INTERNATIONAL STANDARD

ISO 3864-4

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Graphical symbols — Safety colours and safety signs —

Part 4: Colorimetric and photometric properties of safety sign materials

Symboles graphiques — Couleurs de sécurité et signaux de sécurité —

Partie 4: Propriétés colorimétriques et photométriques des matériaux des signaux de sécurité

Reference number
ISO 3864-4:2011(E)

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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 2.

The main task of technical committees is to prepare International Standards. 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.

ISO 3864-4 was prepared by Technical Committee ISO/TC 145, *Graphical symbols*, Subcommittee SC 2, *Safety identification, signs, shapes, symbols and colours*.

This part of ISO 3864, together with ISO 3864-1:—, cancels and replaces ISO 3864-1:2002, which has been technically revised.

ISO 3864 consists of the following parts, under the general title *Graphical symbols — Safety colours and safety signs*:

— *Part 1: Design principles for safety signs and safety markings*

— *Part 2: Design principles for product safety labels*

— *Part 3: Design principles for graphical symbols for use in safety signs*

— *Part 4: Colorimetric and photometric properties of safety sign materials*

Introduction

This part of ISO 3864 has been prepared to provide manufacturers/suppliers of safety signs and test laboratories and instrument manufacturers with specifications of the colorimetric and photometric properties of safety signs comprising different types of material and with test methods.

Consistent use of this part of ISO 3864 will assist in improving knowledge of safety-sign requirements and in furthering understanding of the performance of various types of safety signs in everyday use.

This part of ISO 3864 is intended to be used by all Technical Committees within ISO charged with developing specific safety signing for their industry, to ensure that there is only one set of colorimetric and photometric requirements and test methods for safety signs.

Note that some countries' statutory regulations may differ in some respect from those given in this part of ISO 3864.

Graphical symbols — Safety colours and safety signs —

Part 4:
Colorimetric and photometric properties of safety sign materials

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This part of ISO 3864 establishes the colorimetric and photometric requirements and test methods for the colours of safety signs to be used in workplaces and public areas. It provides the colorimetric and photometric specifications for the named safety and contrast colours prescribed in ISO 3864-1.

The physical requirements that safety signs have to meet are primarily related to daytime colour and normally lit environments. This part of ISO 3864 also includes the colorimetric requirements and test methods for safety signs and phosphorescent material which also operate in unlit environments.

This part of ISO 3864 is applicable to all locations where safety issues related to people need to be addressed. However, it is not applicable to signalling used for guiding rail, road, river, maritime and air traffic and, generally speaking, to those sectors subject to a regulation that may differ.

The colorimetric and photometric properties of retroreflective safety signs, retroreflective materials combined with fluorescent or phosphorescent materials, or luminous safety signs activated by a radioactive source are not specified in this part of ISO 3864.

2 Normative references

The following referenced documents are indispensable for the application 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 3864-1: —[1)], *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 17724:2003, *Graphical symbols — Vocabulary*

CIE 15, *Colorimetry*

CIE 69, *Methods of characterizing illuminance meters and luminance meters: Performance, characteristics and specifications*

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1) To be published. (Revision of ISO 3864-1:2002)

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17724 and the following apply.

3.1
colour region
boundary values of x, y chromaticity coordinates of the CIE 2° standard colorimetric observer and luminance factor or luminance for the named colour

3.2
contrast
C
difference in luminance factors of the graphical symbol and its background, divided by the larger luminance factor β_a, where β_b is the smaller luminance factor

$$C = \left(\beta_a - \beta_b\right) / \beta_a$$

3.3
contrast colour
colour that contrasts with the safety colour in order to make the safety colour more conspicuous

3.4
externally illuminated safety sign
safety sign that is illuminated, when required, by an external source

3.5
internally illuminated safety sign
safety sign that is illuminated, when required, by an internal source

3.6
luminance contrast
k
luminance of the contrast colour, L_1, divided by the luminance of the safety colour, L_2, where L_1 is greater than L_2

$$k = L_1 / L_2$$

[ISO 17724:2003, definition 43]

3.7
luminance factor
β
ratio of the luminance of the surface element in a given direction to that of a perfect reflecting or transmitting diffuser identically illuminated

[ISO 17724:2003, definition 44]

3.8
maintained safety sign
sign in which the integral lamps are energized at all times when normal or emergency mode of operation is required

3.9
non-maintained safety sign
sign in which the integral lamps are in operation only when the power supply to the normal lighting fails

3.10
object colour
named colour of safety sign elements specified in terms of chromaticity coordinates x, y of the CIE 2° standard colorimetric observer and either luminance factor or luminance

3.11
ordinary material
material which is neither retroreflecting nor fluorescent nor phosphorescent nor involves powered light emission nor is activated by a radioactive source

3.12
phosphorescent material
material incorporating phosphors that, if excited by UV or visible radiation, store energy, which is emitted as light over a period of time

3.13
safety colour
specific colour with special properties to which a safety meaning is attributed

[ISO 17724:2003, definition 66]

4 Requirements

4.1 General

All colorimetric and photometric requirements apply to the materials as used in the finished sign.

The safety colours and contrast colours for the geometric shape of safety signs and the graphical symbols for particular types of safety signs are given in ISO 3864-1.

The requirements are based on the CIE 2° standard colorimetric observer, as specified in CIE 15.

Where the requirement involves the colour of the sign material under external illumination, the requirements are based on CIE Standard illuminant D65 at either an angle of 45° with the normal to the surface and the observation made in the direction of the normal (45°a:0° geometry) or normal to the surface and observation made in the direction of 45° to the surface (0°:45°a geometry).

Requirements and test methods are given for safety signs in lit and unlit conditions.

NOTE Information on colour characteristics of externally illuminated, internally illuminated and phosphorescent materials is given in Annex A.

Safety signs without an integral source of light are required to be externally illuminated for their intended function.

Internally illuminated safety signs are classified as “maintained” (integral light source is powered) or “non-maintained” (sign is externally illuminated when the integral light source is unpowered, but in an emergency condition the integral light source is powered). If the sign is intended to be dimmed, the requirements need to be met under this condition as well.

Phosphorescent safety signs have applications in both lit and unlit environments. For example, during an emergency, the excited phosphorescent materials emit light over a period of time.

Requirements are specified in terms of colour region for each named colour.

Requirements for safety signs comprised of ordinary materials are specified in 4.2.1. Requirements for non-maintained internally illuminated safety signs are specified in 4.2.2 (when the integral light source is not powered) and in 4.3 (when the integral light source is powered). Requirements for maintained internally illuminated safety signs are specified in 4.3. Requirements for phosphorescent safety signs under external illumination are specified in 4.2.3.

The materials are no longer considered suitable for safety use if, while in use, the chromaticity coordinates and/or luminance factor fall outside the colour regions given in Table 1 for the type of safety sign material, or the chromaticity coordinates and/or luminance or luminance contrast fall outside the ranges given in Tables 2 and 3 for the type of safety sign.

For classification purposes by manufacturers, the performance requirements and the test method for the emission colour of phosphorescent materials are given in Annex B.

4.2 Object colour under external illumination

4.2.1 Safety sign comprising ordinary materials

When the object colour is tested in accordance with 5.2.1, the chromaticity coordinates of each colour shall fall within the relevant colour region specified in Table 1, as illustrated in Figure 1. The luminance factor for each colour shall be as specified in Table 1.

4.2.2 Unpowered internally illuminated safety signs under external illumination

When an unpowered internally illuminated safety sign is tested in accordance with 5.2.2, the chromaticity coordinates of each colour shall fall within the relevant colour region specified in Table 1, as illustrated in Figure 1. The luminance factor for each colour shall be as specified in Table 1.

4.2.3 Phosphorescent safety signs under external illumination

When the phosphorescent material substrate, or phosphorescent material with colour printed on the phosphorescent surface, is tested in accordance with 5.2.3, the chromaticity coordinates of each colour shall fall within the relevant colour region specified in Table 1, as illustrated in Figure 1. The luminance factor for each colour shall be as specified in Table 1.

4.3 Object colour of powered internally illuminated safety signs

When the object colour of a powered internally illuminated safety sign is tested in accordance with 5.3, the chromaticity coordinates of any test patch of each colour shall fall within the relevant colour region specified in Table 2, as illustrated in Figure 2. The luminance for each colour shall be as specified in Table 2.

The luminance contrast, k, shall be as specified in Table 3.

The ratio of minimum luminance to maximum luminance within either white or the safety colour shall be greater than 1:5. If the luminance of the safety sign is greater than 100 cd/m^2, the ratio of minimum to maximum luminance within the colour shall be greater than 1:10.

In the application of powered internally illuminated safety signs in normal lighting conditions, higher luminance values of the signs should be appropriate to the luminous environment for legibility. The criteria for luminance contrast and the ratio of luminances within each colour shall be met.

The requirements of this clause shall also apply to non-maintained internally illuminated safety signs when the integral light source is powered.

Table 1 — Colour regions: chromaticity coordinates and luminance factor for object colours of ordinary materials, phosphorescent materials and unpowered internally illuminated safety signs under external illumination

Colour region	Corner points of colour region CIE Standard illuminant D65 CIE 2° standard colorimetric observer					Luminance factor β	
		1	2	3	4	Minimum	Maximum
Red	x	0,705	0,592	0,574	0,663	0,07	0,2
	y	0,295	0,291	0,351	0,337		
Yellow	x	0,475	0,538	0,470	0,427	0,45	0,70
	y	0,525	0,462	0,424	0,472		
Green	x	0,201	0,285	0,170	0,026	0,11	0,25
	y	0,776	0,441	0,364	0,399		
Blue	x	0,078	0,180	0,225	0,137	0,05	0,2
	y	0,171	0,239	0,184	0,038		
Phosphorescent	x	0,310	0,310	0,420	0,340	0,65	
yellow-white contrast	y	0,340	0,480	0,480	0,370		
White	x	0,350	0,295	0,285	0,340	0,75	
	y	0,360	0,305	0,315	0,370		
Black	x	0,385	0,300	0,260	0,345		0,03
	y	0,355	0,270	0,310	0,395		

Table 2 — Colour regions: chromaticity coordinates and luminance for powered internally illuminated safety sign colours

Colour region	Corner points of colour region CIE 2° standard colorimetric observer					Integral light source on, no other external illumination
		1	2	3	4	Luminance cd/m^2
Red	*x*	0,705	0,592	0,574	0,663	⩾2
	y	0,295	0,291	0,351	0,337	
Yellow	*x*	0,475	0,538	0,470	0,427	⩾2
	y	0,525	0,462	0,424	0,472	
Green	*x*	0,201	0,285	0,170	0,026	⩾2
	y	0,776	0,441	0,364	0,399	
Blue	*x*	0,078	0,180	0,225	0,137	⩾2
	y	0,171	0,239	0,184	0,038	
Green-white	*x*	0,265	0,240	0,290	0,310	⩾10
	y	0,310	0,380	0,410	0,350	
White	*x*	0,290	0,265	0,370	0,460	⩾10
	y	0,260	0,310	0,405	0,425	
Black	*x*	0,385	0,300	0,260	0,345	[a]
	y	0,355	0,270	0,310	0,395	

[a] Black as a contrast colour or as a symbol colour is not translucent.

Table 3 — Luminance contrast for powered internally illuminated safety signs

Safety colour	Red	Yellow	Green	Blue
Contrast colour	White	Black	White	White
Luminance contrast	$5 < k < 15$	[a]	$5 < k < 15$	$5 < k < 15$

[a] Black as a contrast colour or as a symbol colour is not translucent.

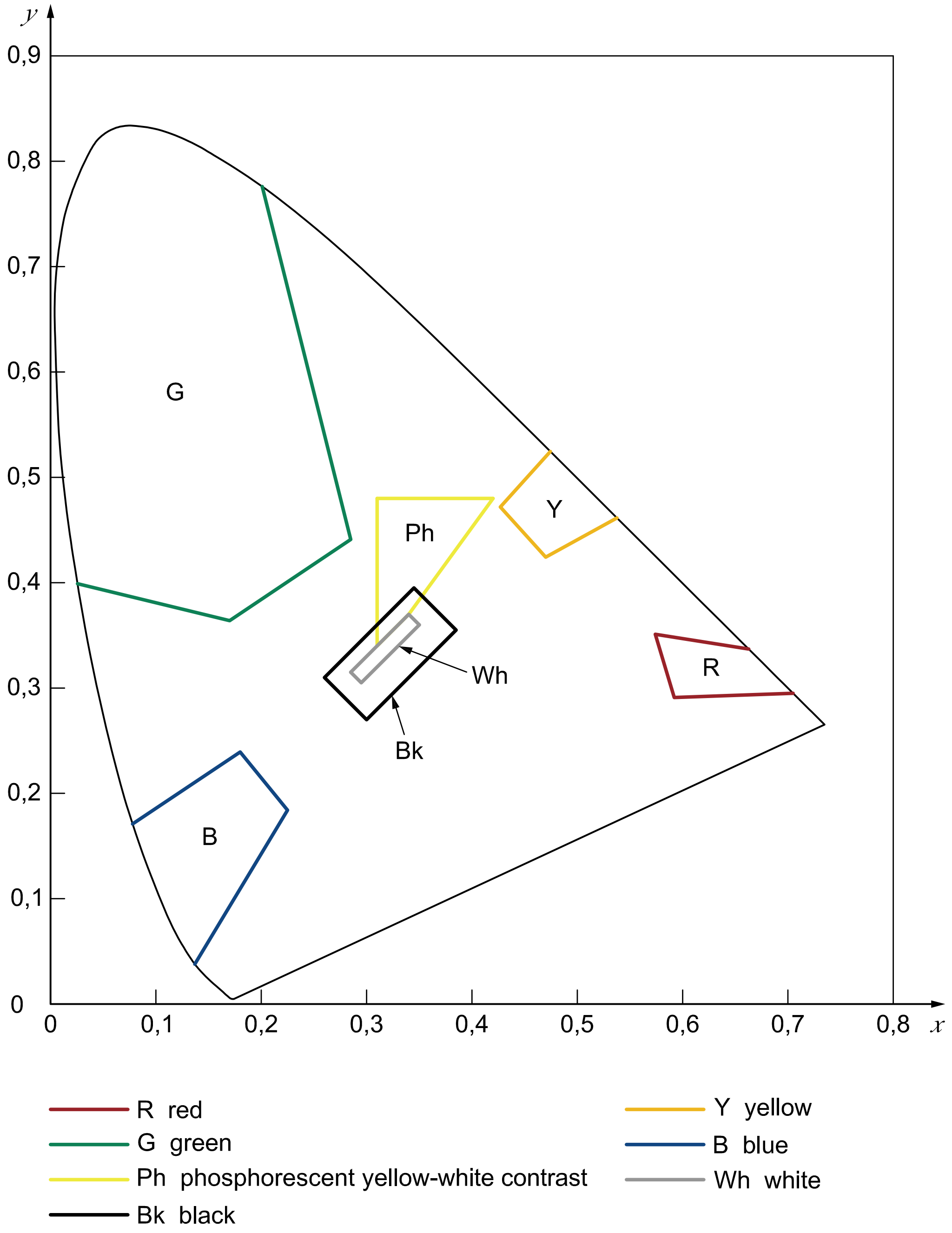

Figure 1 — Object colours of ordinary materials, phosphorescent materials and unpowered internally illuminated safety signs under external illumination — Chromaticity boundaries for red, yellow, green, blue, phosphorescent yellow-white contrast, white and black

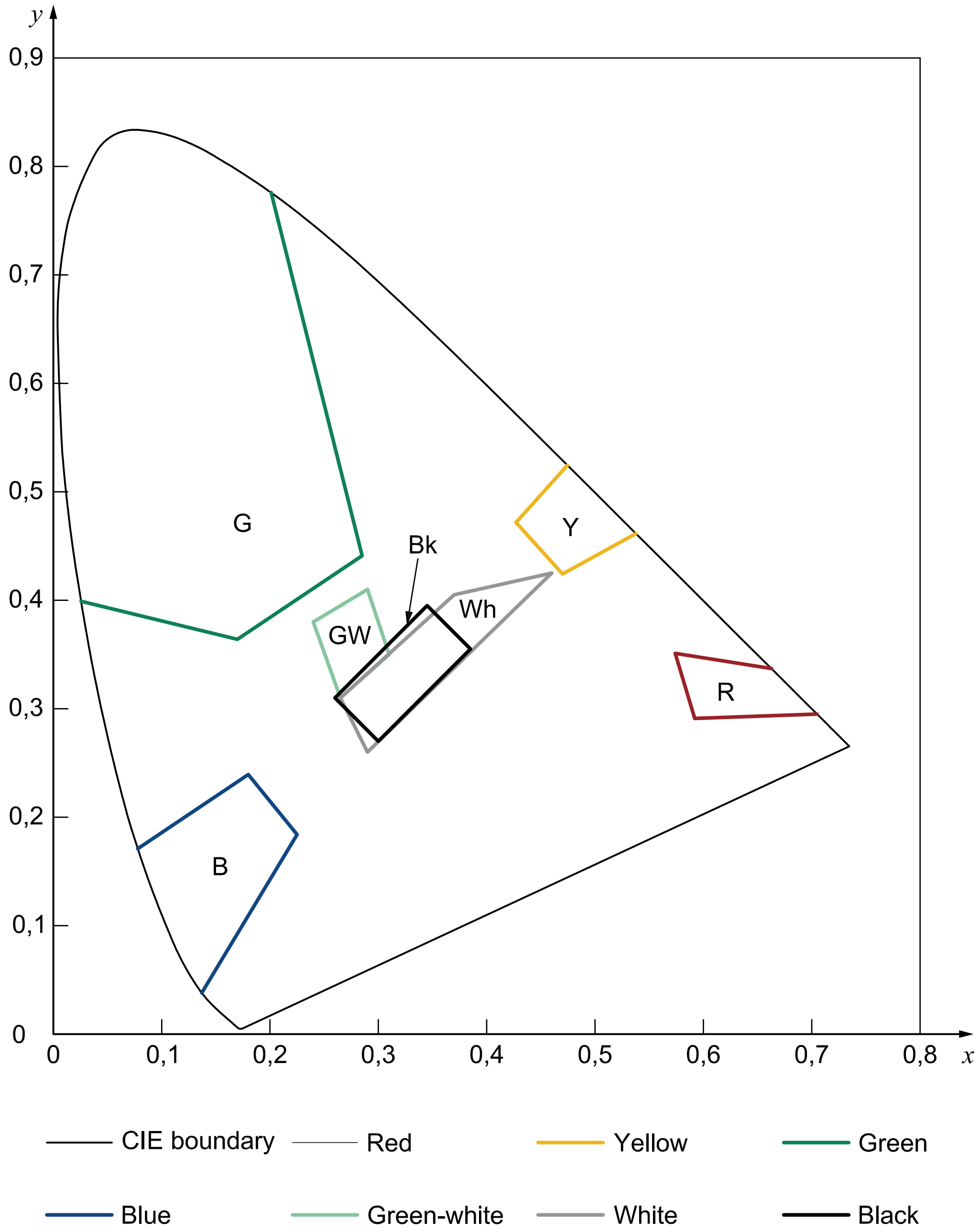

Figure 2 — Object colours of powered internally illuminated safety signs — Chromaticity boundaries for red, yellow, green, blue, green-white, white and black

Note that the colours of the lines giving the chromaticity boundaries in Figures 1 and 2 are arbitrary and only give an indication of the associated colour.

5 Test methods

5.1 General

All testing shall be carried out on finished signs or samples that are representative, with regard to the colour and surface texture, of the material used in the finished sign.

General information on colour measurement is given in Annex A.

Specifications of colour and photometric instrumentation are given in Annex C.

5.2 Object colour under external illumination

5.2.1 Safety signs comprising ordinary materials

The sign face shall be measured using a spectrophotometric colorimeter meeting the specifications given in C.1.1.

Three measurements at the same position shall be taken and the mean values of x, y and Y shall be calculated.

Measurements shall be made on all the safety colours and contrast colours comprising the sign.

5.2.2 Unpowered internally illuminated safety signs under external illumination

Black material shall be placed behind the sign face. The sign face shall be measured using a spectrophotometric colorimeter meeting the specifications given in C.1.1.

Three measurements at the same position shall be taken and the mean values of x, y and Y shall be calculated.

Measurements shall be made on all the safety colours and contrast colours comprising the sign.

5.2.3 Phosphorescent safety signs under external illumination

The phosphorescent safety sign shall be pre-conditioned by being placed in a completely dark enclosure for at least 48 h. The specimens shall not be removed from the dark enclosure until immediately prior to the tests.

The ambient temperature during preconditioning of the sign, excitation and colorimetric and luminance testing shall be 23° C ± 2 °C. The relative humidity shall be (50 ± 10) %. All testing shall be performed in a room/chamber whose ambient light level is at least one order of magnitude lower than the lowest luminance measurement to be made.

Excitation of the phosphorescent sign shall be by light from a D65 daylight simulator fluorescent lamp at 45° to the normal of the surface of the sign to produce 200 lx (±2) measured on the surface/plane of the sign at the position of the test patch. The excitation duration shall be 20 min. No ambient or stray light shall be present during excitation.

A colorimeter meeting the specification given in C.1.2 or C.1.3 shall be positioned normal to the surface of the sign and the size of the test patch shall be selected to be within the dimensions of the graphical symbol or basic geometric shape being measured.

After 20 min, with the D65 daylight simulator fluorescent lamp remaining switched on, measurements of chromaticity coordinates and luminance, L_p, shall be made at intervals of 1 min for a time period of 10 min. Chromaticity coordinates x, y and luminance (in cd/m^2) shall be recorded.

Measurements shall be made on all the safety colours and contrast colours comprising the sign.

The procedure shall be repeated at two other test patches within the same coloured graphical symbol and colours of the basic geometric shape.

To determine the luminance factor, the luminance, L_w, of a calibrated white reflectance standard for 45°:0° geometry (positioned at the same test patch position and under the same D65 daylight simulator illumination conditions), shall be measured at intervals of 1 min for a time period of 10 min. The luminance factor, β, of the phosphorescent sign shall be calculated according to the following equation:

$$\beta = \rho \, (L_p / L_w)$$

where ρ is the reflectance of the calibrated white reflectance standard.

5.3 Object colour of powered internally illuminated safety signs

The test methods of this clause also apply to non-maintained internally illuminated safety signs when the integral light source is powered.

Measurements shall be made in a dark room/chamber with the integral light source powered.

A colorimeter meeting the specification given in C.1.2 or C.1.3 shall be positioned normal to the surface of the sign and the size of the test patch shall be selected to be within the dimensions of the coloured area. The test patch shall be positioned such that the edge of the test patch is at least a distance of half the test patch size from the boundary of the coloured area.

Measurements of the chromaticity coordinates of the safety colour and contrast colour(s) shall be made and the luminance (in cd/m^2) shall be recorded.

A luminance instrument meeting the specifications given in C.2 or a colorimeter meeting the specification given in C.1.2 or C.1.3 shall be positioned normal to the surface of the sign and the size of the test patch should be selected to be within the dimensions of the coloured area. The test patch shall be positioned such that the edge of the test patch is at least a distance of half the test patch size from the boundary of the coloured area.

The minimum and maximum luminance shall be measured over the areas of the safety colour and white contrast colour, if present. Border areas outside the basic geometric shape of the safety sign shall be excluded.

The minimum and maximum luminance contrast shall be calculated as follows:

$$\text{minimum luminance contrast} = \frac{\text{minimum luminance of white contrast colour}}{\text{maximum luminance of safety colour}}$$

$$\text{maximum luminance contrast} = \frac{\text{maximum luminance of white contrast colour}}{\text{minimum luminance of safety colour}}$$

The ratio of minimum to maximum luminance within the safety colour and white contrast colour, if present, shall also be calculated.

Annex A
(informative)

Object colour of different types of safety sign and material

A.1 Externally illuminated

A.1.1 Ordinary materials

The object colour of an ordinary material is produced as a result of the selective absorption of light incident upon the surface. The colour perceived is dependent on a complexity of factors, which includes the spectral distribution of the incident light, the spectral radiance factor of the surface, and several visual parameters such as the state of adaptation of the observer and the colour of the surrounding areas. However, in order to define colour for practical purposes, it is sufficient to use the chromaticity coordinates of the CIE 2° standard colorimetric observer and the luminance factor. These quantities are dependent only on the spectral distribution of the incident light and the spectral luminance factor of the surface. For the purposes of this part of ISO 3864, colorimetric values are calculated under CIE standard illuminant D65.

In considering the ordinary colour of a surface, it is usual to assume that the surface is a uniformly reflecting diffuser. The light reflected from a glossy or semi-glossy surface includes some specular reflection which should usually be excluded when defining the colour, and the geometry of measurement specified should be one that will exclude such reflection. The 45°a:0° and 0°:45°a geometries represent the reciprocity of light and the annular illumination is chosen since the reflected light from the surface of many materials is not uniformly diffuse. The reference geometry is 45°a:0°.

A.1.2 Phosphorescent materials under external illumination

These materials are pigments that exhibit phosphorescence as the result of absorption of energy from the shorter wavelength regions of the visible spectrum and/or in the ultraviolet region, and store energy, some of which is re-radiated at longer wavelengths, producing emissions in the visible region over a period of time.

The colour on excitation by an external light source is the colour of the phosphorescent pigments resulting from reflection of the excitation radiation and the broadband radiation emitted by the phosphorescent pigments or products superimposed on it. Usually, the reflected light is much stronger than the emitted light.

The object colour is dependent on a number of factors, which includes characteristics of the phosphorescent materials and the spectral composition, illuminance level and duration of the excitation source. The test involves measurement at a saturation excitation condition. The test method involves using light from a D65 daylight simulator fluorescent lamp at 45° to the normal of the surface of the sign to produce 200 lx (±2 %) at the surface of the phosphorescent material for 20 min. Measurement is by a tristimulus colorimeter or spectral colorimeter viewing normal to the phosphorescent surface. By measuring a white reflectance standard placed at the same measurement position, the luminance factor can be determined.

A.1.3 Unpowered internally illuminated safety sign under external illumination

When a non-maintained internally illuminated safety sign is externally illuminated and is in an operational mode with the integral light source, unpowered external illumination is reflected from any surface. The test method is the same as that for ordinary materials except for the placement of black material behind any translucent sign face.

A.2 Powered internally illuminated safety signs

This category includes maintained internally illuminated and non-maintained internally illuminated safety signs in an operational mode with the integral light source powered.

There is a wide variety of construction of signs and types and technologies of light sources. The integral light source may illuminate translucent material from behind, from an edge, or be a light-emitting material such as electroluminescent or LED sheets. Surfaces may exhibit properties partially of transmission/emission and partially of diffuse reflection.

Measurement is by a tristimulus colorimeter or spectral colorimeter viewing normal to the sign face surface. The chromaticity coordinates of the CIE 2° standard colorimetric observer and the luminance are used to specify colour. A luminance instrument, again viewing normal to the sign face surface, can be used to determine the luminance contrast, k, between the contrast colour and the safety colour, and the variation of the luminances within each colour.

A.3 Emission colour of phosphorescent material

After phosphorescent material has been exposed to light and all lights are switched off, the phosphorescent material emits visible radiation over a period of time whilst decreasing in luminance. Measurement requires no other light sources to be present.

The emission colour is dependent upon a number of factors, which include characteristics of the phosphorescent material and the spectral composition, illuminance level and duration of the excitation source.

This part of ISO 3864 specifies excitation of the phosphorescent material by light from a D65 daylight simulator fluorescent lamp producing 200 lx (±2 %) measured on the surface/plane of the sign at the position of the test patch for an excitation duration of 20 min.

At the moment of switching off the excitation light source, the luminance of phosphorescent materials can be around the lower level of photopic vision (several cd/m^2) for the normal eye. In the next time period of luminance decay, the luminance is within the level of mesopic vision (between several cd/m^2 to some hundredths of cd/m^2) of the normal eye. Following further decrease of luminance with time, the luminance is within the level of scotopic vision for the normal eye. Colour recognition becomes more difficult in the mesopic vision range and is non-existent in the scotopic range. Throughout the luminance range during the luminance decay, identification of safety sign elements and guidance lines comprising phosphorescent materials is by their contrast to a dark background.

In this part of ISO 3864, the assessment of the emission colour of the phosphorescent material is made by measuring chromaticity coordinates and luminance at two minutes of luminance decay after a high level of excitation. The precision of the measurement allows the colour to be assigned to within a relatively large chromaticity boundary of the CIE diagram.

The assignment is for the purposes of naming and labelling. Colour recognition is extremely poor at extended decay times.

The luminance performance of phosphorescent materials is covered by ISO 16069 and ISO 17398. ISO 17398 classifies phosphorescent materials as A, B, C or D according to the minimum luminance values at specified times during the luminance decay according to a specified test method.

NOTE 1 In ISO 16069, phosphorescent safety signs with the format of ISO 7010-E001 and ISO 7010-E002, emergency exit signs, when in luminance decay, are called directional indicators.

NOTE 2 In ISO 23601, the graphical symbol representation of the location of safety signs on plans can be produced by phosphorescent graphical symbols. ISO 23601 specifies not less than class C according to ISO 17398 for the phosphorescent contrast colour.

Annex B
(normative)

Classification of emission colour of phosphorescent material

B.1 Classification of emission colour

When the phosphorescent material is tested in accordance with B.2, the chromaticity coordinates of the emission colour measured shall fall within the relevant chromaticity boundary specified in Table B.1, as illustrated in Figure B.1. The luminance at 2 min ± 10 s decay time shall be as specified in Table B.1.

The emission colour shall be classified by letter according to the key to Figure B.1.

Table B.1 — Chromaticity coordinates and luminance of phosphorescent emission colours (no external illumination)

Colour region	Chromaticity coordinates of corner points of chromaticity region CIE 2° standard colorimetric observer				Luminance at 2 min decay time
		1	2	3	mcd/m^2
Red	*x*	0,630	0,313	0,735	⩾300
	y	0,370	0,329	0,265	
Yellow	*x*	0,472	0,313	0,575	⩾300
	y	0,528	0,329	0,425	
Green	*x*	0,008	0,313	0,074	⩾300
	y	0,538	0,329	0,834	
Blue	*x*	0,174	0,313	0,050	⩾300
	y	0,005	0,329	0,274	
Yellow-green contrast	*x*	0,074	0,313	0,472	⩾500
	y	0,834	0,329	0,528	

In separate tests, carried out in accordance with ISO 17398, the phosphorescent material shall be classified in accordance with ISO 17398.

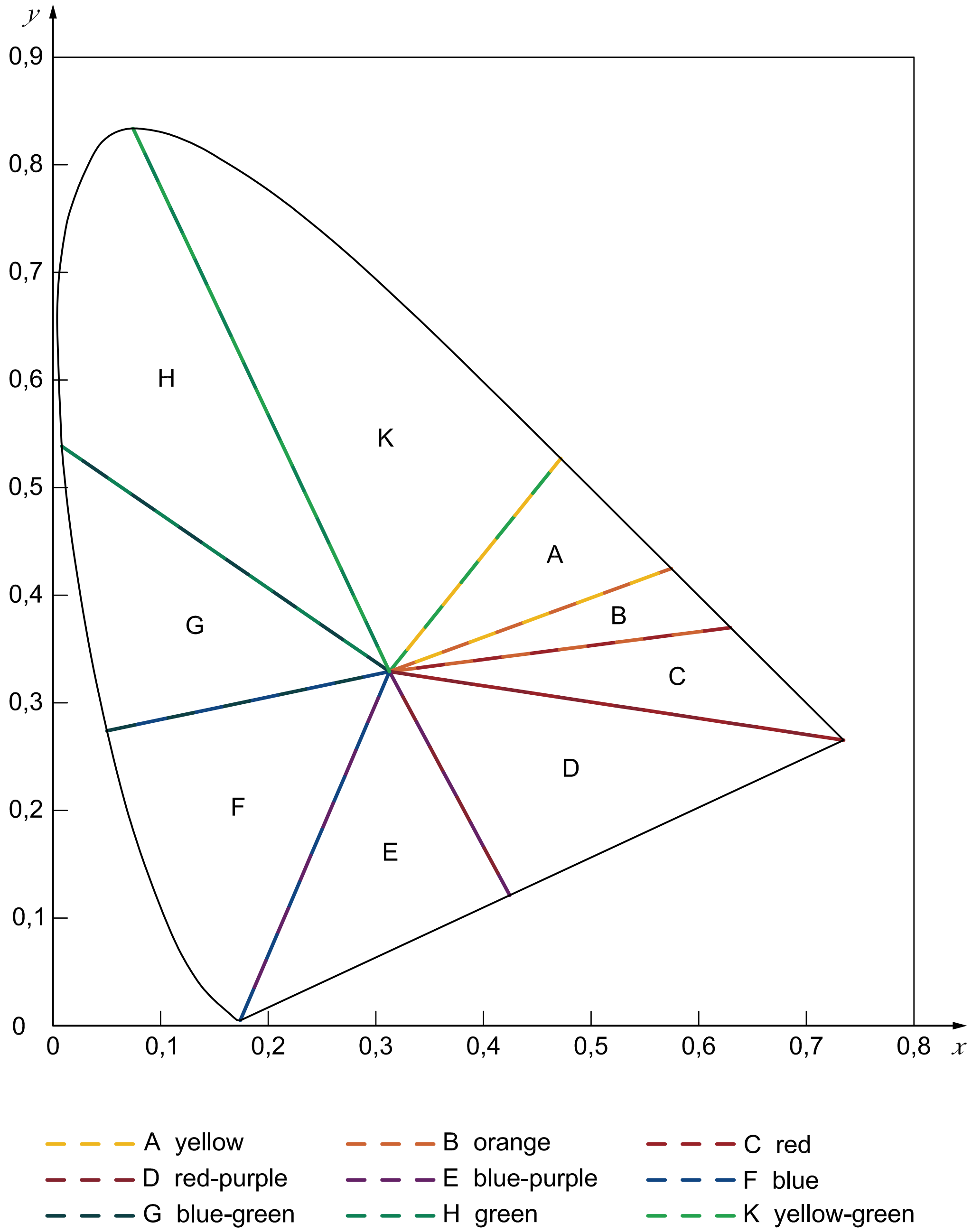

Figure B.1 — Chromaticity boundaries for classification of emission colours of phosphorescent materials

Note that the colours of the lines giving the chromaticity boundaries in Figure B.1 are arbitrary and only give an indication of the associated colour.

B.2 Test method

The phosphorescent material shall be pre-conditioned by being placed in a completely dark enclosure for at least 48 h. The specimens shall not be removed from the dark enclosure until immediately prior to the tests.

The ambient temperature during preconditioning of the material, excitation and colorimetric and luminance testing shall be 23 °C ± 2 °C. The relative humidity shall be (50 ± 10) %. All testing shall be performed in a room/chamber whose ambient light level is at least one order of magnitude lower than the lowest luminance measurement to be made.

Excitation of the phosphorescent material shall be by light from a D65 daylight simulator fluorescent lamp producing 200 lx (±2 %) measured on the surface/plane of the sign at the position of the test patch. The excitation duration shall be 20 min. No ambient or stray light shall be present during excitation.

A colorimeter meeting the specification given in C.1.2 or C.1.3 shall be positioned normal to the surface of the sign and the size of the test patch shall be selected to be within the dimensions of the graphical symbol being measured.

At 20 min, the excitation lamp shall be switched off and measurement immediately commences. At 2 min ± 10 s of the luminance decay time, the chromaticity coordinates x, y and the luminance (in mcd/m^2) shall be recorded.

Annex C
(normative)

Specification of colour and photometric instrumentation

C.1 Colour instrumentation

C.1.1 Spectrophotometric colorimeter

The instrument shall be provided according to CIE 15. Colorimetric values shall be calculated under CIE standard illuminant D65 and CIE 2° standard colorimetric observer conditions. Generally, either monochromatic illumination or polychromatic illumination in one-monochromator instruments can be used, but, when reflected light includes phosphorescence, polychromatic illumination shall be used. In this case, the quality of illuminating light should be more than category B (visible) and C (ultraviolet) grade, when estimated by the CIE 51.2 method.

The instrument shall have the following features:

- spectral condition:
  - wavelength range: 380 nm to 780 nm, at least 400 nm to 700 nm;
  - wavelength sampling interval: ⩽20 nm;
- geometric condition:
  - illuminating and viewing conditions: (45°a:0°) or (0°:45°a);
- photometric condition:
  - measuring range for Y: at least 0 % to 100 %.

NOTE The luminance factor, β, is Y/100.

C.1.2 Tristimulus colorimeter for colour of light

This instrument measures the relative values of tristimulus values (X, Y, Z) directly by tristimulus method. The results are shown in chromaticity coordinates (x, y) and luminance L_v. Values shall be calculated for CIE 2° standard colorimetric observer. The instrument shall have the following minimum features:

- wavelength range: at least 400 nm to 700 nm;
- repeatability of chromaticity coordinates: ±0,003;
- luminance range: 0,01 cd/m^2 to 15 000 cd/m^2;
- luminance repeatability: ±0,01 cd/m^2.

NOTE The luminance, L_v, is Y.

C.1.3 Spectral colorimeter for colour of light

This instrument measures relative spectral radiance L_e (λ) by spectral method. The results are shown in tristimulus values (X, Y, Z), chromaticity coordinates (x, y) and luminance L_v. Values shall be calculated for CIE 2° standard colorimetric observer. The instrument shall have the following features:

— wavelength range: 380 nm to 780 nm;

— bandpass: less than 5 nm;

— luminance range: 0,01 cd/m^2 to 15 000 cd/m^2;

— luminance repeatability: ±0,01 cd/m^2.

NOTE The luminance, L_v, is Y.

C.2 Luminance instrumentation

A luminance meter shall be calibrated to measure photopic luminance (CIE 2° standard colorimetric observer). The instrument shall have the following features:

— spectral error: $f_1' \leqslant 3$ % (with f_1' as defined in CIE 69);

— luminance range: 0,01 cd/m^2 to 15 000 cd/m^2;

— luminance repeatability: 0,01 cd/m^2.

C.3 Illuminance instrumentation

A cosine photopic V(λ) corrected illuminance meter shall be provided, calibrated to measure illuminance in lux (lx), with the following features:

— spectral error: $f_1' \leqslant 5$ % (with f_1' as defined in CIE 69);

— UV response: $u \leqslant 0,5$ % (with u as defined in CIE 69);

— linearity error: $f_3 \leqslant 0,5$ % (with f_3 as defined in CIE 69);

— illuminance range: 10 lx to 1 000 lx;

— resolution: 1,0 lx.

Annex D
(informative)

Guidance on photometric relationships between and within safety and contrast colours of graphical symbols

D.1 General

The recommendations given in this annex are applicable to safety signs that are externally illuminated and to internally illuminated signs that have luminous surfaces. The recommendations do not cover signs utilizing point light sources to depict graphical symbols.

The colour appearance of safety colours and the contrast colour white can be affected by chromatic adaptation. This is a complex issue for which the colour-rendering index for a lamp is sometimes used. A recommendation drawing upon ISO 30061 is that, in order to identify safety colours, the minimum value for the colour, rendering index for a lamp should be greater than 40. The luminaire providing external lighting should not substantially subtract from this.

Guidance on the relationship of the dimensions of the safety sign and distance of observation is given in ISO 3864-1:—, Annex A.

D.2 Externally illuminated signs

Factors, other than the external illumination, which affect the legibility of external illuminated signs, include the dimensions of the graphical symbol elements and the contrast, C, between the safety colours and contrast colours. The contrast, C, should be large, preferably greater than 0,8.

Generally, the reflectance of the safety sign elements themselves should be uniform.

Information on distance factors for externally illuminated safety signs under different levels of illumination are given in ISO 3864-1:—, Annex A. Distance factors are given for people with normal vision and for people with impaired vision, as well as the effect of observing the safety sign from different angles.

D.3 Internally illuminated signs

Factors that affect the legibility of internally illuminated signs include the luminance of the safety colours and contrast colours, luminance contrast and uniformity of luminance within the colour.

The limits for luminance contrast and uniformity of the luminance measured as a ratio of minimum to maximum luminance within the safety colour and within the contrast colour are given in 4.3 and Table 3.

For legibility, the luminance of the safety sign should be appropriate to the lit environment. The minimum luminance values in Table 2 are related to emergency lighting conditions and the minimum specifications for emergency safety signs given in ISO 30061. In normal lighting conditions, the luminance values of the safety sign may need to be increased for legibility and conspicuity in a brighter lit environment.

Information on distance factors for internally illuminated safety signs of different levels of luminance are given in ISO 3864-1:—, Annex A. Distance factors are given for people with normal vision and for people with impaired vision, as well as the effect of observing the safety sign from different angles.

Annex E
(informative)

Examples of safety colours and contrast colours for object colours of ordinary materials

Colour regions for ordinary materials are specified in Table 1 by chromaticity coordinates and a luminance factor. However, manufacturers of safety signs might need guidelines concerning what the respective colours look like. For this purpose, and not for colour matching, examples of colour swatches within the colour region are given in Table E.1. Some of the colour references are specified in various national standards for safety signs.

The colour references in Table E.1 are available as colour swatches. The order of listing within the columns of the table is arbitrary and the rows of the table do not represent any closeness of colour matching.

Table E.1 — Ordinary materials: examples for object colours that fall within the specified chromaticity coordinates and luminance factor for the colour region

Colour swatch	RAL (DIN 6164)	Munsell	BS 5252	NCS
Red	RAL 3001 (7,5: 8,5: 3)	7,5R4/14 G[b]	04E56	S 1080-R GL
	RAL 3001/840-HR (7,6: 7,3: 3.2)	7,5R4/15 G[a]	04E53	S 1085-Y90R
	RAL EFFECT 450-6 (7,6: 8,1: 2,0)	7,5R4/16 G		S 1080-Y90R GL
				S 1580-Y90R
				S 1580-Y90R GL
				S 2570-Y90R GL
Yellow	RAL 1003 (2,5: 6,5: 1)	2,5Y8/12 G	08E53	S 0585-Y20R GL
	RAL 1003/840-HR (2,6: 6,2: 0,9)	2,5Y8/14 G[a]	08E51	S 1070-Y10R
	RAL 1021/840-HR (1,9: 6,6: 0,9)	2,5Y8/16 G	10E55	S 0580-Y10R
	RAL EFFECT 290-6 (2,7: 6,1: 0,8)	5Y8/12 G[b]	10E51	S 1080-Y10R GL
	RAL EFFECT 270-5 (2,0: 6,5: 0,9)	5Y8/14 G		S 1070-Y10R GL
		10YR8/12 G		S 1080-Y10R
		10YR8/14 G		S 0580-Y10R GL
				S 0570-Y10R GL
				S 0570-Y10R
				S 1080-Y
				S 1080-Y GL
				S 1070-Y
				S 0580-Y GL
				S 1070-Y GL
				S 0580-Y

Table E.1 (*continued*)

Colour swatch	RAL (DIN 6164)	Munsell	BS 5252	NCS
Green	RAL 6032 (21,7: 6,5: 4) RAL 6032/840-HR (21,7:5,9:4,0) RAL EFFECT 220-5 (21,7:5,9:4,1)	10G4/10 G[a] 7,5G4/9 G[b] 2.5G4/10 G 5G4/10 G 5G4/8 G 7,5G4/10 G	14E56	S 1565-G GL S 1565-G S 2060-G-GL S 3060-G GL S 2060-G S 2565-G GL S 2565-G S 3060-G S 3060-B90G GL
Blue	RAL 5005 (16,7: 7,2: 3,8) RAL 5005/840-HR (16,7: 6,3: 3,8) RAL 5017/840-HR (17,1: 6,3: 3,6) RAL EFFECT 640-5 (16,7: 6,2: 3,7)	2,5PB3.5/10G[a,b] 10B3/8 G 2,5PB3/8 G 2,5PB3/10 G 5PB4/12 G 5PB3/10 G	20E56 20E53	S 2065-R90B S 3060-R90B S 3560-R90B S 3065-R90B GL S 3065-R90B S 4050-R80B S 3060-R80B S 2565-R80B
White	RAL 9003 (N: 0: 0,5) RAL 9003/840-HR (N: 0,1: 0,4) RAL EFFECT 120-1 (N: 0,1: 0,4)	N9,5 G[a] N9,0 G[b]	00E55	S 0500-N
Black	RAL 9004 (N: 0: 9) RAL 9004/840-HR (N: 0,1: 8,2) RAL EFFECT 790-5 (N: 0,4: 8,6)	N1 G[a] N1,5 G[b]	00E53	S 9000-N

NOTE Munsell and NCS colour swatches can have either a glossy or matte finish. Where the finish is glossy, Munsell uses the label “G”, NCS uses the label “GL”.

[a] JIS Z 9103.

[b] ANSI Z 535.1.

To identify a colour reference in another colour classification system, that colour reference should be tested in accordance with 5.2.1 and meet the specifications in Table 1.

Colours within the colour region and further from the colour region boundaries are likely to take longer to deteriorate and therefore remain within the colour region limits for longer. The rate of colour deterioration may also depend upon the nature of the pigment used in the finished safety sign. Testing of the durability of safety sign material is given in ISO 17398.

Annex F
(informative)

Consideration of defective colour vision

F.1 Types of defective colour vision

Colour deficiency due to the lack of one pigment is called “dichromatism”; this is divided into three types: protan, deutan and tritan. Protan is a lack of red cone pigment, deutan is a lack of green cone pigment and tritan is a lack of blue cone pigment. An observer who is dichromat has two of these three colour deficiencies.

If there is an abnormality in any one of the three cone pigments, this abnormality is called “anomalous trichromatism”. The degree of colour deficiency is just the same as that of dichromatism, or of various degrees to the normal.

The frequency of occurrence of colour deficiency is about 7 % to 8 % for European males, and about 4 % to 5 % for Asian males; most of these colour deficiencies are classed as deutan. For females, in both Europe and Asia, the occurrence is less than 1 %.

Acquired colour vision deficiency encompasses all the colour deficiencies except those with genetic carriers. The difference between congenital and acquired deficiencies may be explained as follows. The person with acquired colour vision deficiency used to have normal colour vision, but this has been affected by disease. In other words, the acquired colour vision deficiency may be classed as a secondary colour deficiency as opposed to the congenital. In a broad sense, changing colour perception due to aging is also classed as acquired even though it is not due to any disease.

The major difference between the acquired and the congenital cases may be explained as follows.

a) In the acquired case, the level of colour deficiency varies by the degree of the diseases or any other disorder, or both. In the congenital case, however, the level of colour deficiency will not change at all throughout the person's lifetime.

b) In the congenital case, the colour deficiency is always binocular, but in the acquired case, it may be either monocular or binocular.

c) In the congenital case, the colour deficiency does not accompany other visual defects. In the acquired case, however, it is always accompanied by one or more visual defects.

d) In the acquired case, the person/observer is conscious of the colour abnormality, but not so in the congenital.

e) In the congenital case, tritan (abnormality in blue, yellow) is extremely rare; it is not as rare in the acquired case.

While a colour-deficient observer can be expected to have difficulty perceiving the safety colour and determining its intended meaning, the degree to which confusion can occur is more likely to be based upon the observer's experience and degree of colour deficiency.

F.2 Effect on colour regions for safety signs

The overall shape of the CIE chromaticity diagram, as given in Figure 1, is based on the CIE 2 standard colorimetric observer who is an observer with normal colour vision or trichromat.

In considering the effects of dichromatism, each of the three colours, red, green and blue, can be mixed on one of the confused lines on the CIE chromaticity diagram. Straight lines of confusion, diverging from the copunctal points for protanopic vision, deuteranopic vision and tritanopic vision, cross the CIE chromaticity diagram. It means, for each dichromat, that all points on each confusion line are recognized as the same colour.

The boundaries to the red and green colour regions given in Figure 1 are based upon avoiding confusion between vivid green and vivid red.

The effects of the various colour deficiencies have been considered in the determination of colour regions for safety signs, in particular where the safety colours green, yellow and red are present. Yellowish green is avoided. In addition to the colours, “brightness contrast sensitivity” is applied in terms of requiring high contrast or high luminance contrast between colours as appropriate to the type of safety sign.

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