BS 950-1:1967

Specification for

Artificial daylight for the assessment of colour —

Part 1: Illuminant for colour matching and colour appraisal

Co-operating organizations

The Illumination Industry Standards Committee under whose supervision this Part of BS 950 was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Association of Public Lighting Engineers
British Electrical and Allied Manufacturers' Association
British Glass Industry Research Association
British Railways Board
Electric Lamp Industry Council*
Electric Light Fittings Association*
Electricity Council, the Central Electricity Generating Board and the Area Boards in England and Wales
Gas Council
Glass Manufacturers' Federation*
Illumination Engineering Society*
Independent Lamp Manufacturers' Export Group*
Institution of Electrical Engineers
Institution of Municipal Engineers
London Transport Board*
Medical Research Council
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Ministry of Labour, H.M. Factory Inspectorate
Ministry of Public Building and Works*
Ministry of Technology — Building Research Station*
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Post Office
Royal Institute of British Architects
Society of British Gas Industries
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 Colour Council
British Leather Manufacturers' Research Association
Oil and Colour Chemists' Association
Research Association of British Paint, Colour and Varnish Manufacturers
Society of Dyers and Colourists
Society of Leather Trades' Chemists
Society of Motor Manufacturers and Traders Ltd.
Textile Institute

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Contents

		Page
Co-operating organizations		Inside front cover
Foreword		ii
1	Scope	1
2	Definitions	1
3	Chromaticity of illuminant	1
4	Spectral distribution of illuminant	3
5	Maintenance of spectral distribution	3
Appendix A Spectral power distribution of artificial daylight, D6500		4
Appendix B Metameric matches		4
Appendix C Practical sources		4
Figure 1 — Chromaticity diagram		2
Table 1 — Chromaticity co-ordinates		1
Table 2 — Spectral distribution		3

Preface

This British Standard is published under the joint authority of the Illuminating Industry Standards Committee and the Photographic Industry Standards Committee, and is concerned with the spectral composition of illuminants corresponding to phases of daylight for producing conditions of artificial daylight.

The standard is divided into two Parts. Part 1 specifies an illuminant of given chromaticity and spectral distribution with a correlated colour temperature of 6 500 °K, which is suitable for colour matching and colour appraisal.

Part 2 states the viewing requirements applicable only to the **graphic arts reproduction industry** where a greater red content is required in the spectrum of the illuminant and for which, accordingly, a correlated colour temperature of 5 000 °K has been selected.

NOTE Where metric equivalents are stated the figures in British units are to be regarded as the standard. The metric conversions are approximate. More accurate conversions should be based on the tables in BS 350, *"Conversion factors and tables"*.

Foreword

This Part of the specification is concerned with an illuminant having the spectral composition based on a phase of daylight. As no artificial light source is likely to have this precise spectral composition the tolerances which light sources must meet in order to be suitable for colour matching and colour appraisal are defined.

The earlier edition was based on Standard Illuminant C, which had the disadvantages 1) that it is difficult to provide with it high illumination levels over large areas; 2) that its ultra-violet content is inadequate for present-day colour matching in view of the prevalence of fluorescent brightening agents and fluorescent pigments; 3) that its chromaticity is on the purple side of the full radiator locus. New measurements on daylight in this country, and elsewhere, have recently become available (Judd, MacAdam and Wyszecki, *J. Opt. Soc. Amer*. **54**, 1031, 1964) and the standard is now based on this work instead of on Standard Illuminant C. These measurements, and others of a different type made in recent years at a number of laboratories in this country, indicate that the chromaticity of daylight most frequently occurring is similar to that adopted in the earlier specification, but on the green side of the full radiator locus. The correlated colour temperature of this region is close to 6 500 °K, and the reconstituted spectral distribution for this colour temperature has been taken from the work of Judd *et al*. to provide the standard. The same distribution has recently been recommended by Experts' Committee **E.1.3.1** of the CIE[1)] as Standard Illuminant D6500 (see Appendix A).

A feature of these measurements has been the close similarity of curves from north sky observations on the one hand, and total sky observations, with or without sunlight, on the other, provided that these conditions refer to similar chromaticities (Henderson and Hodgkiss, *Brit. J. Appl. Phys.* **14**, 125, 1963; **15**, 947, 1964).

This specification requires that artificial sources for colour matching shall satisfy two conditions. The first is that the chromaticity of the light shall lie within certain limits, and the second is that the differences between its spectral distribution and that specified shall be within certain limits.

As regards chromaticity the tolerance area is on the green side of the full radiator locus, in accordance with most determinations of the chromaticity of natural daylight.

Colour matches under sources conforming to this specification will hold in most phases of daylight. As in most cases materials may also be used under artificial light, especially that from incandescent tungsten lamps, colour matches should be checked under two sources (see Appendix B).

[1)] Commission Internationale de l'Eclairage.

There are many instances in which a coloured object is inspected, not with a view to matching it with a standard, but to see if it harmonizes with some other coloured objects, or if its colour fits the observer's judgement of what is required. This may be called colour appraisal, which in critical cases is most often carried out in daylight. Light sources conforming to the specification are suitable for this purpose.

Some information on practical light sources is included in Appendix C.

NOTE Fluorescent lamps referred to in BS 1853, *"Tubular fluorescent lamps for general lighting service"*, as "colour matching" or "northlight" may not necessarily comply with this specification. Lamps referred to as "daylight" will not comply with this specification.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 4 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.

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1 Scope

This Part of this British Standard specifies an illuminant representing a phase of daylight, and the tolerances in both chromaticity and spectral distribution to which artificial light sources shall conform. This illuminant is suitable for colour matching and colour appraisal.

2 Definitions

For the purposes of this British Standard the following definitions apply:

2.1
ultra-violet range

the region of the spectrum which extends from 300 to 400 nm

2.2
colour matching

the visual comparison under a suitable illuminant of two materials or fields, usually contiguous, for the purpose of judging their similarity in colour

2.3
colour appraisal

the inspection of objects or surfaces under a suitable illuminant with a view to making subjective judgements on their colour characteristics. These judgements may vary between the extremes of colour matching and aesthetic appreciation of an isolated colour. Further examples are given in the Foreword

3 Chromaticity of illuminant

The chromaticity of the illuminant shall fall within the 12-sided figure shown in Figure 1 with chromaticity co-ordinates shown in Table 1 and with a centre point given by $x = 0.3127$, $y = 0.3291$, on the 1931 CIE System.

Table 1 — Chromaticity co-ordinates

x	*y*
0.3185	0.3383
0.3192	0.3361
0.3182	0.3320
0.3157	0.3272
0.3125	0.3228
0.3092	0.3202
0.3069	0.3199
0.3062	0.3221
0.3072	0.3262
0.3097	0.3310
0.3129	0.3354
0.3162	0.3380

NOTE The area surrounding the centre point is based on the standard deviations in colour matching, as determined by MacAdam (*J. Opt. Soc. Amer.* **32**, 247, 1942; **33**, 18, 1943). This 12-sided figure corresponds to a tolerance from the nominal chromaticity of 4 times the standard deviation in the direction of the minor axis, and 5 times in the direction of the major axis. The purpose of this is to provide an adequate tolerance in lamp manufacture, while keeping well within the limits of daylight variation but avoiding any chromaticity below the full radiator locus.

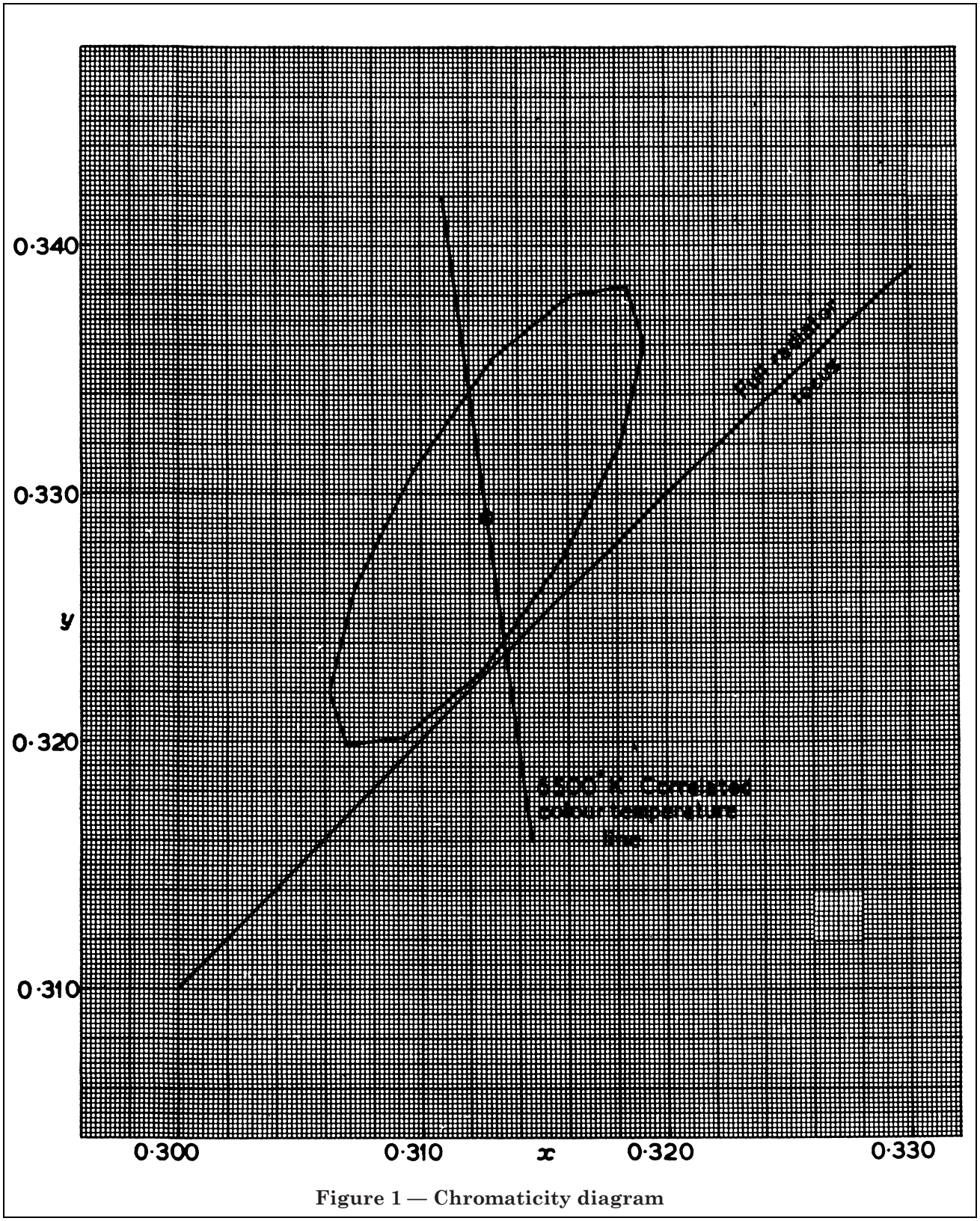

Figure 1 — Chromaticity diagram

4 Spectral distribution of illuminant

The spectral distribution is based on Appendix A. The spectral band composition and tolerances shall be as shown in Table 2.

Table 2 — Spectral distribution

Spectral band	Wavelength range	Band values for 100 lumen flux	Percentage tolerance in band value
	nm	mW	%
U.V.a	300–340	11.2	± 30
U.V.b	340–400	43.2	± 30
		lm	
1	400–455	0.79	± 15
2	455–510	11.2	± 15
3	510–540	23.1	± 15
4	540–590	43.7	± 15
5	590–620	14.4	± 15
6	620–760	6.8	± 15

NOTE 1 Bands 1 to 6 are those used in the NPL method of colour rendering assessment (Crawford, *Brit. J. Appl. Phys.* **14**, 319, 1963). Whereas this method recommends the use of 10 % tolerances on the band values, larger tolerances determined empirically are required at present in this specification to allow for the realization of the standard by fluorescent tubes of varied loading. The tolerances may be altered later if advances are made in providing better light sources. The purpose of these tolerances is to control spectral distribution rather than to assess colour rendering properties.

The CIE Test Colour method for measurement of colour rendering (CIE Publication No. 13, 1965) will be considered later as a requirement in this standard.

NOTE 2 It is recommended that the level of illumination for colour matching shall be between 70 lm/ft^2 and 300 lm/ft^2 (750 lx and 3 200 lx) and the surroundings shall be neutral in colour. The effects of finishes on lamp reflectors or fittings, or of spectrally selective transmission of plastic diffusers must be borne in mind when lighting installations are planned since these variables may seriously alter the quality of the emitted light. Standardized viewing conditions are also desirable because the level of illumination, background colour and brightness, glare and extraneous lighting will all affect the visual response. Reference should also be made to the publication "The IES Code, Recommendations for good interior lighting", published by the Illuminating Engineering Society in 1961, for further details appropriate to different applications.

5 Maintenance of spectral distribution

The manufacturer of a light source or colour matching appliance shall declare the average number of hours running during which his product will conform to the specification.

Appendix A Spectral power distribution of artificial daylight, D6500

Wavelength	Relative power per unit wavelength	Wavelength	Relative power per unit wavelength
nm		nm	
300	0.03	550	104.0
310	3.3	560	100.0
320	20.2	570	96.3
330	37.1	580	95.8
340	39.9	590	88.7
350	44.9	600	90.0
360	46.6	610	89.6
370	52.1	620	87.7
380	50.0	630	83.3
390	54.6	640	83.7
400	82.8	650	80.0
410	91.5	660	80.2
420	93.4	670	82.3
430	86.7	680	78.3
440	104.9	690	69.7
450	117.0	700	71.6
460	117.8	710	74.3
470	114.9	720	61.6
480	115.9	730	69.9
490	108.8	740	75.1
500	109.4	750	63.6
510	107.8	760	46.4
520	104.8	770	66.8
530	107.7	780	63.4
540	104.4		

Appendix B Metameric matches

When two coloured materials have identical spectral reflection curves they will be a visual match under any illuminant.

However, it is possible for two materials to match visually under a given light source without their being a spectral match and such matches are termed “metameric”. They arise because the colouring matters used in each material are different, though this does not mean that spectral matches cannot be obtained unless identical colouring matters are used.

It is important to detect metamerism because materials which are a metameric match under one illuminant may not match under another illuminant whose spectral characteristics are significantly different. The simplest method of determining whether a match made under a light source conforming to the standard is metameric or not is to inspect it also under the light from a tungsten filament lamp and, unless it is known that identical colouring matters have been used, it is recommended that this be done. If the match still holds, it is unlikely to be metameric; if the materials no longer match, but the degree of mis-match is not serious, then it is unlikely that any greater degree of mis-match will occur under any other illuminant, natural or artificial.

A metameric match made under a light source conforming to this specification may not match under certain daylight conditions (e.g. north light from a blue sky or sunlight from a low sun), but it will match under the most frequently occurring phases of daylight. It must be noted, however, that when the degree of metamerism is severe the differences in normal colour vision of individual observers may result in two materials being a visual match for some observers, but a mis-match for others.

Appendix C Practical sources

The specification may be met by using different types of lamp, singly or in combination, with or without filters.

If fluorescent lamps are used they should preferably be of low loading types: 8 ft (2 400 mm) 85 W; 5 ft (1 500 mm) 65 W; 4 ft (1 200 mm) 40 W or 2 ft (600 mm) 20 W; in order to minimize chromaticity differences and changes of relative ultra-violet emission due to lamp temperature changes. The disadvantages of enclosed unventilated fittings in this respect must also be considered.

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