AISM Association Internationale de Signalisation Maritime IALA International Association of Lighthouse Authorities

Recommandation sur les couleurs de surface en signalisation maritime

Recommandation AISM E-108
mai 1998

(non disponible en français, traduction en cours)

Recommendation for the surface colours used as visual signals on aids to navigation

IALA Recommendation E-108
May 1998

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IALA Recommendation on the surface colours used as visual signals on aids to navigation

(IALA Recommendation E-108 , May, 1998)

THE COUNCIL

RECOGNISING the need to harmonise the surface colours used as visual signals on aids to navigation ;

RECOGNISING ALSO that there is a need to specify both ordinary and fluorescent colours;

TAKING INTO CONSIDERATION the proposals of the IALA Engineering Committee;

ADOPTS the "Guidelines on the surface colours used as visual signals on aids to navigation", set out in the Annex to this Recommendation;

RECOMMENDS that:

1. the ordinary colours used as visual signals on aids to navigation be Red, Yellow, Green, Blue, White and Black, and Orange for special purposes requiring high conspicuity; and that their colour limits (extent of chromaticity and luminance factor) be as specified in Table 1 of the Guidelines on the surface colours used as visual signals on aids to navigation.
2. that the fluorescent colours used as signals on aids to navigation be Red, Yellow and Green, and Orange for special purposes requiring high conspicuity; and that their colour limits be as specified in Table 3 of the Guidelines on the surface colours used as visual signals on aids to navigation.
3. National Members take into account the advice given in the Guidelines on the surface colours used as visual signals on aids to navigation, particularly that contained in the "Introduction"
4. Any other kind of surface colour be defined in accordance with the recommendations of the International Commission on Illumination (CIE)[1] and in conformity, as far as practicable, with the colour limits of Table 1 of the Guidelines on the surface colours used as visual signals on aids to navigation.
5. Any additional colours be defined in accordance with the recommendations of the CIE[1] and be considered with extreme caution in regard to the confusions that might arise.

REVOKES IALA Recommendation for the surface colours used as visual signals on aids to navigation, dated May, 1980

1) CIE, *Surface colours for visual signalling*

1st May, 1998

ANNEX

GUIDELINES ON THE SURFACE COLOURS USED AS VISUAL SIGNALS ON AIDS TO NAVIGATION

(SPECIFICATION FOR ORDINARY AND FLUORESCENT COLOURS)

INTRODUCTION

1. GENERAL

A surface colour is a colour perceived to belong to a surface. The colour of an ordinary surface, such as an ordinary paint or an opaque plastics material, is the most common kind of surface colour and is known as an ordinary colour. Other kinds include fluorescent (or luminescent) colours, trans-illuminated colours (for example, the colours of internally illuminated panels) and the colours of retroreflecting materials. A surface colour can be specified in terms of its chromaticity and its luminance factor. The chromaticity is defined by chromaticity coordinates, which may be plotted on a chromaticity diagram, and the luminance factor is a measure of the lightness of the colour relative to a pure white diffusing surface under the same illumination. As a specification must be made with respect to some type of illumination, the International Commission on Illumination (CIE) have precisely defined several standard illuminants; and since the results of the measurement of a colour can depend significantly on the degree of gloss on the surface, the CIE have also recommended various geometries of illumination and measurement[1].

Two colours may be measured as having the same chromaticity and luminance factor under one illuminant but dissimilar ones under a different illuminant. This phenomenon is known as metamerism and its effect can be very significant. It is advisable to check that the appearance of a signal colour will remain reasonably constant under the various types of illumination by which the colour is expected to be seen.

A surface colour is usually seen in relation to other surface colours, and the perception of the colour can be quite markedly influenced by the presence of the other colours. Hence, a signal colour should always be checked, especially at a distance, for its appearance among the surrounding colours.

Deterioration of surface colours in use is a common occurrence, and care must be taken that signal colours always remain in compliance with their specifications. Particular attention should be given to fluorescent colours, because they are liable to undergo rapid changes of chromaticity and luminance factor on exposure to radiation and wear if they are not provided with special protective surfaces. Frequent inspections of fluorescent colours are advised until the normal useful life has been confidently ascertained for each typical situation where these colours are used. Special care may be needed if fluorescent and non-fluorescent colours of the same chromaticity are chosen to be used together, as different deteriorations might produce troublesome dissimilarities of the chromaticities.

2. SPECIFICATION OF THE COLOURS

The recommendations in this document are based largely on experimental work involving the recognition and naming of colours, but they have also taken account of common practice and the limitations of currently available materials.

The method of specifying the colours is in conformity with the recommendations of the CIE[1] and the specifications are expressed in terms of the CIE 1931 standard colorimetric system. The recommended limits of the chromaticity of a colour are specified by means of limiting boundaries that enclose a chromaticity region on a CIE standard chromaticity diagram.

The recommended ordinary and fluorescent colours are respectively specified in Tables 1 and 3, which provide the names of the colours, the equations and names of the boundary lines of the chromaticity regions, and the limits of the luminance factors. The coordinates of the corners of the chromaticity regions are respectively given, for convenience in plotting, in Tables 2 and 4, and the chromaticity regions are respectively shown on CIE standard chromaticity diagrams in Figures 1 and 2.

The standard illuminant specified for the measurement of a colour is D_{65}, which represents a typical phase of daylight and has a correlated colour temperature of approximately 6504 kelvins. It is a tabulation of values across and beyond the visible spectrum[1] and does not exist as a real light source although fairly close approximations to it can be realized. The chromaticity of standard illuminant D_{65} (the illuminant point) is shown in the Figures.

The geometry specified for the measurement of a colour is

45°/normal (45/0), which means that the colour should be illuminated at an angle of 45° to the normal to the surface, and the colour should be measured in the direction of the normal. Measurement with a geometry of normal/45° will usually produce an identical result. The other geometries recommended by the CIE, namely diffuse/normal and normal/diffuse, will generally provide a chromaticity that is closer to the illuminant point in the chromaticity diagram. A great many instruments around the world measure colour by means of one or other of these diffuse geometries. If such a measurement is made and the chromaticity is found to be in compliance with the specified chromaticity region of a chromatic colour, and the luminance factor is found to be significantly above the minimum limit, then the colour can probably be considered to meet the specification. Nevertheless, the likely errors that would be involved in using one of these diffuse geometries should be investigated.

The chromaticity region recommended for each fluorescent colour is identical to the region of the corresponding ordinary colour. The colour of a fluorescent material should be measured with any protective surface that is normally used with the material.

The boundary lines of a chromaticity region, and the restrictions that may apply to the appropriate luminance factor, can together be referred to as the colour limits of a colour. The recommended colour limits are extreme values that should not be transgressed (except as mentioned in 3.1, 3.4, 3.5 and 3.6). More restrictive limits may be defined as appropriate to particular requirements; and they may be desirable for the signal colours used within one signalling system if substantial differences in appearance, either of chromaticity or luminance factor, are to be avoided. Also, the recommended colour limits of a colour are intended to apply throughout its entire service life, so examination of its condition may be required from time to time.

It should be noted that, with the exception of the purple boundary of Red, the specifications have not been designed to assist people with severely defective colour vision, most of whom will have great difficulty distinguishing between Red and Green.

3. CONSIDERATIONS OF PARTICULAR COLOURS

3.1. RED

A minimum value of 0.07 is specified in Table 1 for the luminance factor of ordinary Red, but significantly higher values can usually be realized and, in most circumstances, a value greater than 0.10 should be maintained.

The chromaticity region of Red, which is identical for both ordinary and fluorescent colours, has been defined on the basis of achieving a very high probability of correct recognition for the colour, and it should prove to be quite practicable for ordinary reds with glossy surfaces and for fluorescent reds. There is doubt though, if their surfaces are matt or even semi-matt, whether serviceable materials of various kinds can always be manufactured in compliance with the restriction imposed by the white boundary of the chromaticity region for ordinary Red. Also, it is not yet certain that serviceable materials, with glossy surfaces when new, can necessarily be manufactured so that their compliance continues throughout a reasonable service life if considerable loss of gloss occurs. Therefore, it is proposed that the chromaticity region for ordinary Red may be extended, but only for materials with matt or semi-matt surfaces, to a revised white boundary of $y = 0.840 - x$. This provision for ordinary red colours should not be used unless it is necessary, and then only with the understanding that the probability of correct recognition of the colour will be significantly reduced. The problem discussed here is not expected to arise with any of the other chromatic colours.

3.2. ORANGE

The probability of correct recognition of orange is usually not as high as that of red or yellow; moreover, when these colours subtend very small visual angles, orange and red, or orange and yellow, are very likely to be confused. Hence, in considering signal colours that need to be recognized at a distance, orange does not provide a satisfactory additional colour to a system that includes red and yellow. If orange is completely excluded from a system of signal colours for aids to navigation, the adjacent hue boundaries of Red and Yellow should remain as recommended in the Tables, since, otherwise, correct identification may not be made even at close ranges and the colours will not exhibit a reasonably consistent appearance world-wide.

Nevertheless, orange is probably the best ordinary colour for conspicuity against the sea, and it should preferably be reserved for those objects for which detection in the water is more important than recognition of their colours. The objects that require this consideration are items of emergency equipment, such as life-jackets and life rafts. The highest conspicuity will be obtained with fluorescent colours, and then fluorescent red-orange may be used and may, in some situations, be more conspicuous than fluorescent Orange, but fluorescent red-orange is not likely to be seen as distinct from fluorescent Red.

3.3. YELLOW AND WHITE

Discrimination between yellow and white is not practicable when they subtend very small visual angles, so they should not be considered as separate colours except for close viewing. In particular, it would be inadvisable to create any circumstances that required unequivocal distinction between yellow and white in retroreflecting materials, whether by day or by night.

At sea, the probability of recognizing, or even detecting, white on its own will often be low.

3.4. GREEN

As an ordinary colour, green does not usually show well at sea. However, colours of fluorescent Green can be obtained with exceptionally high purities, and they will be very much more recognizable in most conditions.

It may be desirable, if green is required as a background colour on signs with symbols or alphanumeric characters, to use a special dark colour, that is, one having a value of luminance factor lower than the minimum value recommended in Table 1. In such circumstances, a value as low as 0.05 may be considered for this special dark green, which should anyway have a chromaticity conforming with the specification for ordinary Green, and which should never be used alone anywhere as a signal colour.

3.5. BLUE

On inland waterways, and in estuaries and harbours, where colours may be seen at close range, Blue may prove to be a useful signal colour; but, at a distance, particularly at sea, it is unlikely to be easily recognized.

Although the recommended value of minimum luminance factor in Table 1 is 0.07, values significantly higher are attainable, and they should be required whenever possible if Blue is to be seen alone.

It may be desirable, if blue is required as a background colour on signs with symbols or alphanumeric characters, to use a special dark colour, that is, one having a value of luminance factor lower than the minimum value recommended in Table 1. In such circumstances, a value as low as 0.05 may be considered for this special dark blue, which should anyway have a chromaticity conforming with the specification for ordinary Blue, and which should never be used alone anywhere as a signal colour.

3.6. BLACK

A maximum value of 0.03, as specified in Table 1, is recommended for the luminance factor of ordinary Black if surfaces are glossy, but, if surfaces are matt or semi-matt, then it may be necessary to allow a maximum value of 0.04 although the probability of correct recognition will thereby be lowered.

4. SYMBOLS AND ALPHANUMERIC CHARACTERS

Good legibility requires that symbols and alphanumeric characters should have a good contrast with the colours against which they are seen. A contrast of luminance factors is usually of more advantage than one of hues, and the ratio of the luminance factors should be made as large as is possible. Thus Black should be applied on Yellow, and, in general, White should be used on Red, Green or Blue. However, if the luminance factors of Red or Green are particularly high, as they may be if these colours are fluorescent, then a contrast of Black may be more satisfactory. Sometimes a symbol or an alphanumeric character may be clearer if it is outlined in a contrasting colour or is shown on a distinct panel of contrasting colour.

5. COLOURS OF RETROREFLECTING MATERIALS

Two different specifications for the colours of retroreflecting materials are required if the colours are to be defined adequately for the purposes of this document. The specifications would define the colours for conditions of illumination that are representative of those occurring by day on the one hand and by night on the other. With regard to this document, a specification of the colours for night-time conditions is unquestionably the more useful, but the methods of measurement have not yet been internationally resolved. A specification of the colours for daytime conditions has been undertaken by the CIE[2], and the proposed chromaticity regions are, for the same conditions of illumination, largely identical with the recommended regions, in this document, for the corresponding ordinary colours: completely identical regions for all the colours are feasible and would be preferable. A particular problem with a specification for daytime conditions relates to the geometry of measurement and the limits of the luminance factors. The two specifications for the colours of retroreflecting materials will have to await recommendations by IALA in the future.

FIGURE 1. ZONES DE CHROMATICITÉ DES COULEURS ORDINAIRES
CHROMATICITY REGIONS FOR ORDINARY COLOURS

Zones recommandées pour les couleurs ordinaires spécificées au tableau 1; les coordonnées des sommets sont indiquées au tableau 2.

Recommended regions for the ordinary colours specified in Table 1, the coordinates of the corner points being provided in Table 2.

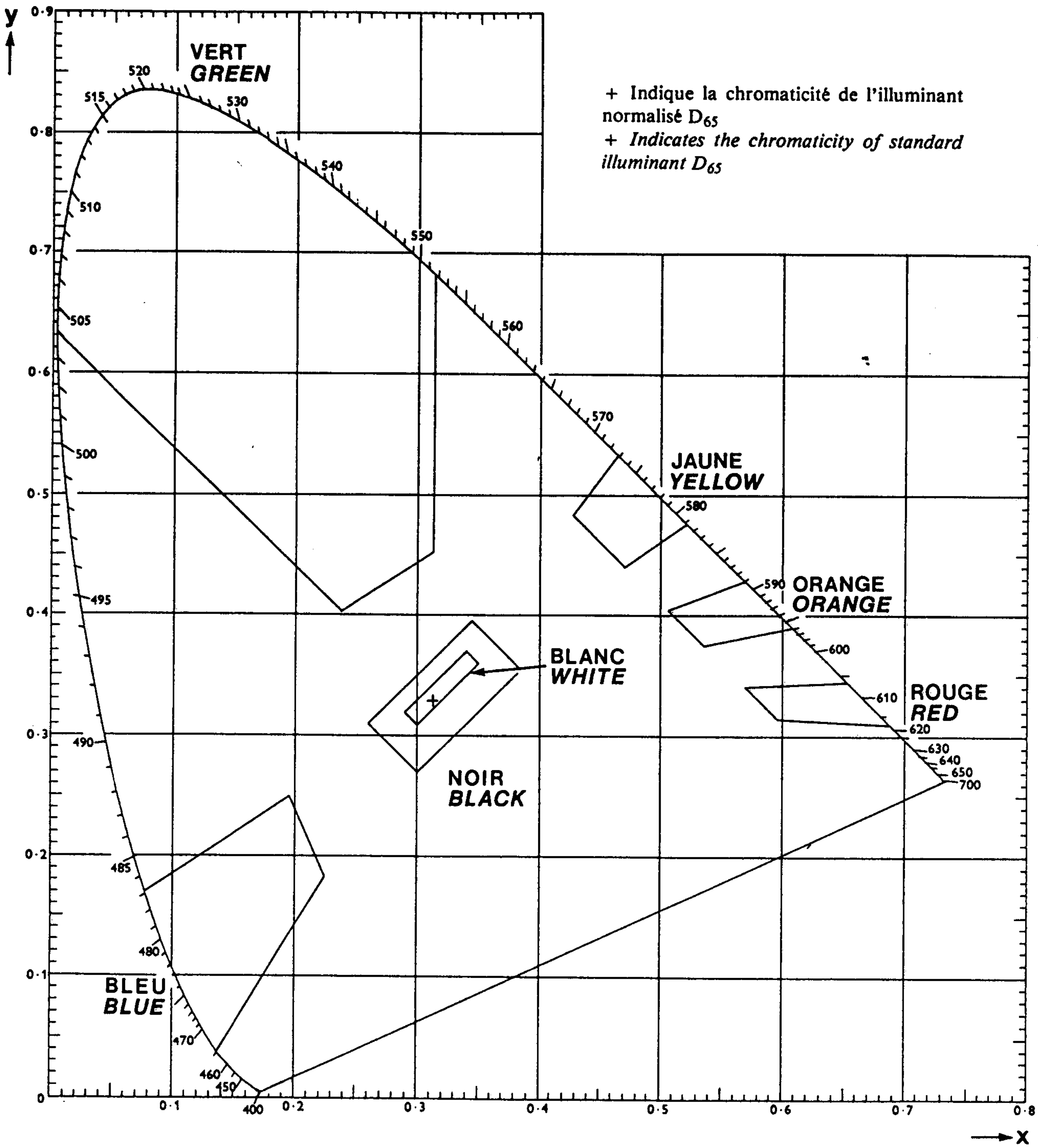

FIGURE 2. ZONES DE CHROMATICITÉ DES COULEURS FLUORESCENTES
CHROMATICITY REGIONS FOR FLUORESCENT COLOURS

Zones recommandées pour les couleurs fluorescentes spécifiées au tableau 3; les coordonnées des sommets sont indiquées au tableau 4.

Recommended regions for the fluorescent colours specified in Table 3, the coordinates of the corner points being provided in Table 4.

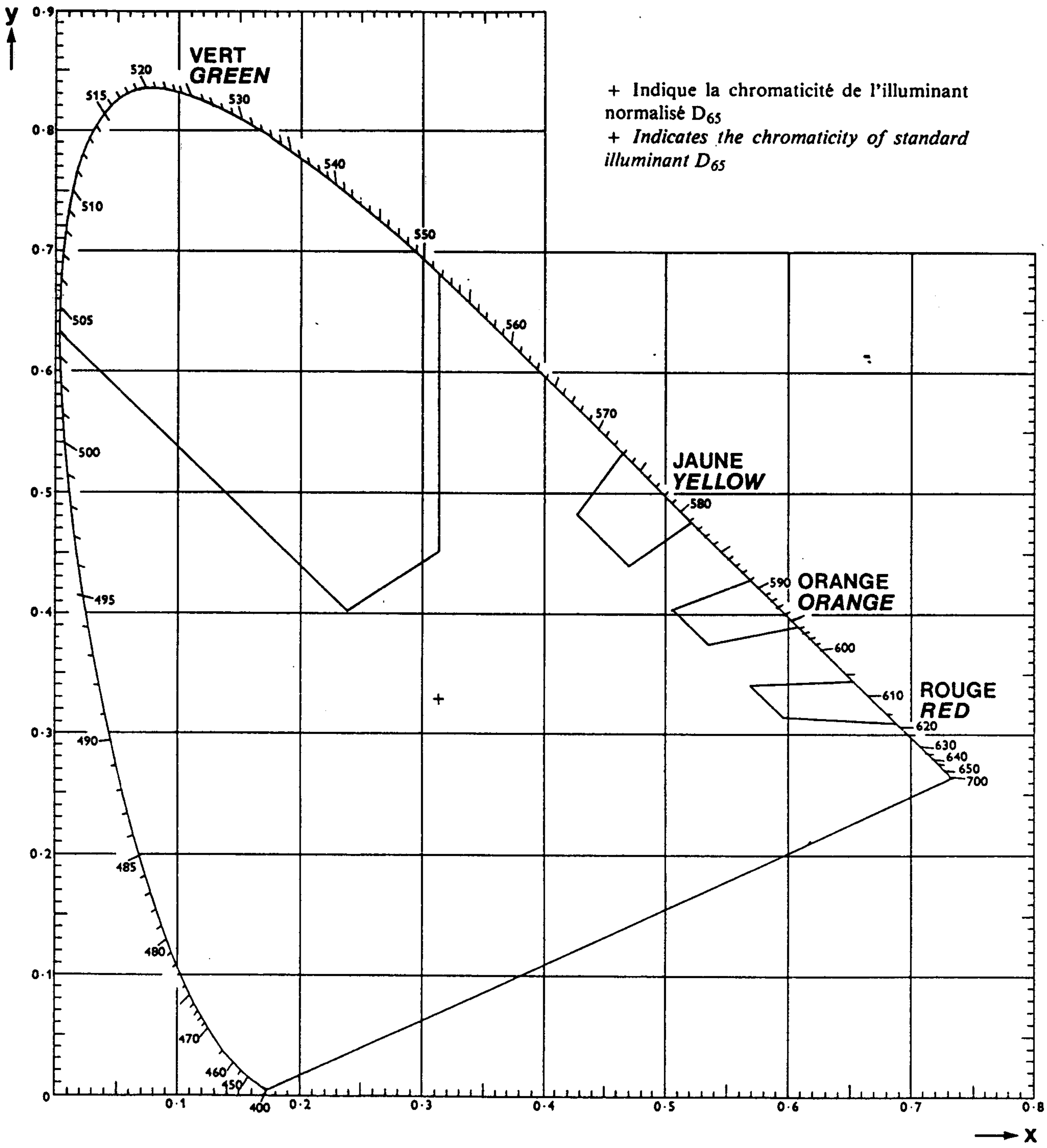

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TABLE 1. SPECIFICATION OF ORDINARY COLOURS

Recommended limits of ordinary colours in terms of the CIE 1931 standard colorimetric system, measurement with 45/0 geometry, and evaluation with standard illuminant D_{65}.

Colour	*Boundary*	*Equations of the boundary lines*	*Luminance factor*	
			Minimum	*Maximum*
Red	Purple White Orange	y = 0.345 − 0.051x y = 0.910 − x y = 0.314 + 0.047x	0.07	—
Orange	Red White Yellow	y = 0.265 + 0.205x y = 0.910 − x y = 0.207 + 0.390x	0.20	—
Yellow	Orange White Green	y = 0.108 + 0.707x y = 0.910 − x y = 1.35x − 0.093	0.50	—
Green	Yellow White Blue	x = 0.313 y = 0.243 + 0.670x y = 0.636 − 0.982x	0.12	—
Blue	Green White Purple	y = 0.118 + 0.675x y = 0.700 − 2.30x y = 1.65x − 0.187	0.07	—
White	Purple Blue Green Yellow	y = 0.010 + x y = 0.610 − x y = 0.030 + x y = 0.710 − x	0.75	—
Black	Purple Blue Green Yellow	y = x − 0.030 y = 0.570 − x y = 0.050 + x y = 0.740 − x	—	0.03

TABLE 2. CORNERS OF THE CHROMATICITY REGIONS OF ORDINARY COLOURS

(x,y) chromaticity coordinates of the corners of the recommended regions for ordinary colours specified in Table 1.

Colour	1		2		3		4	
	x	y	x	y	x	y	x	y
Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Orange	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429
Yellow	0.522	0.477	0.470	0.440	0.427	0.483	0.465	0.534
Green	0.313	0.682	0.313	0.453	0.238	0.402	0.004	0.632
Blue	0.078	0.171	0.196	0.250	0.225	0.184	0.137	0.038
White	0.350	0.360	0.300	0.310	0.290	0.320	0.340	0.370
Black	0.385	0.355	0.300	0.270	0.260	0.310	0.345	0.395

TABLE 3. SPECIFICATION OF FLUORESCENT COLOURS

Recommended limits of fluorescent colours in terms of the CIE 1931 standard colorimetric system, measurement with 45/0 geometry, and evaluation with standard illuminant D_{65}.

Colour	*Boundary*	*Equations of the boundary lines*	*Minimum luminance factor*
Red	Purple White Orange	y = 0.345 − 0.051x y = 0.910 − x y = 0.314 + 0.047x	0.25
Orange	Red White Yellow	y = 0.265 + 0.205x y = 0.910 − x y = 0.207 + 0.390x	0.40
Yellow	Orange White Green	y = 0.108 + 0.707x y = 0.910 − x y = 1.35x − 0.093	0.80
Green	Yellow White Blue	x = 0.313 y = 0.243 + 0.670x y = 0.636 − 0.982x	0.25

TABLE 4. CORNERS OF THE CHROMATICITY REGIONS OF FLUORESCENT COLOURS

(x,y) chromaticity coordinates of the corners of the recommended regions for fluorescent colours specified in Table 3.

Colour	1		2		3		4	
	x	y	x	y	x	y	x	y
Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345
Orange	0.610	0.390	0.535	0.375	0.506	0.404	0.570	0.429
Yellow	0.522	0.477	0.470	0.440	0.427	0.483	0.465	0.534
Green	0.313	0.682	0.313	0.453	0.238	0.402	0.004	0.632