APPENDIX (1)

COLOURS FOR AERONAUTICAL GROUND LIGHTS, MARKINGS, SIGNS AND PANELS

1. GENERAL

Note: The following specifications define the chromaticity limits of colors to be used for aeronautical ground lights, markings, signs and panels. The specifications are in accord with the 1983 specifications of the International Commission on Illumination (CIE). except for the colour orange in Figure A1-2.

It is not possible to establish specifications for colors such that there is no possibility of confusion. For reasonably certain recognition, it is important that the eye illumination be well above the threshold of perception, that the color not be greatly modified by selective atmospheric attenuations and that the observer's color vision be adequate. There is also a risk of confusion of color at an extremely high level of eye illumination such as may be obtained from a high-intensity source at very close range. Experience indicates that satisfactory recognition can be achieved if due attention is given to these factors.

The chromaticities are expressed in terms of the standard observer and coordinate system adopted by the International Commission on Illumination (CIE) at its Eighth Session at Cambridge, England, in 1931.

The chromaticities for solid state lighting (e.g. LED) are based upon the boundaries given in the standard S 004/E-2001 of the International Commission on Illumination (CIE), except for the blue boundary of white.

2. COLORS FOR AERONAUTICAL GROUND LIGHTS

<u>2.1 Chromaticities for lights having filament-type light sources</u>

2.1.1 The chromaticities of aeronautical ground lights shall be within the following boundaries:

CIE Equations (see Figure A1-1a):

a) <u>Red</u>

Purple boundary	$y = 0.980 – x$
Yellow boundary	$y = 0.335$ except for visual approach slope indicator systems;
Yellow boundary	$y = 0.320$, for visual approach slope indicator systems.

Note: See Chapter 5 5.3.5.14 and 5.3.5.30

b) Yellow

Red boundary	y = 0.382
White boundary	y = 0.790 – 0.667x
Green boundary	y = x – 0.120

c) Green

Yellow boundary	x = 0.360 – 0.080y
White boundary	x = 0.650y
Blue boundary	y = 0.390 – 0.171x

d) Blue

Green boundary	y = 0.805x + 0.065
White boundary	y = 0.400 – x
Purple boundary	x = 0.600y + 0.133

e) White

Yellow boundary	x = 0.500
Blue boundary	x = 0.285
Green boundary	y = 0.440 and y = 0.150 + 0.640x
Purple boundary	y = 0.050 + 0.750x and y = 0.382

f) Variable white

Yellow boundary	x = 0.255 + 0.750y and y = 0.790 - 0.667x
Blue boundary	x = 0.285
Green boundary	y = 0.440 and y = 0.150 + 0.640x
Purple boundary	y = 0.050 + 0.750x and y = 0.382

Note: Guidance on chromaticity changes resulting from the effect of temperature on filtering elements is given in CARC Guidance material visual aids.

2.1.2 Where dimming is not required, or where observers with defective color vision must be able to determine the color of the light, green signals shall be within the following boundaries:

Yellow boundary	y = 0.726 – 0.726x
White boundary	x = 0.650y

Blue boundary	y = 0.390 – 0.171x

Where the colour signal is to be seen from long range, it has been the practice to use colours within the boundaries of 2.1.2.

2.1.3 Where increased certainty of recognition from white is more important than maximum visual range, green signals shall be within the following boundaries:

Yellow boundary	y = 0.726 – 0.726x
White boundary	x = 0.625y – 0.041
Blue boundary	y = 0.390 – 0.171x

2.2 Discrimination between lights having filament-type sources

2.2.1 If there is a requirement to discriminate yellow and white from each other, they shall be displayed in close proximity of time or space as, for example, by being flashed successively from the same beacon.

2.2.2 If there is a requirement to discriminate yellow from green and/or white, as for example on exit taxiway center line lights, the y coordinates of the yellow light shall not exceed a value of 0.40.

Note: The limits of white have been based on the assumption that they will be used in situations in which the characteristics (color temperature) of the light source will be substantially constant.

2.2.3 The color variable white is intended to be used only for lights that are to be varied in intensity, e.g. to avoid dazzling. If this color is to be discriminated from yellow, the lights shall be so designed and operated that:

a) the x coordinate of the yellow is at least 0.050 greater than the x coordinate of the white; and

b) the disposition of the lights will be such that the yellow lights are displayed simultaneously and in close proximity to the white lights.

2.3 Chromaticities for lights having a solid state light source

2.3.1 The chromaticities of aeronautical ground lights with solid state light sources, e.g. LEDs, shall be within the following boundaries:

CIE Equations (see Figure A1-1b):

a) Red
- Purple boundary y = 0.980 – x

- Yellow boundary y = 0.335, except for visual approach slope indicator systems;
- Yellow boundary y = 0.320, for visual approach slope indicator systems.

Note: See Chapter 5, paragraph 5.3.5.14 and 5.3.5.30.

b) Yellow
- Red boundary y = 0.387
- White boundary y = 0.980 – x
- Green boundary y = 0.727x + 0.054

c) Green (also refer 2.3.2 and 2.3.3)
- Yellow boundary x = 0.310
- White boundary x = 0.625y – 0.041
- Blue boundary y = 0.400

c) Blue
- Green boundary y = 1.141x – 0.037
- White boundary x = 0.400 – y
- Purple boundary x = 0.134 + 0.590y

d) White
- Yellow boundary x = 0.440
- Blue boundary x = 0.320
- Green boundary y = 0.150 + 0.643x
- Purple boundary y = 0.050 + 0.757x

e) Variable white
- The boundaries of variable white for solid state light sources are those of e) White above.

2.3.2 Where observers with defective colour vision must be able to determine the colour of the light, green signals should be within the following boundaries:

Yellow boundary y = 0.726 – 0.726x
White boundary x = 0.625y – 0.041
Blue boundary y = 0.400

2.3.3 In order to avoid a large variation of shades of green, if colours within the boundaries below are selected, colours within the boundaries of 2.3.2 should not be used

Yellow boundary x= 0.310
White boundary x = 0.625y – 0.041
Blue boundary y = 0.726 – 0.726x

<u>2.4 Colour measurement for filament-type and solid state-type light sources</u>

2.4.1 The colour of aeronautical ground lights shall be verified as being within the boundaries specified in Figure A1-1a or K1-1b, as appropriate, by measurement at five points within the area limited by the innermost isocandela curve (isocandela diagrams in Appendix 2 refer), with operation at rated current or voltage. In the case of elliptical or circular isocandela curves, the colour measurements shall be taken at the centre and at the horizontal and vertical limits. In the case of rectangular isocandela curves, the colour measurements shall be taken at the centre and the limits of the diagonals (corners). In addition, the colour of the light shall be checked at the outermost isocandela curve to ensure that there is no colour shift that might cause signal confusion to the pilot.

Note 1: For the outermost isocandela curve, a measurement of colour coordinates should be made and recorded for review and judgement of acceptability by the State.

Note 2: Certain light units may have application so that they may be viewed and used by pilots from directions beyond that of the outermost isocandela curve (e.g. stop bar lights at significantly wide runway-holding positions). In such instances, the State should assess the actual application and if necessary require a check of colour shift at angular ranges beyond the outermost curve.

2.4.2 In the case of visual approach slope indicator systems and other light units having a colour transition sector, the colour shall be measured at points in accordance with 2.4.1, except that the colour areas shall be treated separately and no point shall be within 0.5 degrees of the transition sector.

3. COLORS FOR MARKINGS, SIGNS AND PANELS

Note: The specifications of surface colors given below apply only to freshly colored surfaces. Colors used for markings, signs and panels usually change with time and therefore require renewal.

Note: The specifications recommended in 3.4 below for transilluminated panels are interim in nature and are based on the CIE specifications for transilluminated signs. It is intended that these specifications will be reviewed and updated as and when CIE develops specifications for transilluminated panels.

3.1 The chromaticities and luminance factors of ordinary colors, colors of retro-reflective materials and colors of transilluminated (internally illuminated) signs and panels shall be determined under the following standard conditions:

a) angle of illumination: 45°;

b) direction of view: perpendicular to surface; and

c) illuminant: CIE standard illuminant D65.

3.2 The chromaticity and luminance factors of ordinary colors for markings and externally illuminated signs and panels shall be within the following boundaries when determined under standard conditions. CIE Equations (see Figure A1-2):

a) Red

Purple boundary	y = 0.345 – 0.051x
White boundary	y = 0.910 – x
Orange boundary	y = 0.314 + 0.047x
Luminance factor	ß = 0.07 (mnm)

b) Orange

Red boundary	y = 0.285 + 0.100x
White boundary	y = 0.940 – x
Yellow boundary	y = 0.250 + 0.220x
Luminance factor	ß = 0.20 (mnm)

c) Yellow

Orange boundary	y = 0.108 + 0.707x
White boundary	y = 0.910 – x
Green boundary	y = 1.35x – 0.093
Luminance factor	ß = 0.45 (mnm)

d) White

Purple boundary	y = 0.010 + x
Blue boundary	y = 0.610 – x
Green boundary	y = 0.030 + x
Yellow boundary	y = 0.710 – x
Luminance factor	ß = 0.75 (mnm)

e) Black

Purple boundary	y = x – 0.030
Blue boundary	y = 0.570 – x
Green boundary	y = 0.050 + x
Yellow boundary	y = 0.740 – x
Luminance factor	ß = 0.03 (max)

f) Yellowish green

Green boundary	y = 1.317x + 0.4
White boundary	y = 0.910 – x
Yellow boundary	y = 0.867x + 0.4

g) Green

Yellow boundary	x=0.313
White boundary	y=0.243+0.670x
Blue boundary	y=0.493-0.524x
Luminance factor	β=0.10 (mnm)

Note: The small separation between surface red and surface orange is not sufficient to ensure the distinction of these colors when seen separately.

3.3 The chromaticity and luminance factors of colors of retro-reflective materials for markings, signs and panels shall be within the following boundaries when determined under standard conditions.

CIE Equations (see Figure A1-3):

a) <u>Red</u>

Purple boundary	y = 0.345 – 0.051x
White boundary	y = 0.910 – x
Orange boundary	y = 0.314 + 0.047x
Luminance factor	ß = 0.03 (mnm)

b) <u>Orange</u>

Red boundary	y = 0.265 + 0.205x
White boundary	y = 0.910 – x
Yellow boundary	y = 0.207 + 0.390x
Luminance factor	ß = 0.14 (mnm)

c) <u>Yellow</u>

Orange boundary	y = 0.160 + 0.540x
White boundary	y = 0.910 – x
Green boundary	y = 1.35x – 0.093
Luminance factor	ß = 0.16 (mnm)

d) <u>White</u>

Purple boundary	y = x
Blue boundary	y = 0.610 – x
Green boundary	y = 0.040 + x
Yellow boundary	y = 0.710 – x
Luminance factor	ß = 0.27 (mnm)

e) <u>Blue</u>

Green boundary	y = 0.118 + 0.675x
White boundary	y = 0.370 – x
Purple boundary	y = 1.65x – 0.187
Luminance factor	ß = 0.01 (mnm)

f) <u>Green</u>

Yellow boundary	y = 0.711 – 1.22x
White boundary	y = 0.243 + 0.670x
Blue boundary	y = 0.405 – 0.243x
Luminance factor	ß = 0.03 (mnm)

3.4 The chromaticity and luminance factors of colors for luminescent or transilluminated (internally illuminated) signs and panels shall be within the following boundaries when determined under standard conditions.

CIE Equations (see Figure A1-4):

a) Red

Purple boundary	y = 0.345 – 0.051x
White boundary	y = 0.910 – x
Orange boundary	y = 0.314 + 0.047x
Luminance factor (day condition)	ß = 0.07 (mnm)
Relative luminance to white (night condition)	5% (mnm) 20% (max)

b) Yellow

Orange boundary	y = 0.108 + 0.707x
White boundary	y = 0.910 – x
Green boundary	y = 1.35x – 0.093
Luminance factor (day condition)	ß = 0.45 (mnm)
Relative luminance to white (night condition)	30% (mnm) 80% (max)

c) White

Purple boundary	y = 0.010 + x
Blue boundary	y = 0.610 – x
Green boundary	y = 0.030 + x
Yellow boundary	y = 0.710 – x
Luminance factor (day condition)	ß = 0.75 (mnm)
Relative luminance to white (night condition)	100%

d) Black

Purple boundary	y = x – 0.030
Blue boundary	y = 0.570 – x
Green boundary	y = 0.050 + x
Yellow boundary	y = 0.740 – x
Luminance factor (day condition)	ß = 0.03 (max)

Relative luminance to white (night condition)	0% (mnm) 2% (max)

e) <u>Green</u>

Yellow boundary	x=0.313
White boundary	y=0.243+0.670x
Blue boundary	y=0.493-0.524x
Luminance factor	β=0.10 minimum (day conditions)
Relative luminance to white (night conditions)	5% (minimum) 30% (maximum)

Figures A1-1 to A1-4 are on pages 10 to 14 of this appendix.

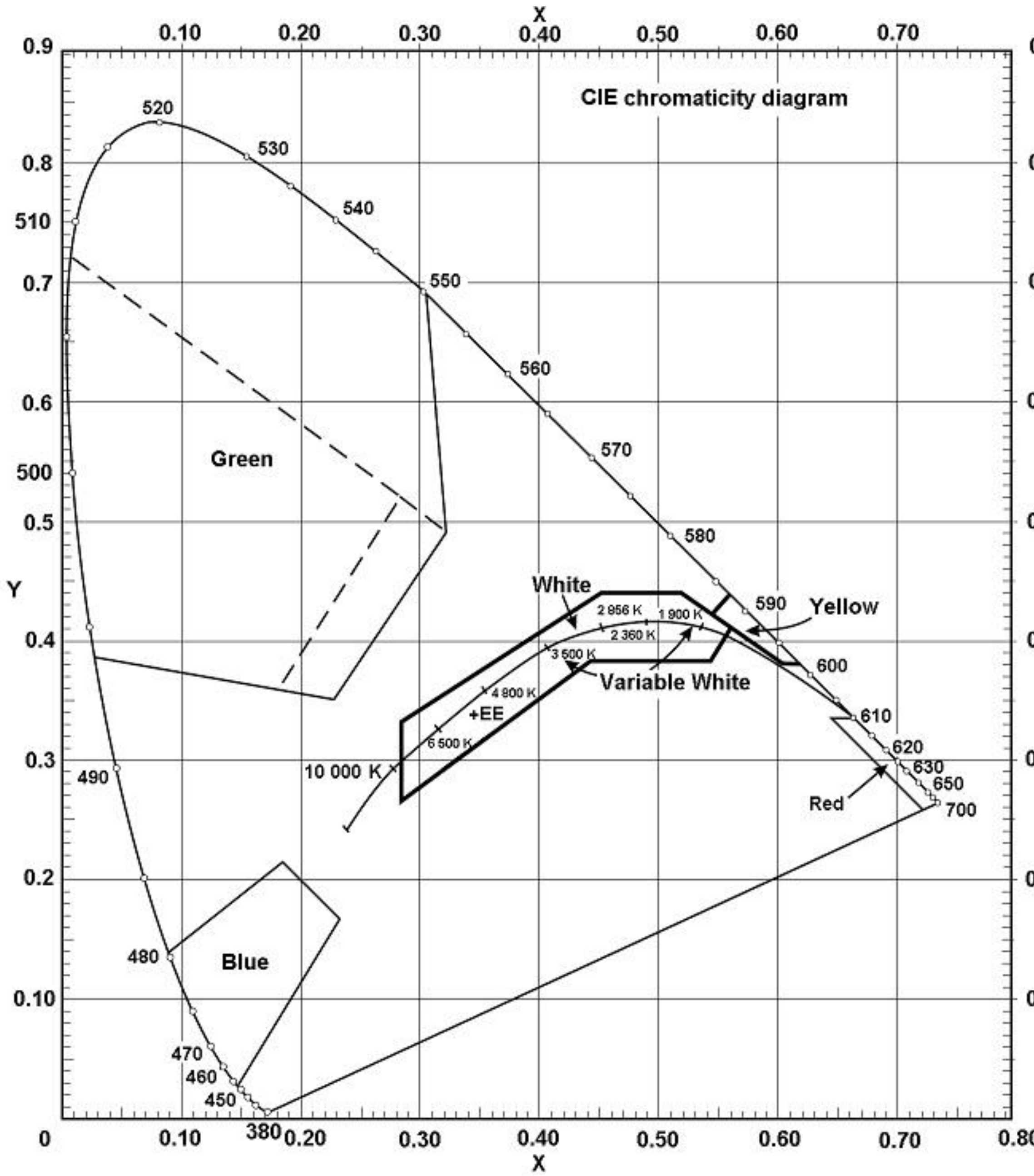

Figure A1-1a
Colors for aeronautical ground lights (filament-type lamps)

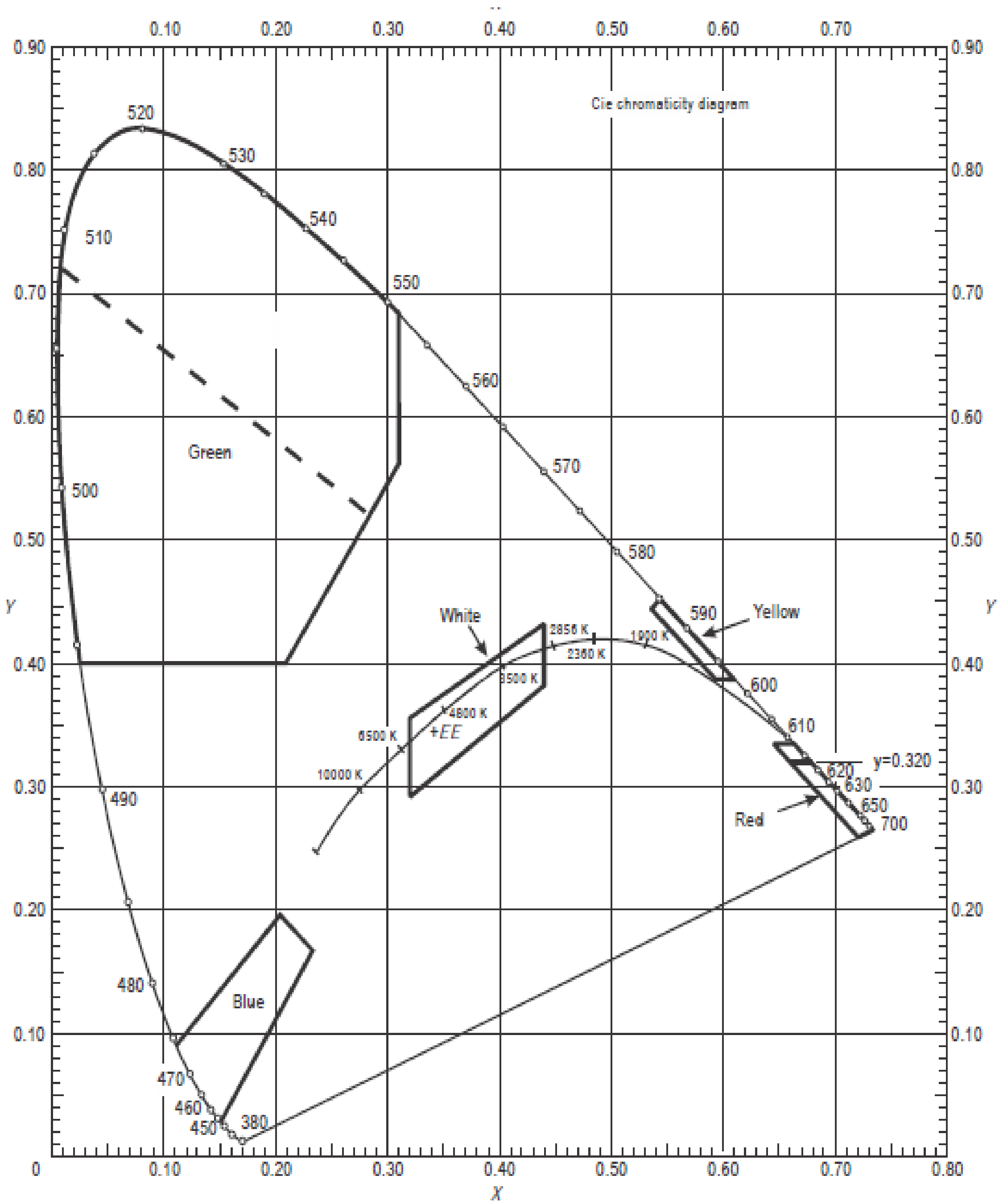

Figure A1-1b
Colors for aeronautical ground lights (solid state lighting)

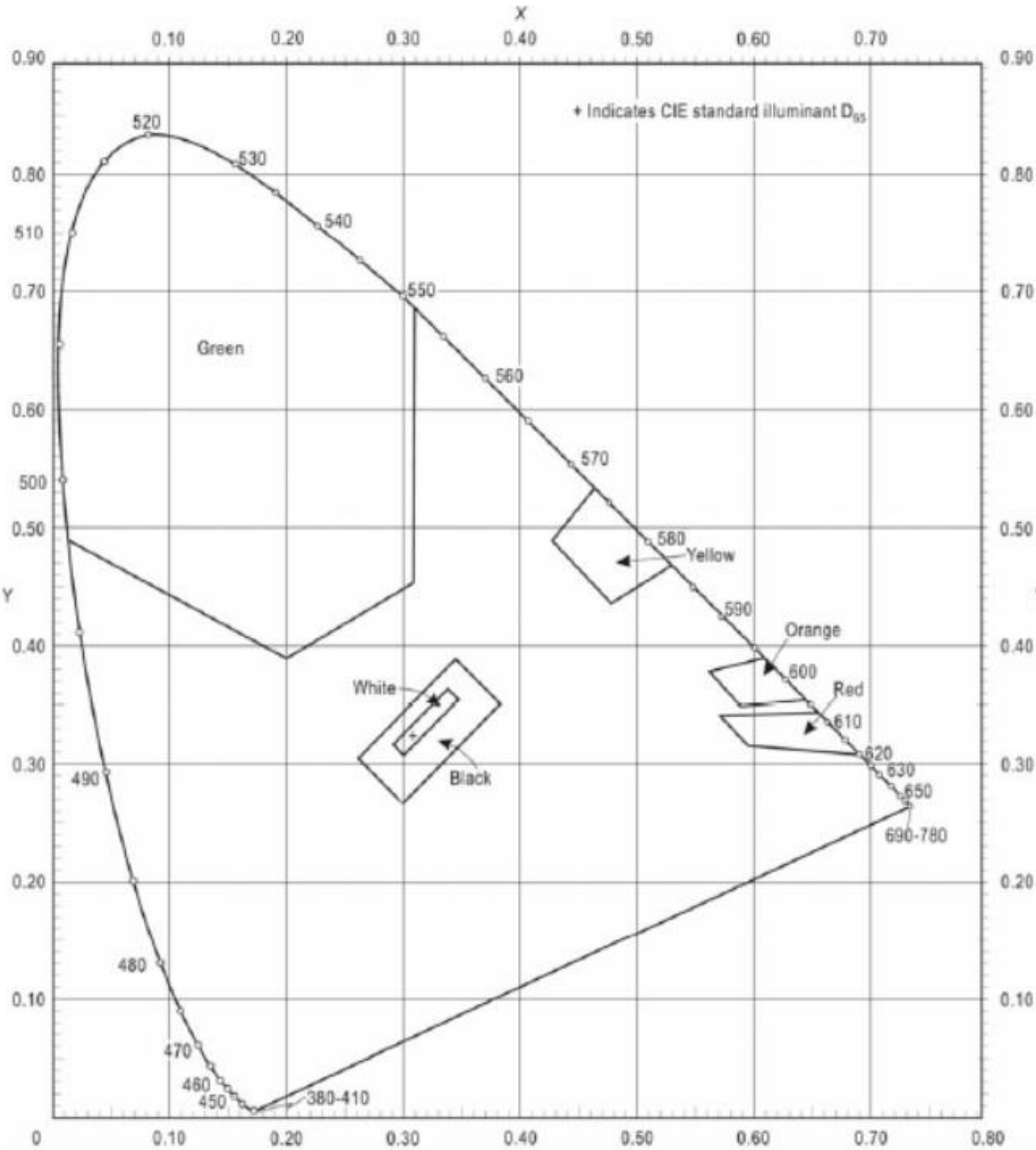

Figure A1-2
Ordinary colors for markings and externally illuminated signs and panels

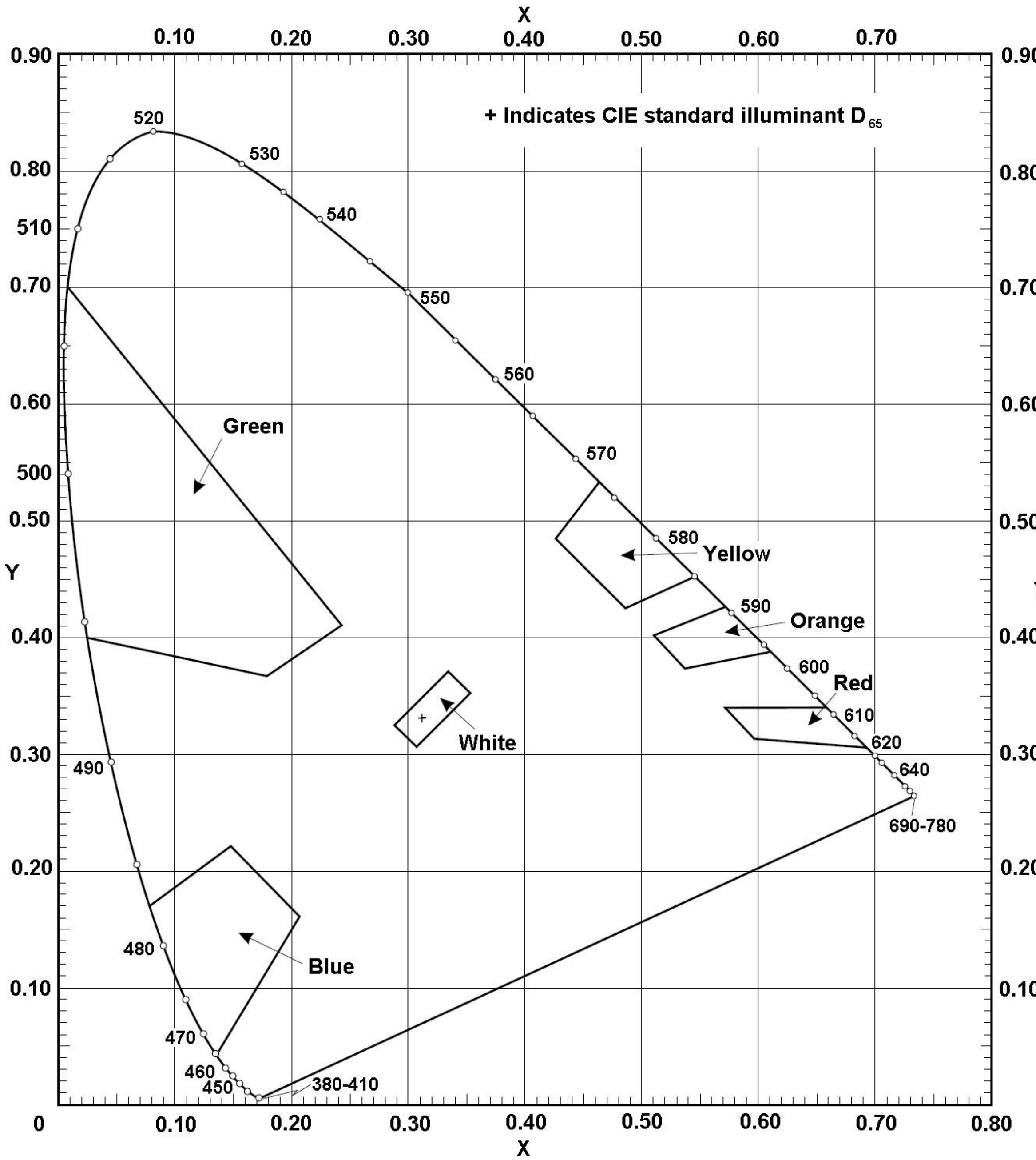

Figure A1-3
Colors of retro-reflective materials for markings, signs and panels

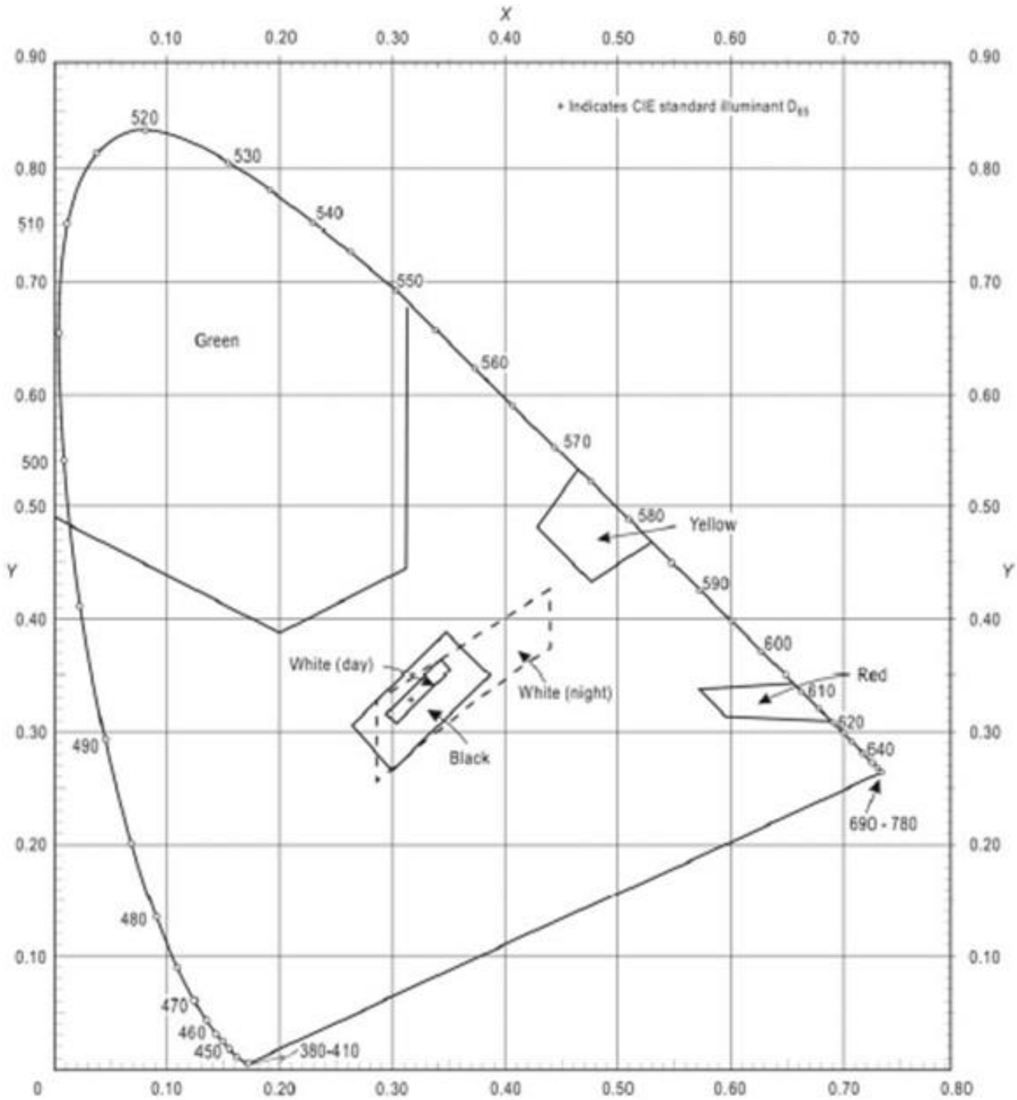

Figure A1-4
Colors of luminescent or trans-illuminated (internally illuminated) signs and panels