

Australian/New Zealand Standard®

Guide to the specification of colours

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RECONFIRMATION
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Guide to the specification of colours

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee CH/3 on Paints and Related Materials as a revision of the 1983 edition of AS 2633. The objective of this Standard is to provide guidance to those involved in the specification of colours.

Requirements for the specification of colours will vary depending on a number of factors, such as the degree of precision required and how the specification is to be applied. This Standard describes the various systems that are in use for specifying colours and includes specific recommendations to assist in the selection of an appropriate method. Guidance is also given on the specification of tolerances.

This edition has been substantially reviewed and rewritten and contains additional definitions and diagrams.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

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SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard sets out the factors which should be taken into account in the specification of colours. It describes the various methods used to specify colours, and gives guidelines to assist in the selection of the most appropriate method for a given application. Guidelines are also provided for the specification of tolerances.

NOTES:

- 1 In this Standard, the abbreviations used for designating the names of colours are —

R—red
Y—yellow
G—green
B—blue
P—purple

Combinations of these designations are also used, e.g.

GY—green, yellow

- 2 Appendix A provides an example of specification of a colour domain.

1.2 REFERENCED DOCUMENTS A list of documents referred to in this Standard is given in Appendix B. Appendix B also lists several documents which are suggested for further reading.

1.3 DEFINITIONS For the purpose of this Standard, the following definitions apply:

NOTE: The definitions are only intended to make clear the meaning given to certain terms used in this Standard. For more technically precise definitions of some of the terms, reference should be made to AS 1852.845*.

1.3.1 Brightness (luminosity)—the attribute of a visual sensation according to which an area appears to emit more or less light.

1.3.2 Chroma—a value calculated from the CIELAB a^*b^* values intended to be the metric measure of saturation.

1.3.3 Chromaticity—property of a colour stimulus (involving the attributes of hue and saturation but not lightness) which may be defined by coordinates on a plane diagram in the CIE trichromatic system.

1.3.4 Chromaticity diagram—a plane diagram in which points specified by chromaticity coordinates represent the chromaticities of colour stimuli, each chromaticity being represented by a single point on the diagram.

NOTE: See Figure 3.1 for an illustration of the CIE 1931 chromaticity diagram.

* AS 1852.845 is an Australian endorsement of IEC Publication 50(845). The definitions contained in the International Electrotechnical Vocabulary were prepared in collaboration with the International Commission of Illumination (CIE) and are identical with those given in CIE Publication No 17.4, International Lighting Vocabulary.

1.3.5 CIE (Commission Internationale de l'Eclairage)—the international standardization body for photometry and colorimetry.

1.3.6 CIELAB—a colour system adopted by the CIE in 1976. It should not be confused with the HunterLab system which is a proprietary name and different system. Three coordinates are derived from CIE tristimulus values to define a colour, L^* , a^* and b^* . CIELAB is intended for use by industries using surface colours such as paints, plastics and textiles.

1.3.7 CIELUV—a chromaticity diagram and colour system also adopted by the CIE in 1976. Three coordinates are derived to define a colour, either L^* , u' and v' or L^* , u^* and v^* for chromaticity representation and colour differences respectively. Intended for the lighting industry and aperture colours.

1.3.8 Colour—that aspect of the interaction of light, both with the human visual system and with substances in the field of view of that system, which gives rise to descriptive terms such as red, yellow, green, blue, purple (chromatic colours) and white, black, grey, light, dark (achromatic colours) which can be described quantitatively in terms of three different light stimuli.

1.3.9 Colour domain—a defined region of chromaticities which may be represented by an area on a chromaticity diagram.

NOTE: Appendix A gives an example of the specification of colour domains, together with an illustration of the domains on a CIE 1931 chromaticity diagram.

1.3.10 Colour rendering—a general expression for the effect of a light source on the colour appearance of objects in comparison with their colour appearance under a reference light source.

NOTE: The colour rendering properties of a light source are usually specified in terms of the CIE General Colour Rendering Index (see CIE Publication 2.2).

1.3.11 Colour space—a three-dimensional geometric representation defining a range of colour, the dimensions of which are hue, saturation and lightness.

1.3.12 Correlated colour temperature (of a light source)—the colour temperature corresponding to the point on the Planckian which is nearest to the point representing the chromaticity of the illuminant or source considered on an agreed uniform-chromaticity-diagram. The consequence is the identification of a Planckian radiator whose perceived colour most closely resembles that of a given light source at the same luminance and viewing conditions. The unit is the Kelvin (K).

1.3.13 Distribution temperature—the temperature of a Planckian radiator (black body) which, by the laws of thermodynamics, defines the distribution of energy through the spectrum.

1.3.14 Dominant wavelength—the wavelength of the monochromatic light stimulus that, when combined in suitable proportions with the specified achromatic (white) stimulus, gives a match with the colour stimulus considered. It is the physical analogue of the sensation of hue.

NOTE: See Figure 1.1 for the relationship between dominant wavelength and other attributes.

1.3.15 Excitation purity—the ratio of the distance between the chromaticity of a colour stimulus and the chromaticity of a reference achromatic point (white) with the distance between the chromaticity of the dominant wavelength of a colour stimulus and the chromaticity of a reference achromatic point (white). On this method, white has an excitation purity of 0 and spectral colours have an excitation purity of 1. It is the physical analogue of chroma and saturation.

NOTE: See Figure 1.1 for the relationship between excitation purity and other attributes.

1.3.16 Hue—the attribute of colour perception by means of which an object is judged to be red, green, yellow, blue or intermediate between some adjacent pair of these. Black, white and neutral grey have no hue.

NOTE: See Figure 1.1 for the relationship between excitation purity and other attributes.

1.3.17 Hue angle—a value calculated from the CIELAB a^*b^* values intended to be the metric measure of hue.

1.3.18 Illuminance—a measure of the amount of visible light reaching a surface. Defined as the ratio of the luminous flux incident on an infinitesimal element of surface containing the point under consideration by the area of that element. The unit is the lumen per square metre or lux.

1.3.19 Illumination—the process of lighting an object.

1.3.20 Lightness (of a related colour)—the brightness of an area judged relative to the brightness of a similarly illuminated area that appears to be white or highly transmitting. See also psychometric lightness.

1.3.21 Luminance—used in describing luminous energy emitted from a surface. The luminance (L or β) at a point of a surface and in a given direction is the quotient of the luminous intensity in the given direction of an infinitesimal element of the surface containing the point under consideration, by the orthogonally projected area of the element on a plane perpendicular to the given direction. The unit is the candela per square metre, cd/m^2 , occasionally called the nit. It is a physical analogue of brightness.

1.3.22 Luminance factor—the ratio of the luminance of an object to the luminance of a perfectly reflecting object under the identical conditions.

NOTES:

- 1 Measured values of luminance factor depend on the angle of incidence, the method of measurement of the reflected flux, and the spectral character of the incident flux;
- 2 Where the luminance factor is with respect to a narrow wavelength range, the term 'special luminance factor' is normally used.

1.3.23 Luminous flux—the radiant flux (power) in a beam of radiation weighted by the agreed spectral responsivity of the human visual system. The unit is the lumen (lm).

NOTE: At the wavelength 555 nm, the weighting factor is 683 lumens per watt of radiation.

1.3.24 Metamerism—two colours judged visually to be the same colour under certain conditions (lighting, observer, sample size and surround) can have quite different spectral characteristics. Under other conditions they may not be a match. For instance, two pieces of printed material may match under an incandescent lamp but differ quite dramatically in daylight. Such matches are said to exhibit metamerism.

1.3.25 Munsell chroma—an index of the saturation of a colour expressed on a scale extending from /0 (no colour), by steps of approximately equal visual importance. The scale is nominally open ended but rises in practice to about /18 for the most saturated specimens producible.

1.3.26 Munsell colour notation—a system of letters or numbers by which the colour of any opaque object may be specified with respect to Munsell hue (H), Munsell value (V), and Munsell chroma (C), written in the form $H V/C$, e.g. 5R 4/6.

1.3.27 Munsell hue—the attribute of a specimen, in the Munsell colour system, which correlates with the perceived hue of the specimen.

1.3.28 Munsell value—an index of the lightness of a surface, ranging from 0/ (absolute black) to 10/ (absolute white), which is related to the reflectance of the surface.

1.3.29 Psychometric lightness—the CIELAB L^* value calculated from the tristimulus value Y , intended to be the metric measure of Munsell value or lightness.

1.3.30 Reflectance (reflectance factor, luminous reflectance) —the ratio of the luminous flux reflected from a surface to the incident luminous flux. Reflectance is usually expressed as a decimal in the range 0 to 1, but may also be expressed as a percentage.

NOTES:

- 1 Measured values of reflectance depend on the angle of incidence, the method of measurement of the reflected flux, and the spectral character of the incident flux.
- 2 Where the reflectance refers to a narrow wavelength range, the term 'spectral reflectance' is normally used.

1.3.31 (Relative) spectral energy distribution—a statement, in either graphical or tabular form, of the (relative) amount of energy emitted by a light source per unit wavelength interval as a function of wavelength across the electromagnetic spectrum.

NOTE: See Figure 2.2 for an illustration in graphical form of the spectral energy distributions of the CIE Standard Illuminants A and D_{65} , and Illuminants B and C.

1.3.32 Saturation (purity, chromatic strength, chroma)—the vividness of the basic hue. For example, scarlet is a saturated colour and pale pink is a desaturated colour. Both are red in hue but with different degrees of saturation. Neutral grey and white have zero saturation.

1.3.33 Standard colorimetric observer—an ideal observer whose colour-matching properties correspond to the CIE colour-matching functions. (Refer CIE No S002.)

1.3.34 Standard illuminant—a defined relative spectral energy distribution over the wavelength range that influences colour perception.

NOTE: Over time, the CIE has recommended a number of standard illuminants for use in the calculation of numerical values of colour. Of these, CIE standard illuminants A and D_{65} remain (Refer CIE No 15.2 and CIE No S001). (See also Table 2.1.)

1.3.35 Standard source—an artificial light source used for test purposes which is intended as a practical representation of a standard illuminant.

NOTE: Over time, the CIE has specified and recommended a number of standard sources, which are intended to represent the corresponding CIE standard illuminants (refer CIE No 15.2). Standard source A (a gas-filled tungsten filament lamp operating at a distribution temperature of 2856 K) is the only currently specified standard source. For sources D_{55} , D_{65} and D_{75} , the CIE sets out a method of assessing daylight simulators (refer CIE No 51).

1.3.36 Transmittance (transmission factor, luminous transmittance)—the ratio of the transmitted radiant or luminous flux to the incident flux. Transmittance is usually expressed as a decimal in the range 0 to 1, but may also be expressed as percentage transmission.

NOTES:

- 1 Measured values of transmittance depend on the angle of incidence, the method of measurement of the transmitted flux, and the spectral character of the incident flux.
- 2 Where the transmittance is with respect to a narrow wavelength range, the term 'spectral transmittance' is normally used.

1.3.37 Uniform-chromaticity-scale diagram (UCS diagram)—chromaticity diagram in which the coordinate scales are chosen with the intention of making equal intervals represent, as nearly as possible, equal perceptual steps of colour.

NOTE: See Figure 3.3 for an illustration of the CIE 1976 chromaticity diagram.

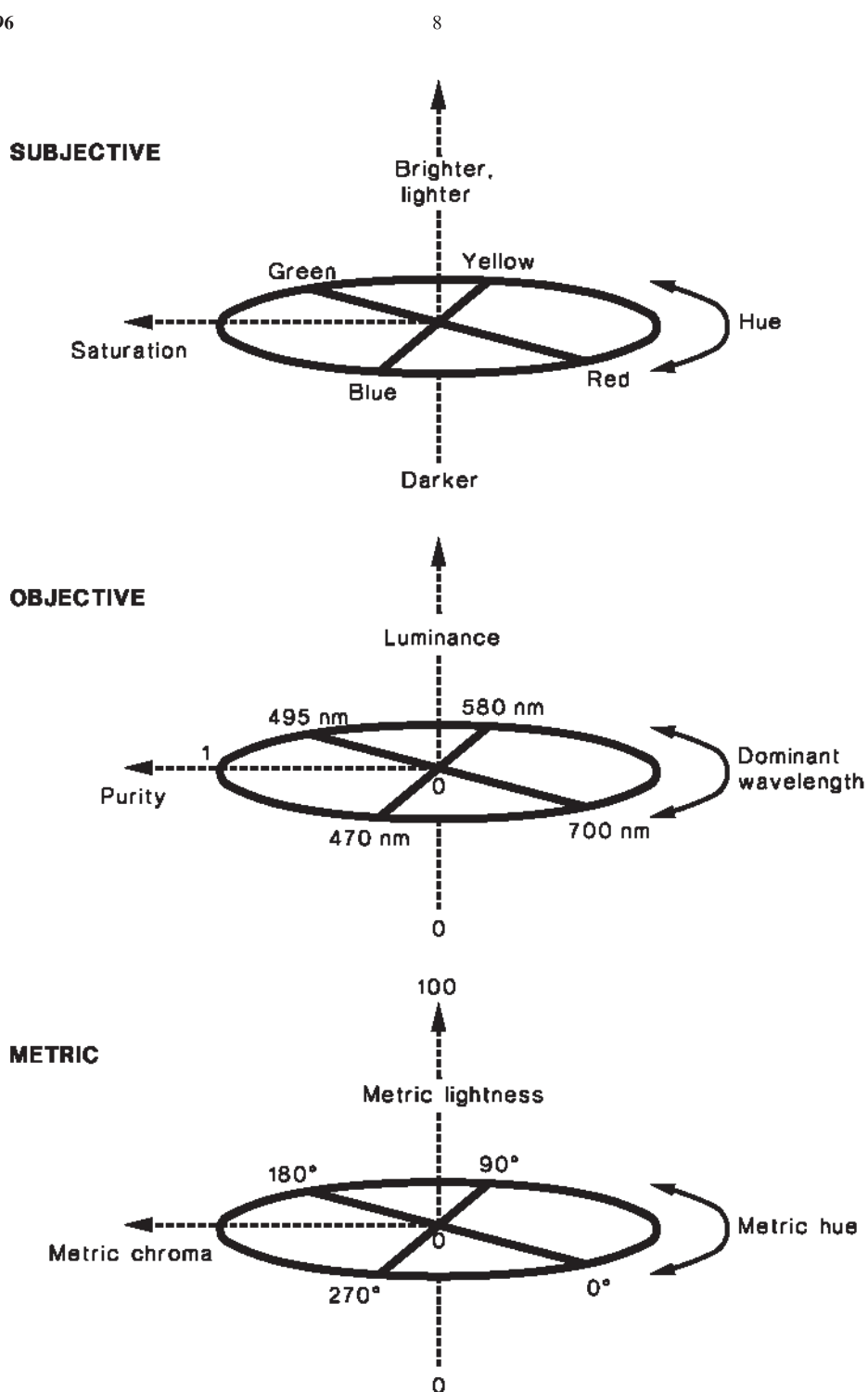


FIGURE 1.1 RELATIONSHIPS BETWEEN COLOUR ATTRIBUTES

SECTION 2 FUNDAMENTAL CONSIDERATIONS

2.1 THE PHYSICAL DETERMINANTS OF COLOUR The colour of an object depends principally on the spectral energy distribution of the light transmitted, reflected, or emitted by the object. The actual appearance of a colour will, in addition, be influenced by the surface texture of the object, the colour of other surfaces within the field of view of the observer and the colour vision of the observer. In colour measurement, these factors are held to be constant by specifying a standard observer and standard viewing or measurement conditions.

The colour of an object that reflects light depends on the spectral reflectance of the object, and on the spectral energy distribution of the light illuminating the object. Similarly, the colour of a light source will depend on its spectral energy distribution, and on the spectral transmittance of any filter or other absorbing medium interposed between the source and the observer's eye. These relationships are illustrated in Figure 2.1.

2.2 THE IMPORTANCE OF SPECIFYING THE ILLUMINATION CONDITIONS

2.2.1 Effect of different light sources As indicated in Clause 2.1 and illustrated in Figure 2.1, the spectral energy distribution of the light can have a very significant, at times dramatic, effect on the colour of objects. It is therefore essential that the light source be specified as part of any specification of colour.

It should not be assumed that visual comparison of a test colour and a standard colour sample when both are illuminated by the one light source is an adequate test. Colours may match under one light source but appear very different under another. This phenomenon is known as metamerism. There will be uncertainty and dispute about colour unless a test light source is specified.

Where a colour in practical application is likely to be illuminated by different sources of light, e.g. daylight and incandescent light at night, it may be necessary to specify that the colour shall comply with the colour specification under more than one illuminant.

Some surface colours contain fluorescing dyestuffs so that their colour becomes very dependent on the amount of ultraviolet radiation emitted by the illuminating light source (see Note 2 to Table 2.1).

2.2.2 Equipment with integral light source For equipment which contains its own light source, e.g. a traffic signal lantern, the colour of the light emitted by the apparatus can be specified without reference to a test light source. However, care must be taken to ensure that different light sources which may cause a substantial change in the colour of the emitted light cannot be substituted for the original light source.

2.2.3 Specification of applied voltage The spectral characteristics of an incandescent light source change with change of applied voltage. Where colour is to be specified within close tolerances, consideration should be given to specifying the permissible variations of voltage. Significant changes of colour will occur if the light source is to be dimmed by changing the applied voltage.

2.2.4 Specification of illumination and viewing geometries The appearance of colours and the measured numerical values of colour can depend quite markedly on the angle of incidence of the illuminant and also the angle of observation. For test purposes, the illumination and viewing (detecting) geometry should be specified to avoid variability in the assessment of colour.

TABLE 2.1
CIE STANDARD ILLUMINANTS, ILLUMINANTS AND SOURCES

Standard illuminant (Note 1)	Temperature K	Source	Intended representation
A	Distribution temperature 2856	Source A Gas filled tungsten filament lamp	Incandescent lighting
D ₆₅	Correlated colour temperature 6504	No precise realization is available. Approximations may be rated by reference to CIE publication 51	Overcast daylight with a component of ultraviolet radiation
Illuminant (Note 1)	Correlated colour temperature K	Source	Intended representation
B	4874	Source A with a special filter (Note 3)	Direct noon sunlight
C	6774	Source A with a special filter (Note 3)	Overcast sky daylight
D ₅₅	5500	No precise realisation is available. Approximations may be rated by reference to CIE publication 51	Other phrases of daylight additional to D ₆₅
D ₇₅	7500		
D ₅₀	5000	See ANSI PH2.23	Used in the graphics arts industry for viewing coloured transparencies and prints
F2	4200	See ASTM E308	Standard cool white fluorescent tube
F7	6500	See ASTM E308	Broad band daylight fluorescent tube
F11	4000	See ASTM E308	Narrow-band white fluorescent tube

NOTES:

- 1 The relative spectral energy distributions for the illuminants A, B, C, D₆₅ are tabulated in Reference 3. Illuminants C and D₆₅ represent similar phases of daylight over a limited range of wavelengths appropriate to the purpose of colour measurement and should not be regarded as broader representations of the spectral energy distribution of daylight.
- 2 Illuminants B and C are not considered to be adequate representations of daylight and have been abandoned as standard illuminants. Illuminant B is rarely used. Illuminant C has been commonly used in the past, but Illuminant D₆₅ is now preferred. Illuminant D₆₅ is particularly appropriate for the calculation of numerical values for the colour of materials that include fluorescent whiteners or other fluorescent dyestuffs since its spectral energy distribution includes a near ultraviolet component (300nm to 400 nm—see Figure 2.2) representing the ultraviolet component of natural daylight.
- 3 The special filters used for Sources B and C are defined in CIE No. 15.2.

In colour measurements, different conditions of illumination and viewing may be chosen.

In one geometry, a beam of light is directed onto the sample from one direction, usually 45°, and is viewed normally to the surface, i.e. 0°. This is known as 45/0 geometry. The reverse conditions, 0/45, which usually give equivalent results, may also be used.