

Specification for

Colours of light signals

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Department of Employment (HM Factory Inspectorate)	London Transport Executive*
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Electricity Supply Industry in England and Wales	Royal Institute of British Architects
Engineering Equipment Users' Association	Society of British Gas Industries
Glass Manufacturers' Federation*	Society of Glass Technology

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Plastics Federation	Trinity House
British Railways Board	Vehicle Actuated Road Signal Development Association
Colour Group (Great Britain)	
Ministry of Defence Procurement Executive	
Transport and Roads Research Laboratory (Department of the Environment)	

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Foreword

This British Standard has been prepared under the authority of the Illumination Industry Standards Committee.

This revision has been undertaken to lay down performance requirements for plastics filters which are now in common use and to make those alterations that are necessary because of the changing availability of coloured glass.

This standard specifies the colour of light emitted by signalling equipment, though it also defines the colours of filters that may be used with various light sources to achieve these requirements. It also includes guidance on the stability of light sources and filters and photometric test requirements for both complete signals and for filters tested separately.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 36, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This British Standard specifies the colours of light signals for all purposes. While it has been based on requirements for transport signalling it is equally applicable to signal colours for other purposes, e.g. indicating lights.

Guidance on means of achieving these colours and of maintaining the performance of signals is also provided.

2 References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this British Standard the definitions given in BS 4727-4 apply, together with the following.

3.1 signal

- a) A message in coloured light which is conveyed to an observer.
- b) A device which emits that light.

NOTE The applicable sense will be immediately apparent from the context in which the term appears.

3.2 chromaticity

throughout this standard, chromaticities are defined in terms of CIE¹⁾ 1931 chromaticity co-ordinates x , y and z . The co-ordinate x is analogous to the proportion of red, y to the proportion of green and z to the proportion of blue

3.3 colour limits

limiting values of some or all of the three chromaticity co-ordinates x , y and z

3.4 filter

a device which modifies by transmission the spatial distribution or the colour, or both, of the light passing through it

3.5 plain filter

a filter of uniform thickness which effects no significant change in the direction of a beam of light normally incident upon it

3.6 colour filter

a selective filter that makes a significant change to the chromaticity of the light passing through it

3.7 lens

a filter, which may be a colour filter, used to modify the divergence of the light rays passing through it from a small source of light

3.8 diffuser

a filter used to increase the spatial distribution of a beam of light and depending essentially on the phenomenon of diffusion

3.9 spreader

a filter which increases the spatial distribution of a luminous flux in one plane only

3.10 chromaticity of a signal

the chromaticity co-ordinates of the light emitted by the signal when operated in the manner intended in service

3.11 chromaticity of a filter

the chromaticity co-ordinates of the light transmitted by the filter when light from a standard light source passes through it in the manner intended in service

NOTE For the purpose of this standard the standard source is the CIE Standard Illuminant A (a tungsten filament lamp operated at a correlated colour temperature of 2856 K).

3.12 transmittancy of a colour filter

ratio of the luminous transmittance of the filter to that of a colourless filter of the same pattern and refractive index

preferred abbreviation: T_{cy}

3.13 magnesium oxide screen

a silvered plate on which pure magnesium oxide has been freshly deposited to a thickness of at least 1 mm and manifesting no discontinuity when examined with the naked eye, or a screen of compressed magnesium oxide or barium sulphate powder as described in BS 4432-1

NOTE The references in this standard to magnesium oxide screens can be related to other white reference materials which may be employed for the same use. However, where other materials are used, correction factors may be required for some tests.

¹⁾ Commission Internationale de l'Eclairage

4 General introduction

Coloured light signals are means of conveying information or instructions. They are usually generated by a light source together with a plain colour filter, coloured lens or combination of a lens or mirror and a colour filter. Self-coloured lights such as discharge or fluorescent lamps are also used and signals in general may be continuous, intermittent or flashing.

Section 2 specifies the limiting chromaticity requirements of the various colour class ranges of red, yellow, green, blue and white light signals; it relates only to the colour of the light emitted by the signal and is in no way concerned with the method used to obtain this coloured light. Although the colours complying with the requirements of Section 2 are properly defined as signal red, signal green etc., the word "signal" has been omitted for ease of reading in much of the text of this standard.

Section 3 deals with light sources, filters and combinations of these which may be used to produce coloured light to the requirements of Section 2. Some general guidance relating to problems of the stability of the signals and colour filters is contained in Appendix A.

Section 4 deals with photometric procedures by which complete light signals and filters may be tested for compliance with this standard. A means of inspection, which may be convenient when dealing with large numbers of filters, is described in Appendix B.

Appendix D gives information on the requirements and recommendations of a number of international bodies for the colours of light signals.

It is normally sufficient for purchasers of complete light signal equipments to specify the required colour and class, in accordance with Section 2 and the intensity and distribution of the light output required. The inclusion in such specifications of additional requirements for specific light sources and filters may impose unnecessary restrictions on the design and method of manufacture and should be avoided if possible.

The content of Section 3 should not, therefore, normally form a part of the specification of a complete equipment but may be regarded as an indication of what can be achieved with various combinations of filters and light sources and as guidance to designers and manufacturers in meeting a particular requirement. However, Section 3 may be used as a specification for replacement light sources and filters and in those cases where a purchaser has a particular reason for including such detailed requirements in a specification for a complete item of equipment.

Section 2. Colours emitted by light signals

5 General

When coloured lights are fixated and only just visible they appear nearly colourless, with the exception of red. As they get brighter, green lights become recognizable, thus providing the common three colour system of red, green and an intermediate colour which, at still higher luminosities, becomes distinguishable into yellow, white or blue.

These considerations have dictated the choice of colours of signals that are frequently seen near the limits of visibility but in order to preserve the similarity of message that each colour conveys, the use of these colours has naturally spread to signals that are normally only seen at close range.

In multi-coloured signalling systems it is possible to improve the certainty of colour recognition by ensuring that any pair of colours which must be distinguished are as far apart as possible in chromaticity, consistent with their having adequate intensity. For this reason, this standard subdivides each of the main signal colours so that appropriate colour areas can be chosen where high differentiation is required.

The use of blue as a light signal colour must be treated with some caution. Confusion of blue with other colours may occur unless the illuminance produced by the light at the eye of the observer (the point brilliance) is substantially above threshold. Since the luminous efficacy of radiation in the blue region of the spectrum is low, it is difficult to ensure adequate illuminance except at short ranges. Furthermore, colour recognition is uncertain if the angular subtense of the light at the observer is too small, say less than about 10 minutes of arc. It should also be noted that, owing to a yellowing of the lens of the eye with age, older observers may have elevated thresholds for detection and recognition of blue light.

6 Ranges of colours

In this standard, a colour of class A has the widest range of chromaticities and embraces the more restricted ranges designated classes B and C. Where two coloured lights need to be distinguished with extra reliability by observers with normal colour vision they should be chosen from their respective restricted ranges so that they are separated as much as possible in the CIE chromaticity co-ordinate diagram (see Figure 1). For example, class C white and red lights are distinguished from a yellow light with more reliability than are the class B whites and reds which, in turn, are more readily distinguished from yellow than the whites and reds permitted by class A.

7 Limits of chromaticity of light signals

The colour of the light emitted by a signal, when tested in accordance with the requirements specified in Section 4, shall lie within the boundaries for the specified colour on the CIE (1931) chromaticity co-ordinate diagram (see Figure 1) defined by the equations in Table 1, together with the spectrum locus (except for white) and the purple boundary (for red classes A and C only).

The definitive requirements of this standard are in terms of the equations in Table 1 but the chromaticity diagrams of Figure 1, Figure 2 and Figure 3 have been included as illustrations of the various colour boundaries. Figure 1 is a plot of the chromaticity diagram showing all boundaries and Figure 2 and Figure 3 show in greater detail the boundaries for red and yellow respectively.

When it is required to plot the areas of acceptable chromaticity regions on a diagram, it is often easier and quicker to do this by joining points corresponding to the intersections of the boundaries than by drawing the boundaries from their specifying equations. The co-ordinates of these points are, therefore, given approximately in Table 1A.

8 Choice of restricted colour limits

In choosing the restricted class of coloured lights to be adopted in a multi-coloured signalling system, consideration should be given to the risks of confusion between the various pairs of colours, so that if there is a conflict between several needs that which is most serious can be given priority. Also, in certain circumstances it may be necessary to consider the needs of observers with abnormal colour vision.

In the majority of cases where the ability to interpret a light signal is important, the individuals concerned will have been selected so as to eliminate those with defective colour vision. Where no such selection is possible, as in the case of road traffic lights, the more prevalent classes of persons with abnormal colour vision i.e. those who confuse reds and greens, can be helped by a particular choice of these two signal colours. This choice would avoid yellow-greens and would select blue-greens rather than mid-greens and would also select reds with a substantial yellow component rather than darker reds. Thus, the use of a class B red together with a class C green would provide many such persons with a certain amount of colour distinction between these two signals, where they would otherwise have to rely for identification solely on the position of the light within the signal head.

For some purposes, the $y = 0.3$ dark limit of class B red may be irrelevant and the appropriate range of chromaticities may be specified as B + C.

Table 2 gives typical applications of colour classes of light signals to the various branches of transport.

9 Colour stability

Having decided upon the chromaticity limits for a particular light signal application, it is a normal requirement that the colour should remain within these limits throughout the working life of the signal and in all its anticipated conditions of usage. The colour of the light emitted depends upon the chromatic qualities of the light source or of the colour filter/light source combination and these qualities are in turn dependent upon a large number of factors which are fully discussed in Section 3 and Appendix A. It is important that these factors be fully appreciated by anyone designing or specifying a requirement for a light signal as they may impose limitations on what can actually be achieved in practice. A particular problem arises in connection with the dimming of signals, in which the colour temperature of the light source is lowered when the light output of the lamps is deliberately reduced (see clause 19).

10 Effects of the atmosphere

When a signal is required for use at long distances in a wide variety of conditions, consideration should be given to the effect that the passage of light through the atmosphere may have on its apparent colour.

In clear atmospheres the only problem is faintness of the signal when seen at a great distance and this usually has the effect of making the colour difficult to recognize with precision. In some types of mist, haze or smoke the bluer fractions of the light emitted by the signal are scattered and lost to a greater extent than the red fractions so that a yellow will appear more orange and a green more yellow: this effect may be more pronounced for some types of discharge lamp than for continuous-spectrum signals. In tunnels containing diesel exhaust, there is a general darkening but no significant colour change.

In no case, however, is there a risk of a red (stop) or a yellow (caution) signal being incorrectly read as green (proceed) as the changes in appearance that occur all operate in the direction of greater safety.

11 Effect of temperature of operation

For signals which may be required to operate over a wide temperature range, it is important to recognize that when the temperature of a filter is raised or lowered its transmittancy and colour will vary. These changes can be quite large and are particularly significant for red and yellow signals, where the chromaticity may change with temperature to such an extent as to move the colour of the light emitted from one colour class into another. Reference should be made to **A.3** and **A.4** for guidance on this point.

Section 3. The production of coloured light

12 General

Section 2 specifies the chromaticity of light signals for various purposes but is not concerned with how the coloured light is obtained. This section of the standard deals with light sources, filters and combinations of these which may be used to produce this coloured light. The requirements for colour filters are equally applicable to coloured lenses.

13 Self-coloured light sources

A limited range of coloured lights which come within the compass of this standard can be produced directly from discharge tubes with suitable gases or vapours or from fluorescent lamps according to the combination of phosphors in these lamps. Other self-coloured light sources include incandescent lamps of which the chromaticity is controlled by their operating temperature. The approximate characteristics of the self-coloured light sources in most general use are given in Table 3.

While self-coloured light sources have advantages, their size, shape, occasional low light output and the requirement for control gear to operate discharge tubes and fluorescent lamps prevent them from being widely used as light signals.

13.1 Light emitting diodes. For the small indicator light type of signal increasing use is being made of the light emitting diode (LED), the most commonly used varieties of which radiate in the region of 650 nm (corresponding to class C red). Yellow LEDs at about 590 nm (corresponding to class A or B yellow) and yellow-green LEDs at about 560 nm (outside the boundaries of any of the greens covered by this standard) are also available but with lower intensities than red LEDs. However, considerable development work is in progress on these devices and it may be anticipated that other colours falling within the requirements of this standard will eventually become available.

Table 1 — Limits for signal colours. Boundary equations in terms of CIE (1931) chromaticity co-ordinates

Colour name	Colour class	Boundary towards blue	Boundary towards green	Boundary towards yellow	Boundary towards red	Boundary ^a towards purple	Boundary towards white
Signal red	A	—	—	$y = 0.335$	—	$y = 0.980 - x$	—
	B	—	—	$y = 0.320$	$y = 0.300$	$y = 0.990 - x$	—
	C	—	—	$y = 0.300$	—	$y = 0.995 - x$	—
Signal yellow	A	—	$y = x - 0.120$	—	$y = 0.382$	—	$y = 0.790 - 0.667x$
	B	—	$y = x - 0.120$	—	$y = x - 0.170$	—	$y = 0.790 - 0.667x$
	C	—	$y = x - 0.160$	—	$y = 0.382$	—	$y = 0.790 - 0.667x$
Signal green	A	$y = 0.390 - 0.171x$	—	$x = 0.390 - 0.171y$	—	—	$x = 0.650y$
	B	$y = 0.390 - 0.080x$	—	$x = 0.520 - 0.500y$	—	—	$x = 0.650y - 0.030$
	C	$y = 0.390 - 0.080x$	—	$y = 0.600 - 0.434x$	—	—	$x = 0.625y - 0.041$
Signal blue	A	—	$y = 0.065 + 0.805x$	—	—	$x = 0.133 + 0.600y$	$y = 0.400 - x$
Signal white ^b	A	$x = 0.285$	$y = 0.150 + 0.640x$	$y = 0.640 - 0.400x$	$y = 0.390$	$y = 0.050 + 0.750x$	—
	B	$x = 0.285$	$y = 0.150 + 0.640x$	$x = 0.540$	—	—	—
	C	$x = 0.285$	$y = 0.150 + 0.640x$	$y = 0.640 - 0.400x$	$y = 0.390$	$y = 0.050 + 0.750x$	—
NOTE The term "amber" still appears in parliamentary legislation, legal specifications etc., as a synonym for yellow but such usage is deprecated.							—

^a Not to be confused with the "purple boundary" joining the extremes of the spectrum locus which is marked separately on Figure 1.

^b There is a risk of yellowish whites being confused with a yellow signal. Whites with an x co-ordinate greater than 0.500 cannot be reliably recognized as white and their use is deprecated.

Table 1A — Approximate limits for signal colours in terms of the chromaticity co-ordinates of the intersections of their boundaries

Colour name	Colour class	x	y	x	y	x	y	x	y	x	y	x	y
Signal red	A	0.645	0.335	0.665	0.335	0.735	0.265	0.721	0.259	—	—	—	—
	B	0.670	0.320	0.680	0.320	0.700	0.300	0.690	0.300	—	—	—	—
	C	0.695	0.300	0.700	0.300	0.735	0.265	0.731	0.264	—	—	—	—
Signal yellow	A	0.546	0.426	0.560	0.440	0.617	0.382	0.612	0.382	—	—	—	—
	B	0.546	0.426	0.560	0.440	0.585	0.415	0.576	0.406	—	—	—	—
	C	0.570	0.410	0.580	0.420	0.617	0.382	0.612	0.382	—	—	—	—
Signal green	A	0.266	0.724	0.309	0.475	0.228	0.351	0.028	0.385	—	—	—	—
	B	0.105	0.829	0.281	0.478	0.212	0.373	0.027	0.388	—	—	—	—
	C	0.004	0.598	0.263	0.486	0.193	0.375	0.027	0.388	—	—	—	—
Signal blue	A	0.090	0.137	0.186	0.214	0.233	0.167	0.148	0.025	—	—	—	—
Signal white	A	0.285	0.332	0.471	0.452	0.540	0.424	0.540	0.390	0.453	0.390	0.285	0.264
	B	0.285	0.332	0.471	0.452	0.500	0.440	0.500	0.390	0.453	0.390	0.285	0.264
	C	0.285	0.332	0.440	0.432	0.440	0.380	0.285	0.264	—	—	—	—

Table 2 — Typical applications of colour classes for light signals

Colour	Red	Yellow	Green	Blue	White
Application	Class				
Aircraft	A	B	A	A	B
Airfields (general)	A	B	A	A	B
Airfields (high recognition)	C	B	B	A	B
Lighthouses	A	A	A	A	A ^a
Railway signals (day colour lights)	C ^b	B	C	—	C ^c
Railway signals (semaphore)	C	C	C	—	—
Road traffic lights	B	A	C	—	—
Ship's lights	B + C	—	B	—	A ^a

^a The acceptable area for white lights of class A extends appreciably towards the yellow boundary of the CIE chromaticity diagram in order to include the light from oil lamps as these are still used in some signalling systems, and thus also includes light from high pressure sodium sources. The colour of both these lights is, however, undesirably yellow for signalling purposes because there is a risk of its being confused with a true yellow light. Accordingly, it is recommended that wherever possible a white light which is as yellowish as this should be avoided and that a class B white light should be employed instead.

^b Restricted to y not greater than 0.295 for high intensity red signals.

^c Restricted to between $x = 0.330$ and 0.420 and known as "lunar white".

Table 3 — Self-coloured light sources

Source	Approximate chromaticity		Colour class
	x	y	
Neon discharge (hot cathode)	0.67 to 0.68	0.32 to 0.33	Red A
Neon discharge (cold cathode)	0.69	0.31	Red B
Neon discharge (high intensity)	0.70	0.30	Red B
Red fluorescent	0.69	0.31	Red B
Sodium vapour discharge (low pressure)	0.58	0.42	Yellow B
Green fluorescent	0.23 to 0.25	0.61	Green A
Green mercury halide	0.28	0.60	Green A
Blue fluorescent	0.19	0.16	Blue A
Blue mercury halide	0.22	0.18	Blue A (Borderline)
Oil flame	0.53	0.41	White A
Sodium vapour discharge (high pressure)	0.52	0.43	White A
Acetylene flame	0.48	0.41	White B
Xenon discharge (continuous)	0.31 to 0.32	0.30 to 0.33	White C
Xenon discharge (flashing)	0.30 to 0.34	0.30 to 0.35	White C
"Northlight" fluorescent	0.31 to 0.32	0.32 to 0.34	White C
"Daylight" fluorescent	0.36 to 0.38	0.36 to 0.39	White C
White mercury halide	0.32 to 0.43	0.35 to 0.40	White C
Tungsten filament: ^a			
a) at rated conditions (100 % light output)	0.44 to 0.48	0.40 to 0.41	White B
b) at 10 % light output	0.48 to 0.54	0.41 to 0.42	White A or B
c) at 1% light output	0.52 to 0.58	0.39 to 0.41	White A

^a This information is generally applicable to gas filled lamps. For tungsten halogen lamps insufficient data is available at present to make positive pronouncements concerning lamp performance.

13.2 Electroluminescent panels.

Electroluminescent panels, comprising areas (usually plane) or phosphors excited by an electric field to uniform luminance, may be used for indicators where ambient illumination is low, for example in signs giving information in words or digits, or for indicating obstacles. At present there is no application for distant signals in view of the low intrinsic luminance of the panels, while the available range of somewhat unsaturated colours would make the colour coding unsatisfactory.

14 White light sources with colour filters

The majority of coloured light signals are produced by passing light from a nominally white source through a colour filter of glass or plastics. The white light source is usually an incandescent filament lamp whose colour lies on or near the Planckian locus between the colour temperatures of about 2 000 K and 3 300 K and its appearance ranges from the yellowish white of an oil flame to the purer white of a tungsten halogen lamp. Other white light sources of correlated colour temperatures up to 8 000 K may be used for special signals.

The filter which is placed in front of the light source transmits only selected wavelength bands from the total light emitted from the source. It is therefore necessary to consider the filter/source combination as a whole when designing a signal within specified colour limits because a variation in the characteristics of either filter or source can have a marked effect on the chromaticity of the resulting light emitted from the signal.

White light sources of low colour temperature have emissions which are rich in orange and red light, while those of high colour temperature such as a xenon arc show a preponderance of green and blue. Thus when a light signal of a specified colour is needed, the absorption characteristics of the filter must compensate for the characteristics of the light source and the two must always be used in conjunction with one another. A change of light source to one of increased colour temperature would make the light through a red filter appear less red, that through a yellow filter appear more green, and that through a green, white or blue filter more blue. The possibility of employing a self-coloured light source whose chromaticity is close to but outside the required limits, combined with a very pale colour filter to bring the emitted light within the required colour class is sometimes worth considering. For example, it is possible to obtain a high intensity blue signal by the combination of an xenon discharge lamp and an appropriate pale blue filter.

15 White light sources

The most commonly used white light sources and their approximate colour temperatures are given in Table 4.

Table 4 does not include mercury discharge and fluorescent lamps because their correlated colour temperature figures would be of little value as part of this standard.

For practical convenience, the light sources considered in this standard are assumed to be Planckian.

The range of light source colour temperatures is sufficiently large to justify the use of different sets of chromaticity limits for colour filters required to be combined with these sources and to produce coloured light within a colour class as specified in Table 1.

16 Colour filters for general purposes

The chromaticity co-ordinates of the different colour filters suitable for use with light sources ranging in colour temperature from 1 900 K to 3 300 K are set out in Figure 4–Figure 15 for the more important colour classes of Table 1. Figures have not been included for xenon light sources or for blue filters because their use is at present very specialized and it is considered that designers of signals using xenon sources or blue filters will be competent to determine for themselves the required filter characteristics. White signals (except for “lunar white” — see clause 17) normally employ self-coloured light sources without filters. With the exception of green, the figures apply to both glass and plastics filters; separate figures for green glass and green plastics are included because the wider variety of characteristics between different types of plastics in the green area necessitates narrower limits than for similar glass filters.

By reference to Figure 4 – Figure 15, as explained in 16.1, it is possible to determine the boundaries within which the chromaticity co-ordinates of glass and plastics filters shall lie, when measured with Standard Illuminant A, in order to produce light of any specified colour class when combined with a light source of any specified colour temperature (or range). For some purposes, however, it may be agreed between the manufacturer and the user to adopt more restricted chromaticity limits for colour filters which may be required for use with more than one category of light source, as for example in the case of some railway signals (see clause 17).