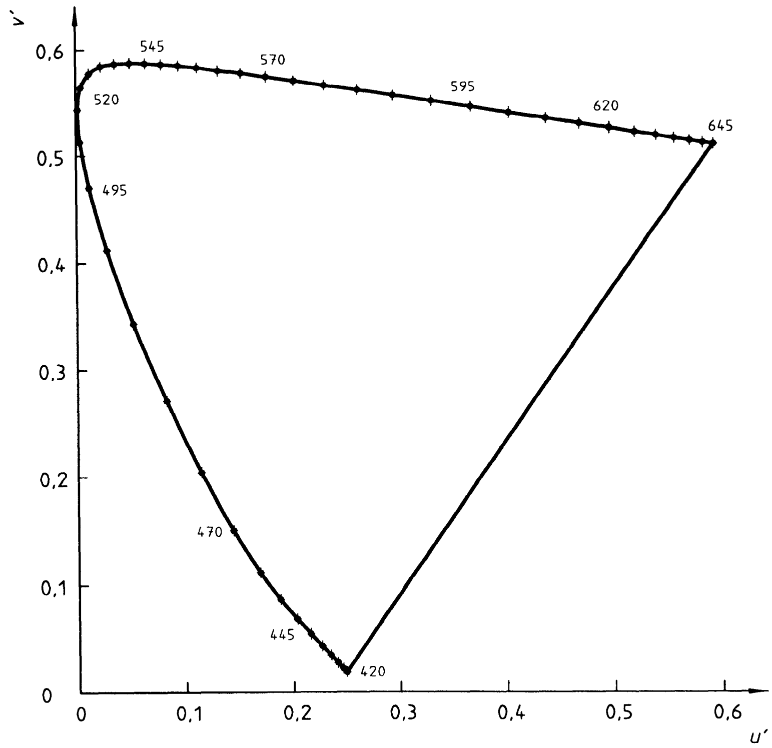
3.7 chromaticity coordinates: Ratio of each of a set of three tristimulus values relative to their sum. [CIE 17.4 / IEC 50, 845-03-33]

NOTES
1 As the sum of the three chromaticity coordinates equals one, two of them are sufficient to define a chromaticity.
2 In the CIE standard colorimetric systems, the chromaticity coordinates are represented by the symbols x, y, z and x_{10}, y_{10}, and z_{10}.

3.8 chromaticity diagram: Plane diagram in which points specified by chromaticity coordinates represent the chromaticities of colour stimuli. [CIE 17.4 / IEC 50, 845-03-35]

NOTE –In the CIE standard colorimetric systems, y is normally plotted as ordinate and x as abscissa, to obtain an x, y chromaticity diagram (see figure 1 and 3.10).

1) To be published.



NOTE – The numbers along the curve are the wavelengths of light, in nanometres.

Figure 1 — CIE 1976 uniform-chromaticity-scale diagram; CIE 1976 UCS diagram

3.9 chromostereopsis: Phenomenon in which two visual objects that differ in dominant wavelength and/or brightness appear to be at different distances from the viewer.

3.10 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 (1):

$$(1)\quad \begin{cases} u' = \dfrac{4X}{X+15Y+3Z} = \dfrac{4x}{-2x+12y+3} \\ v' = \dfrac{9Y}{X+15Y+3Z} = \dfrac{9y}{-2x+12y+3} \end{cases}$$

X, Y, Z are the tristimulus values in the CIE 1931 or 1964 standard colorimetric systems, and x, y are the corresponding chromaticity coordinates of the colour stimulus considered. [CIE 17.4 / IEC 50, 845-03-53].

NOTE – This diagram is a modification of and supersedes, the CIE 1960 UCS diagram in which v was plotted against u in rectangular coordinates. The relationships between the two pairs of coordinates are:

$u' = u{:}v' = 1{,}5v$

3.11 CIE 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 equations (2):

$$(2)\quad \begin{cases} L^* = 116(Y/Y_n)^{\frac{1}{3}} - 16; \quad Y/Y_n > 0{,}008\ 856 \\ u^* = 13L^*(u' - u'_n) \\ v^* = 13L^*(v' - v'_n) \end{cases}$$

$\boldsymbol{Y}$, $\boldsymbol{u'}$, $\boldsymbol{v'}$ describe the colour stimulus considered and $\boldsymbol{Y}_n$, $\boldsymbol{u'}_n$, $\boldsymbol{v'}_n$ describe a specified white achromatic stimulus. (See CIE 15.2) [CIE 17.4 / IEC 50, 845-03-54]

NOTE – Approximate correlates of CIE 1976 u, v lightness, CIE 1976 u, v saturation, CIE 1976 u, v chroma and CIE 1976 u, v hue may be calculated as follows:

$$CIE\ 1976\ lightness\ L^* = 116(Y/Y_n)^{\frac{1}{3}} - 16; \qquad Y/Y_n > 0{,}008\ 856$$

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

$$CIE\ 1976,\ v,\ u\ chroma\ C^*_{uv} = \left[u^{*2} + v^{*2}\right]^{\frac{1}{2}} = L^* s_{uv}$$

$$CIE\ 1976\ v,u\ hue\text{-}angle\ h_{uv} = \arctan\left[(v'-v'_n)/(u'-u'_n)\right] = \arctan(v^*/u^*)$$

3.12 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 (3): (See CIE 15.2) [CIE 17.4 / IEC 50, 845-03-55]

$$(3) \qquad \Delta E^*_{uv} = \left[(\Delta L^*)^2 + (\Delta u^*)^2 + (\Delta v^*)^2\right]^{\frac{1}{2}}$$

NOTE – The CIE u, v hue-difference may be calculated as follows:

$$\Delta H^*_{uv} = \left[(\Delta E^*_{uv})^2 - (\Delta L^*)^2 - (\Delta C^*_{uv})^2\right]^{\frac{1}{2}}$$

3.13 CIE standard illuminants: Illuminants A, B, C, D_{65} and other illuminants D, defined by the CIE in terms of relative spectral power distributions. (See CIE 15.2) [CIE 17.4 / IEC 50, 845-03-12]

NOTE – These illuminants are intended to represent:
- A, Planckian radiator at a temperature of about 2856 K;
- B, direct solar radiation (obsolete);
- C, average daylight (obsolete);
- D_{65}, daylight including the ultraviolet region.

3.14 colour detection: Perception of the presence of a colour on a visually noisy background.

3.15 colour discrimination: Detection of colour difference between visual stimuli.

3.16 colour identification: Perception signified by the ability to name a colour.

3.17 colour interpretation: Association of a particular colour to a meaning or function.

3.18 colour temperature: Temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus. It is expressed in kelvins. [CIE 17.4 / IEC 50, 845-03-49]

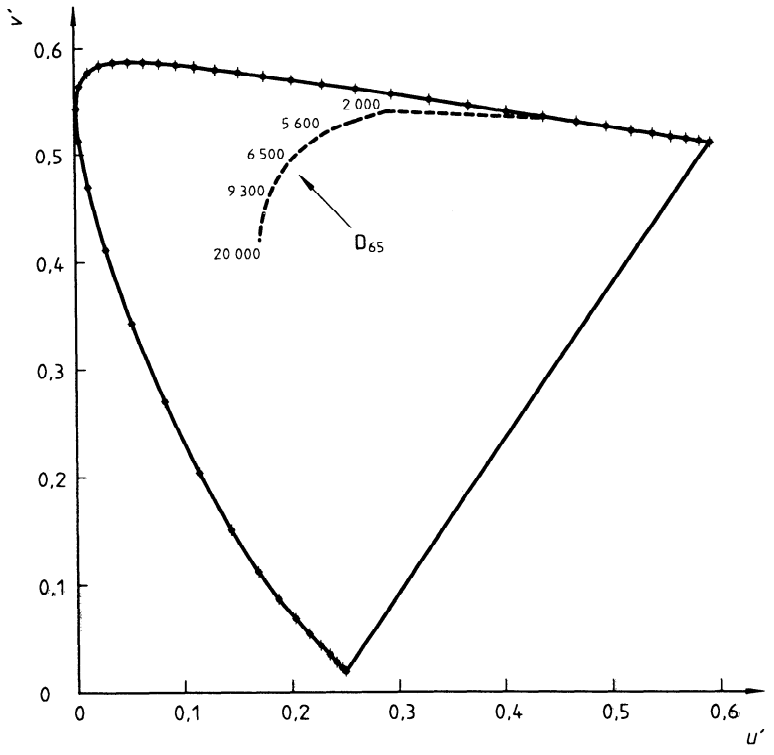


Figure 2 — Location of CIE illuminant D_{65} and colour temperatures on a 1976 CIE UCS diagram

3.19 chromaticity uniformity difference: A distance in the CIE 1976 UCS diagram.

$$\Delta u'v' \equiv \sqrt{\left(u'_1 - u'_2\right)^2 + \left(v'_1 - v'_2\right)^2}$$

where

u'_1, v'_1 and u'_2, v'_2

are the coordinates of the same colour displayed at sites 1 and 2.

3.20 complementary wavelength (of a colour stimulus) (λ_c): Wavelength of the monochromatic stimulus that, when additively mixed in suitable proportions with the colour stimulus considered, matches the specified achromatic stimulus. (CIE 17.4 / IEC 50, 845-03-45)

3.21 convergence: The exact intersection of electron beams of a colour CRT at a specific point on the plane of its phosphor screen. See figure 3.

Misconvergence is the departure from convergence. See figure 4.

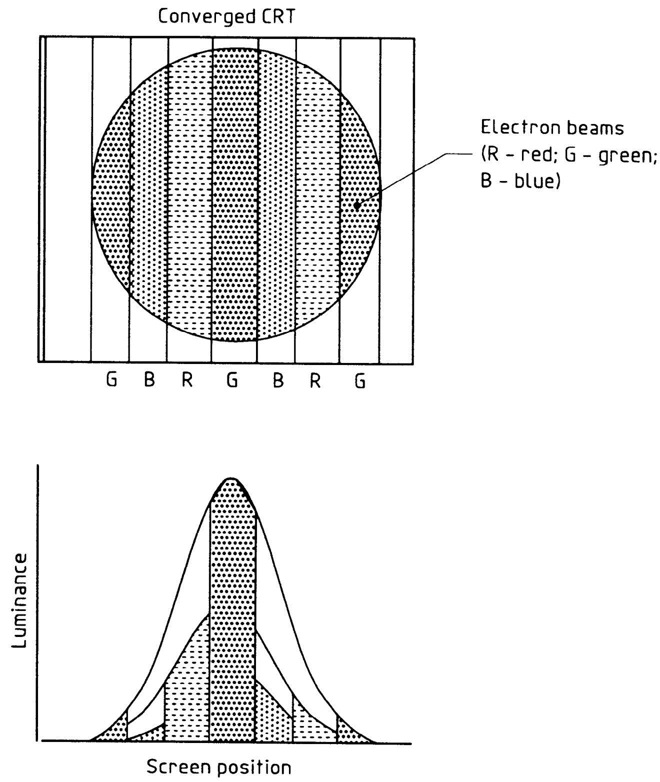


Figure 3 – CRT converged R,G,B electron beams

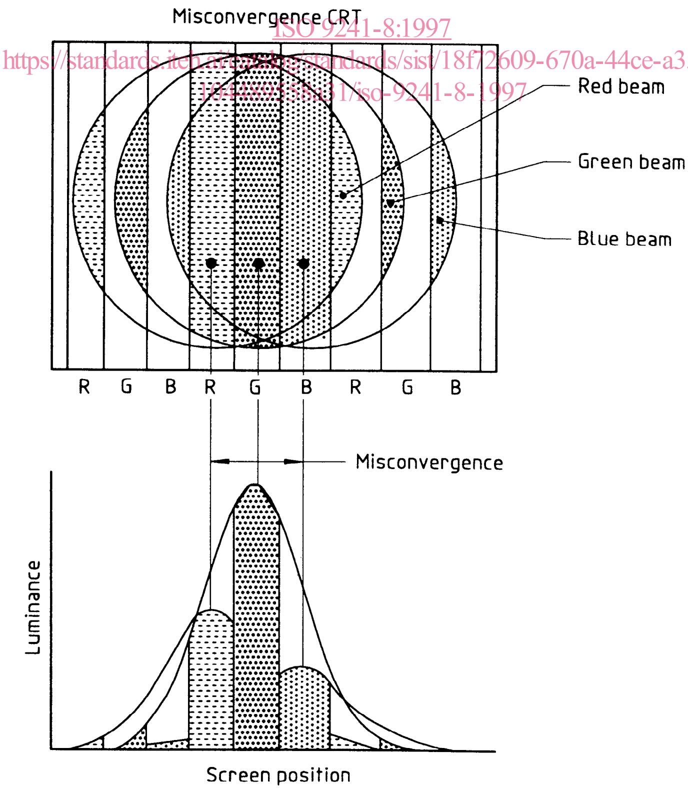


Figure 4 – CRT misconverged R,G,B electron beams

3.22 default colour set: Predetermined group of colours assigned by the software application or operating system.

3.23 defective colour vision: Anomaly of vision in which there is a reduced ability to discriminate some or all colours. [CIE 17.4 / IEC 50, 845-02-13]

3.24 depth-of-field: Range of visual focus of images from the distance at which all images are in focus.

3.25 design viewing distance: Distance, or range of distances, between the screen and the operator's eyes for which the display is designed to be viewed (see ISO 9241-3:1992, 2.12).

3.26 dominant wavelength: 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. [CIE 17.4 / IEC 50, 845-03-44]

3.27 hue: Attribute of a visual sensation, according to which an area appears to be similar to one of the perceived colours red, yellow, green or blue, or a combination of two of them. [CIE 17.4 / IEC 50, 845-02-35]

3.28 just-noticeable difference: Perceptual unit which specifies the amount of least physical change of an image at which the difference can be detected.

3.29 lightness: Brightness of an area judged relative to the brightness of a similarly illuminated area that appears to be white or highly transmitting. [CIE 17.4 / IEC 50, 845-02-31]

3.30 luminance contrast: Ratio between the higher (L_H) and lower (L_L) luminances that define the feature to be detected and measured by contrast modulation, calculated by:

$$C_m \equiv \frac{L_H - L_L}{L_H + L_L}$$

or contrast ratio (CR), defined as:

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

[ISO 9241-3:1992, 2.22]

3.31 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. It is expressed in reciprocal steradians (sr^{-1}) [IEC 50, 845-04-71]

3.32 colorimetric purity, p_c: Quantity defined by the relation

$$p_c = \frac{L_d}{(L_n + L_d)}$$

where L_d and L_n are the respective luminances of a monochromatic stimulus and of a specified achromatic stimulus that match the colour stimulus considered in an additive mixture. [CIE 17.4 / IEC 50, 845-03-47]

3.33 reference white: Specified white achromatic stimulus Y_n, u'_n, v'_n.

3.34 saturated colour: Colour with a colorimetric purity of one (1).

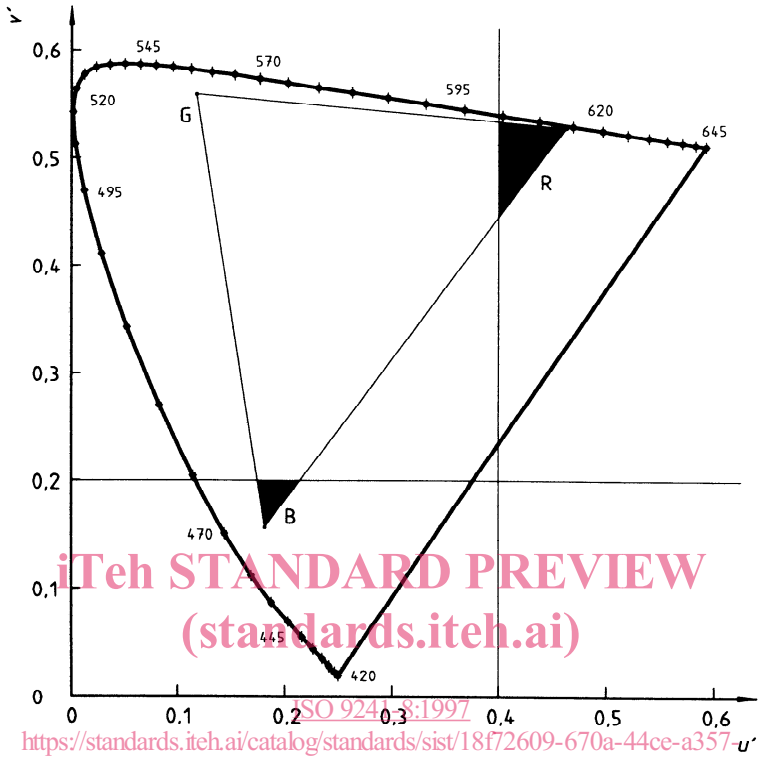
3.35 saturation: Chromaticness, or colourfulness, of an area judged in proportion to its brightness. [CIE 17.4 / IEC 50, 845-02-41]

3.36 simple graphics: Computer-generated graphs, charts, icons and pictures composed of lines or area-fill which are not continuous shades, photo-like in appearance or having few gray levels.

3.37 spectrum locus: Locus in a chromaticity diagram or colour space of the points that represent monochromatic stimuli throughout the spectrum.

3.38 spectrally extreme colours: Extreme blue (any colour with $v' < 0{,}2$) and extreme red (any colour with $u' > 0{,}4$).

The extreme regions are illustrated in figure 5.



NOTE – Filled-in areas show spectrally extreme colours of a cathode ray tube gamut (indicated by the triangular outline).

Figure 5 – Spectrally extreme colours

3.39 stereopsis: Binocular, visual perception of depth or three-dimensional space.

3.40 tritanopia, small-field: Normal reduction in colour discrimination for short-wavelength (perceived as blue) images of small angular subtense (approximately 20 minutes of arc or less) stimulating the central fovea of the eye.

3.41 tristimulus values: Amounts of the three reference stimuli, in a given trichromatic system, required to match the colour of the stimulus considered. [CIE 17.4 / IEC 50, 845-03-22]

3.42 uniform-chromaticity-scale (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. [CIE 17.4 / IEC 50, 845-03-52]

4 Guiding principles

Colour can enhance the visual and cognitive processing of information on display screens. For example, colour can help locate, classify, and associate images (i.e. show a relationship between information).