

# JIS

**JAPANESE INDUSTRIAL STANDARD**

**Retroreflective Sheeting  
and Tape for Safety**

**JIS Z 9117—1984**

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## JAPANESE INDUSTRIAL STANDARD

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## Retroreflective Sheeting and Tape for Safety

Z 9117-1984

1. Scope

This Japanese Industrial Standard specifies nonexposed lens type retroreflective sheets and tapes for use in the following applications, hereinafter referred to as the "retroreflective sheets".

- (1) Road signs and other road accessories, cars, lower parts of poles, railroad crossing barriers, and the like for securing safety and smoothness of traffic in roads, railroads, tunnels, and the like.
- (2) Reflective safety signs specified in JIS Z 9105, mine safety signs specified in JIS M 7001, and other articles such as safety helmets for hazard prevention at night or in dark places in factories, mines, construction working area, and other working areas.

Remark: The units and numerical values given in { } in this standard are in accordance with the International System of Units (SI), and are appended for reference.

2. Definition

The main terms used in this standard mean as follows, and others as specified in JIS Z 8105:

- (1) road signs Road signs specified in the Ordinance concerning road signs, dividing lines, and road markings.
- (2) road accessories Various installations ancillary to roads based on the Roads Law, such as guard rails.
- (3) retroreflection The phenomenon in which light is reflected to the illuminating direction of the light.
- (4) illumination axis The axis connecting the projector and the center of the test piece surface.
- (5) observation axis The axis connecting the receptor and the center of the test piece surface.



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- (6) observation angle Angle included between the illumination axis and observation axis.
- (7) entrance angle The angle included between the illumination angle and the normal line to the test piece surface at its center.
- (8) retroreflection coefficient ( $R'$ ) The quotient obtained by dividing the luminous intensity ( $I$ ) of the light reflected by the retroreflective surface in the direction of the observation angle by the product of the illuminance ( $E_s$ ) received by the retroreflective surface placed perpendicular to the direction of the incident light and the area ( $A$ ) of the retroreflective surface (refer to Fig. 2).

$$R' = \frac{I}{E_s \cdot A}$$

The retroreflection coefficient is expressed in  $\text{cd} \cdot \text{lx}^{-1}, \text{m}^{-2}$ .

### 3. Grades and Types

Retroreflective sheets shall be classified into two grades according to the reflection performance, and into two types according to the kind of adhesives used, as shown in Table 1.

Grade 1 shall be used in outdoor environments exposed to sunlight throughout the year, and Grade 2 shall be used in environments in which the frequency of exposure to direct sunlight and wind or rain is low, as a rule.

Table 1. Grades and Types

Grade \ Types	Pressure bonding type	Hot pressure bonding type
Grade 1	R 1-P	R 1-H
Grade 2	R 2-P	R 2-H

### 4. Performance

The performance of retroreflective sheets shall meet the following requirements:

- (1) Colour The colour of retroreflective sheets shall conform to Table 2 when measured by the measuring method specified in 7.2 (for the ranges of chromaticity coordinates, refer to Attached Figure).

Table 2. Colour

Colour	Ranges of chromaticity coordinates <sup>(1)</sup>								Lower limit value <sup>(1)</sup> of luminance factor( $\beta$ )	Reference colour value <sup>(2)</sup>
	1		2		3		4			
	$x$	$y$	$x$	$y$	$x$	$y$	$x$	$y$		
White	0.363	0.372	0.319	0.318	0.297	0.335	0.340	0.390	0.35	5.0GY 7/1
Yellow	0.532	0.468	0.493	0.453	0.467	0.481	0.492	0.508	0.27	2.5 Y 6/15
Red	0.722	0.278	0.608	0.323	0.580	0.363	0.654	0.346	0.05	10.0 R 3/15
Yellowish red	0.635	0.365	0.571	0.374	0.559	0.401	0.597	0.403	0.15	2.5 YR 5/16
Green	0.101	0.492	0.191	0.441	0.157	0.379	0.116	0.387	0.04	10.0 G 3/10
Blue	0.103	0.138	0.151	0.192	0.197	0.151	0.162	0.063	0.01	5.0PB 1/10

Notes <sup>(1)</sup> The values of chromaticity coordinates  $x$  and  $y$  and of luminance factor ( $\beta$ ) are values obtained under the geometric conditions a of illumination and reception (45° illumination, perpendicular reception) specified in JIS Z 8722 and based on the standard illuminant D<sub>65</sub> and the CIE 1931 standard colorimetric system. However, the luminance factor is expressed by values obtained by giving the value for the perfect diffusion reflecting surface as 1.00.

<sup>(2)</sup> The reference colour values are based on JIS Z 8721 and the standard illuminant C.

Reference colour specimens are shown in Reference.

- (2) **Reflection Performance** The reflection performance values of retro-reflective sheets shall be not smaller than the values shown in Table 3 for Grade 1 and not smaller than the values shown in Table 4 for Grade 2 when measured by the measuring method specified in 7.3.

Table 3. Reflection Performance of Grade 1

Observation angle	Entrance angle	White	Yellow	Red	Yellowish red	Green	Blue
12'	5°	70	50	15	25	9.0	4.0
	30°	30	22	6.0	7.0	3.5	1.7
	40°	10	7.0	2.0	2.2	1.5	0.5
20'	5°	50	35	10	20	7.0	2.0
	30°	24	16	4.0	4.5	3.0	1.0
	40°	9.0	6.0	1.8	2.0	1.2	0.4
2°	5°	5.0	3.0	0.8	1.2	0.6	0.2
	30°	2.5	1.5	0.4	0.6	0.3	0.1
	40°	1.5	1.0	0.3	0.4	0.2	0.06



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Table 4. Reflection Performance of Grade 2

Observation angle	Entrance angle	White	Yellow	Red	Yellowish red	Green	Blue
12'	5°	35	25	10	13	5.0	3.0
	30°	18	12	4.5	6.5	2.2	1.2
	40°	7.0	4.0	1.7	2.0	1.2	0.5
20'	5°	25	15	5.0	9.0	3.5	2.0
	30°	12	10	3.0	3.5	2.0	1.0
	40°	6.0	4.0	1.0	1.5	0.8	0.4
2°	5°	4.0	2.2	0.6	1.0	0.4	0.2
	30°	1.8	1.0	0.3	0.5	0.2	0.09
	40°	1.0	0.8	0.1	0.3	0.1	0.06

- (3) Glossiness The values of glossiness of retroreflective sheets shall be not smaller than 40 when measured by the measuring method specified in 7.4.
- (4) Weather Resistance The weather resistance of retroreflective sheets shall meet the requirements of (a) to (e) when they are tested by either of the testing methods specified in 7.5. In this case, for Grade 1, the reflection performance value after 5 years of outdoor exposure (south-west, vertical) shall be not less than 80 % of the value in Table 3 as a basic rule, but the test of 7.5 may be performed as a substitute therefor.
- (a) When the colour is measured by using a colorimeter, it shall be within the range of chromaticity shown in Table 2.
- (b) There shall not occur blisters, fissures, scales, peeling off of edges, corrosion, or the like.
- (c) There shall not occur shrinkage or expansion beyond 0.8 mm from the edges.
- (d) The reflection performance value shall be not less than 80 % of the value of Table 3 for Grade 1 and not less than 80 % of the value of Table 4 for Grade 2.
- (e) The retroreflective sheet shall not be peeled off from the aluminium plate.

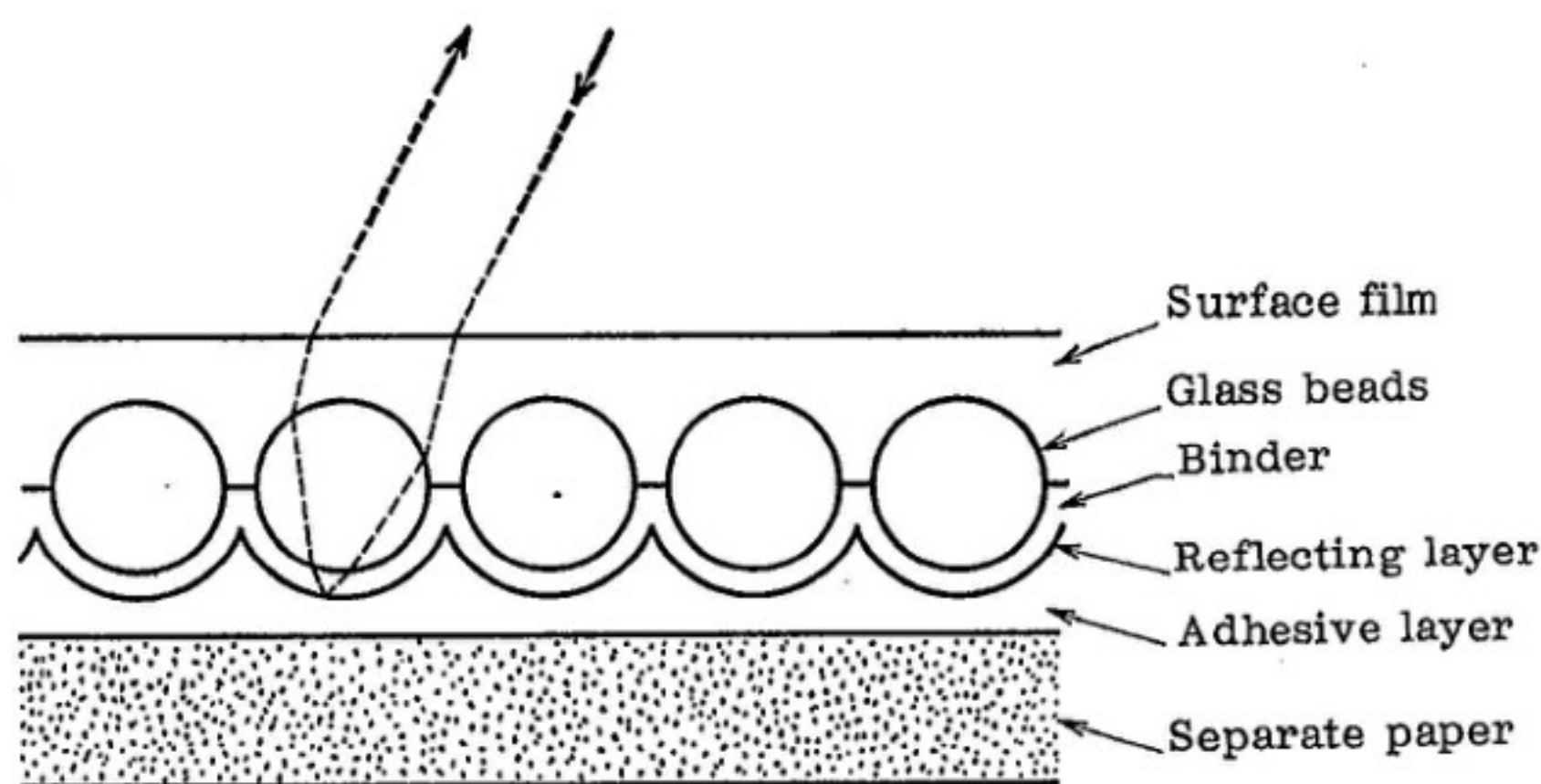
- (5) Separability of Separate Paper When the test of 7.6 is performed, the separate paper shall be easily separable, and there shall not occur abnormalities such as tearing of the separate paper or transfer of the adhesives to the separate paper.
- (6) Adhesion When testing is performed by the testing method specified in 7.7, the adhesive surface of the test piece shall not be peeled off from the aluminium plate to which it is stuck over a length of 50 mm or larger.
- (7) Elongation and Tensile Strength When retroreflective sheets are tested according to the testing method specified in 7.8, the elongation shall be not less than 10 % and the tensile strength shall be not lower than 2.25 kgf { 22.07 N }.
- (8) Shrinkage When retroreflective sheets are tested by the testing method specified in 7.9, they shall not shrink by 0.8 mm or more in 10 min and by 3.2 mm or more in 24 h.
- (9) Flexibility When retroreflective sheets are tested according to the testing method specified in 7.10, there shall not occur defects such as fissures, cracks, etc. on their surface.
- (10) Solvent Resistance When retroreflective sheets are tested according to the testing method specified in 7.11, there shall not occur defects such as dissolution, swelling, fissures, blisters, etc.

## 5. Construction

Retroreflective sheets shall have a construction in which, as shown in Fig. 1, the illuminant light is transmitted through the surface film, glass beads, and binder layer to the reflecting layer, during the process it is coloured by the pigment intermixed in the surface film or binder, and the coloured light is retroreflected in the illuminating direction. In addition, the back surface of the retroreflecting sheet shall be applied with an adhesive for sticking onto other objects, and this adhesive layer shall be protected with a separate paper.



Fig. 1. Construction (Example)



## 6. Material

The following materials shall be used for retroreflective sheets:

- (1) Surface Film The surface film for protecting the glass beads, reflecting layer, and the like shall be made of a colourless or coloured transparent material having water resisting property moisture resistance, and flexibility.
- (2) Glass Beads The glass beads shall consist of transparent spherical fine particles having a high refractive index.
- (3) Binder The binder for binding the glass beads into a uniform single layer shall consist of a high-quality and weatherproof material.
- (4) Pigment The pigment to be intermixed in the surface film or binder shall consist of a material resistant to discoloration.
- (5) Reflecting Layer The reflecting layer shall consist of a material having a high reflectance to attain a high efficiency of retroreflection.
- (6) Pressure Bonding Type Adhesives The pressure bonding type adhesives shall be the adhesives used for sticking the retroreflective sheet to other objects by simply applying pressure to the sheet, and shall consist of a material which does not corrode other objects and is weatherproof.
- (7) Hot Pressure Bonding Type Adhesives The hot pressure bonding type adhesives, shall be the adhesives used for sticking the retroreflective sheet to other objects by bonding it under heat and pressure, and shall consist of a material which does not corrode other objects and is weatherproof.



- (8) Separate Paper The separate paper for protection of the adhesives and retroreflective sheet shall be easy to peel off without using water, solvent, or the like.

## 7. Testing Methods

7.1 Test Conditions The test conditions for retroreflective sheets shall be as follows:

- (1) Atmospheric Conditions for Testing Unless otherwise specified, the atmospheric conditions shall be a temperature of  $20 \pm 2^{\circ}\text{C}$  and a relative humidity of  $65 \pm 5\%$  as specified in JIS Z 8703.
- (2) Division of Test Pieces The test pieces used shall be test pieces cut out from the original sheet, hereinafter referred to as the "pieces A", and test pieces prepared by sticking the original sheet onto aluminium plates conforming to A 5052 P of JIS H 4000, hereinafter referred to as the "aluminium plates", hereinafter referred to as the "pieces B".
- (3) Method of Preparing Pieces B The pieces B shall be prepared by elaborately grinding the surface of an aluminium plate in the longitudinal direction with No. 400 abrasive paper specified in JIS R 6253, washing it with a suitable solvent such as benzine, drying it well and wiping it with a well-dried clean cloth, and then sticking the adhesive surface of the retroreflective sheet on the surface of the thus pretreated aluminium plate. The thickness of the aluminium plate shall be not smaller than 0.5 mm.
- (4) Pretreatment of Test Pieces Both pieces A and B shall be left standing before testing for 24 h under the temperature and humidity conditions specified in (1).

7.2 Measurement of Colour The measurement of colour of retroreflecting sheets shall be performed under the conditions specified in 4.3.1 of JIS Z 8722, that is, the geometric conditions of illumination and reception by illuminating the sample from the direction of 45 degrees and receiving the reflected light of the normal direction, and the colour under the standard illuminant  $D_{65}$  shall be measured and indicated based on the CIE 1931 standard colorimetric system. When the value of Y among the tristimulus values obtained in this measurement is expressed by the ratio to the luminance of the perfect diffusion reflecting surface, it becomes the luminance factor ( $\beta$ ). The measuring surface shall be a circle of 50 mm in diameter as a rule. In order to enhance the measuring precision, it is desirable to calibrate the measuring instrument by using colour calibrating collation pieces of retroreflecting sheets having colour close to that of the sample.



**7.3 Measurement of Retroreflection Performance** The retroreflection performance of retroreflective sheets shall be measured as follows:

- (1) **Test Pieces** Three pieces B each 70 mm in width and 150 mm in length shall be arranged to form a rectangle of 210 mm x 150 mm and subjected to the retroreflection performance test.
- (2) **Test Apparatus** The test apparatus shall consist of a projector having an emitting opening of 26 mm or smaller in diameter and a photoelectric receptor having an effective diameter of 26 mm or smaller, and as shown in Fig. 2, the distance ( $d$ ) between the test piece surface and the receptor surface shall be adjusted to 15.0 m or larger. In this case, the light source used shall be the standard source A, and the spectral sensitivity of the receptor used shall agree with the relative luminous efficiency of the standard observer as a rule.

In addition, the illuminance of the incident light on the test piece surface shall be as uniform as possible.

- (3) **Observation Angle and Entrance Angle** The observation angle values used shall be  $12'$ ,  $20'$ , and  $2^\circ$ , and the entrance angle values used shall be  $5^\circ$ ,  $30^\circ$ , and  $40^\circ$ . In this case, the directions of observation angle and entrance angle shall be taken as positive in the anticlockwise direction.
- (4) **Measurement** Illuminance  $E_i$  shall be measured with the receptor placed at the position of the test piece and right opposite the projector. Then returning the arrangement to that shown in Fig. 2, the values of illuminance  $E_r$  on the receptor produced by the reflection from the test piece shall be measured with respect to 3 entrance angles respectively at 3 observation angles, and the retroreflection coefficient  $R'$  shall be calculated from the following formula:

$$R' = \frac{I}{E_i \cdot A}$$

where  $R'$  : retroreflection coefficient

$E_i$  : illuminance on the plane normal to incident light at center of test piece (lx)

$A$  : surface area of test piece ( $m^2$ )

$I$  : luminous intensity (cd) in the direction of observation axis produced by test piece, to be calculated from the following formula:

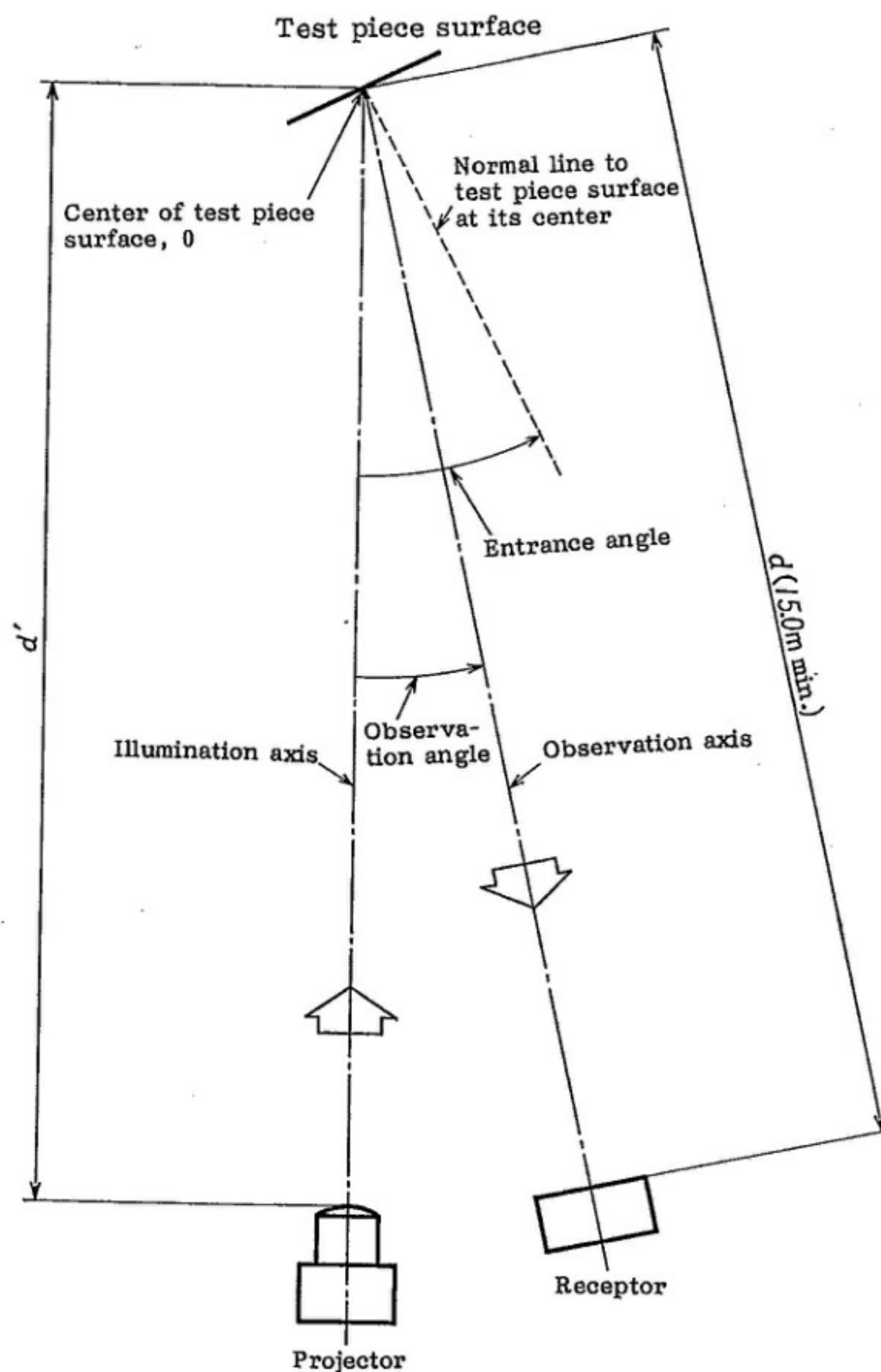
$$I = E_r \cdot d^2$$

where  $E_r$  : illuminance on receptor in the arrangement of Fig. 2 (lx)

$d$  : distance between the center of test piece surface and the receptor (m)



Fig. 2. Retroreflection Performance Testing Apparatus



Remark: The distance  $d'$  (m) between the surface of the projector lens and the center of the test piece surface shall be made almost equal to  $d$ .

**7.4 Measurement of Glossiness** The glossiness of retroreflective sheets shall be measured by Method 3 (60° specular glossiness) specified in JIS Z 8741 respectively two times with 3 pieces B of 70 mm in width and 150 mm in length.

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**7.5 Weather Resistance Test** The weather resistance test of retroreflective sheets shall be performed by exposing the test pieces used in the test of 7.3 by either of the methods shown in the following (1) and (2), then measuring the colour by the method specified in 7.2, and examining the retroreflection performance by the method specified in 7.3.

The number of test pieces used shall be 3.

- (1) **Dew Cycle Type Accelerated Weathering Test** Illumination shall be made under the conditions shown in Table 5 by using a dew cycle type sunshine carbon arc accelerated weathering tester.

Table 5. Conditions of Dew Cycle Type Accelerated Weathering Test

Item	Conditions
Number of sunshine carbon arc lamps	One (with 4 pairs of upper and lower carbons, without using optical filter)
Power source voltage	Single-phase a.c. 180 to 230 V
Cycles of extinction and illumination	60 min and 60 min
Conditions during illumination	
Average discharge voltage and current	50 V $\pm$ 2 %, 60 A $\pm$ 2 %
Temperature indicated by black panel thermometer	63 $\pm$ 3°C
Conditions during extinction	
Air temperature	30°C
Relative humidity	98 % min.
Temperature of cooling water to backside of test piece	About 7°C
Test period (total extinction and illumination time)	80 h for Grade 1, 20 h for Grade 2 (continuous test without replacement of carbon electrode)
Water spray to test piece surface	Not applied
Irradiance received by test piece surface	285 $\pm$ 50 W/m <sup>2</sup> for 300 to 700 nm

- (2) **Sunshine Carbon Arc Type Accelerated Weathering Test** The sunshine carbon arc type accelerated weathering test shall be performed by illuminating under the conditions shown in Table 6 by using the tester specified in JIS B 7753.



Table 6. Conditions of Sunshine Carbon Arc  
Type Accelerated Weathering Test

Item	Conditions
Number of sunshine carbon arc lamps	One (with 4 pairs of upper and lower carbons)
Power source voltage	Single-phase a.c. 180 to 230 V
Average discharge voltage and current	50 V $\pm$ 2 %, 60 A $\pm$ 2 %
Illuminating time	1000 h for Grade 1, 250 h for Grade 2 (The replacement of carbon electrode shall be made in a short time at every 24 to 60 h, with the number of times of replacement made as small as possible)
Temperature indicated by black panel thermometer	63 $\pm$ 3°C
Water spraying time	18 minutes in 120 minutes of illumination
Water pressure of supply water source	0.8 to 1.3 kgf/cm <sup>2</sup> {78 to 127 kPa}
Bore of nozzle	About 1 mm
Irradiance received by test piece surface	255 $\pm$ 45 W/m <sup>2</sup> for 300 to 700 nm

**7.6 Separability Test of Separate Paper** The separability test of the separate sheet shall be performed by placing a weight weighing 175 g per cm<sup>2</sup> on a retro-reflective sheet of 50 mm in width and 150 mm in length, and after leaving it standing for 4 h in a thermostatic bath at 70  $\pm$  2°C, withdrawing and letting it cool under the test conditions of 7.1 (1), and peeling off the separate paper by finger tips without using water or solvent. During the process of peeling the separate paper, examination shall be made for the occurrence of abnormalities such as splitting of the separate paper or transfer of the adhesives to the separate paper.

The test pieces prepared shall be 5 pieces A, of which 3 shall be used in this test.



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**7.7 Adhesion Test** The adhesion test of adhesives used in retroreflective sheets shall be performed as follows according to the kind of adhesives:

- (1) **For Pressure Bonding Type Retroreflective Sheets** The two remaining test pieces prepared in 7.6 shall respectively be divided into two test pieces of 25 mm in width and 150 mm in length, and the adhesive surface of each test piece shall be bonded for a length of about 100 mm to an aluminium plate treated preliminarily under the conditions of 7.1 (3) by using the pressure bonding apparatus specified in 8.2.3 of JIS Z 0237 and by reciprocating the roller one time on the test piece at a traveling speed under pressure of 5 mm/s. After pressure bonding and pre-treating the test piece according to 7.1 (4), the test piece shall be retained horizontally with the retroreflective sheet facing downward. Then the lower end of the unstuck part of the sheet about 50 mm in length shall be gripped with a suitable gripping tool and a weight of 800 g, including the gripping tool, shall be vertically suspended quietly from the gripping tool for 5 minutes, and the peeling length shall be measured.

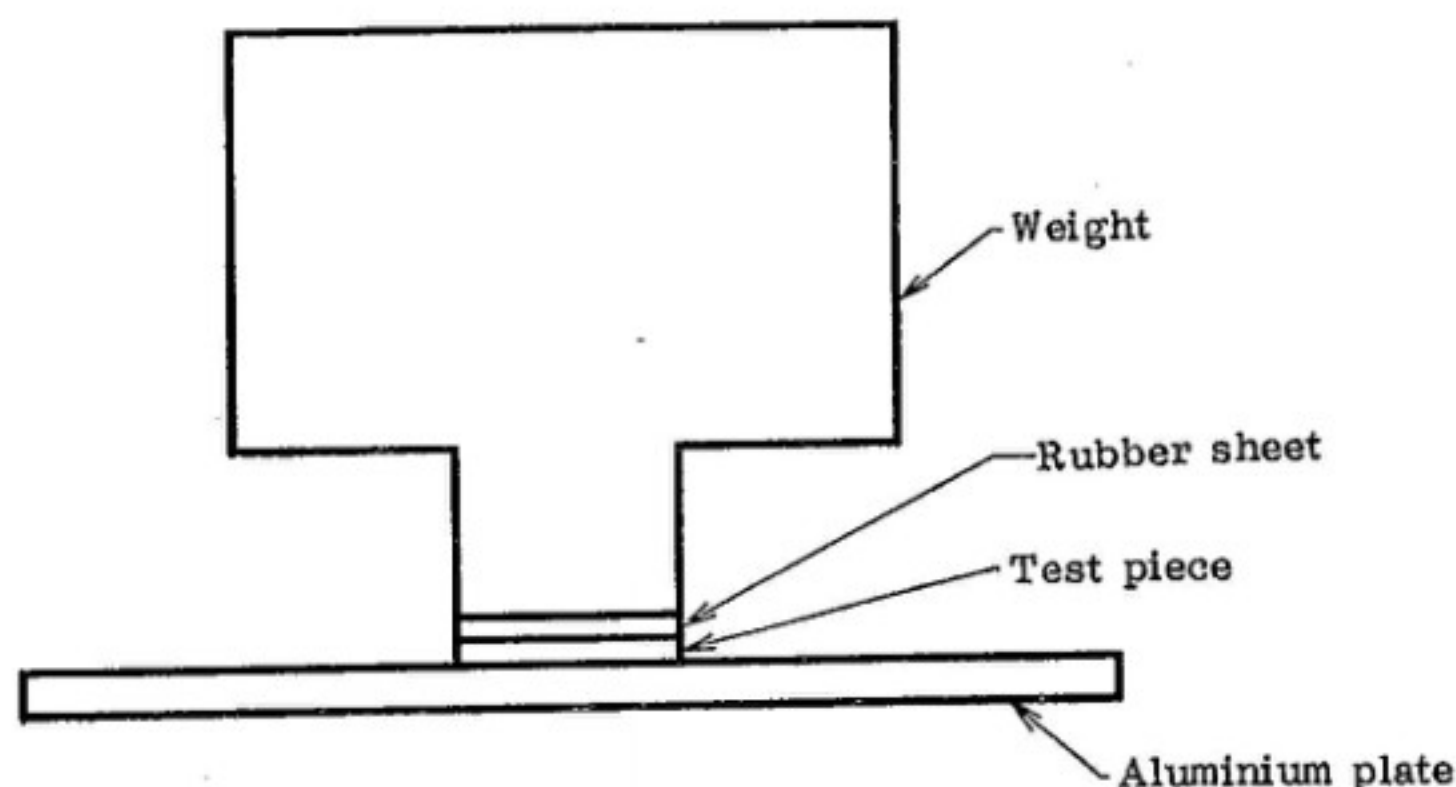
The number of test pieces tested shall be 3.

- (2) **For Hot Pressure Bonding Type Retroreflective Sheets** The two remaining test pieces prepared in 7.6 shall respectively be divided into two test pieces of 25 mm in width and 150 mm in length, and each test piece shall be temporarily bonded, with a length of 50 mm from the end of its adhesive surface left unstuck, on an aluminium plate treated preliminarily under the conditions of 7.1 (3). Then as shown in Fig. 3, a rubber sheet of 25 mm in width, 100 mm in length, and 1 to 3 mm in thickness shall be layed on the retroreflective sheet, and in addition, a weight weighing 175 g per cm<sup>2</sup> of the retroreflective sheet shall be placed on the rubber sheet. Then the weighted sheet shall be left standing for 30 min in a thermostatic bath at a temperature in the specified range of 85 to 100°C. In this case, it is desirable to preheat the weight.

In this test, the sticking of the test piece may also be performed by using a hot pressure bonding apparatus for retroreflective sheet. After withdrawing and letting cool the bonded test piece under the pretreatment conditions of 7.1 (4), a peeling test shall be performed according to the equivalent method to the pressure bonding type, and the peeling length after 5 min shall be measured.

The number of test pieces shall be 3.

Fig. 3





**7.8 Elongation and Tensile Strength Test** A piece A of 25 mm in width and 350 mm in length shall be fixed with gripping tools, leaving a length of 25 mm from each end free to make the gripping distance 300 mm, and the elongation and tensile strength shall be measured at a pulling speed of 300 mm/min.

The number of test pieces shall be 3.

**7.9 Strinkage Test** After measuring accurately the dimensions of 3 pieces A of 225 mm by 225 mm in size, the separate paper shall be peeled off, and each piece shall be left standing with the adhesive surface directed upward on a horizontal plane. Thus the shrinkage value shall be measured after 10 min and 24 h, respectively.

The number of test pieces shall be 3.

**7.10 Flexibility Test** A piece B of 70 mm in width and 280 mm in length, with its reflective surface facing upward, shall be wound around a round rod of 19 mm in diameter to about 180 degrees in one second, and examination shall be carried out on the existence of abnormalities on the reflective surface.

The number of test pieces shall be 3.

**7.11 Solvent Resistance Test** After immersing 5 pieces B of 25 mm in width and 150 mm in length in the solvents shown in Table 7 for the prescribed duration of time, they shall be withdrawn and dried at room temperature, and their solvent resistance shall be examined.

Table 7. Kinds of Solvents and Durations of Immersion

Kind of solvents	Duration of immersion (min)
Methanol as specified in JIS K 8891 Kerosene No. 2 as specified in JIS K 2203 Turpentine Oil as specified in JIS K 5908	10
The following solvents as specified in JIS K 2435 (1) Pure toluene No. 1 (2) 5-degree xylene No. 1	1

## 8. Inspection

Retroreflecting sheets shall be inspected with respect to the performance, construction, and material and the results shall comply with the specifications of 4. to 6.

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## 9. Marking

Retroreflective sheets shall be marked with the following items of information at a suitable location on each package.

In addition, their separate papers shall be marked with the manufacturer's name or its symbol.

(1) Designation of product

Example: Retroreflective sheet for safety (or tape)

(2) Grade, type, and colour

Example 1: Pressure bonding type Grade 1 red or R1-P red

Example 2: Hot pressure bonding type Grade 2 green or R2-H green

(3) Date of manufacture or its abbreviation

(4) Manufacturer's name or its symbol

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### Applicable Standards:

JIS B 7753-Light-and-Water-Exposure Apparatus (Open-Flame Sunshine Carbon-Arc Type)

JIS H 4000-Aluminium and Aluminium Alloy Sheets and Plates, Strips and Coiled Sheets

JIS K 2203-Kerosine

JIS K 2435-Benzenes (Benzene·Toluene·Xylene·Solvent-naphtha)

JIS K 5908-Turpentine Oils

JIS K 8891-Methanol

JIS M 7001-Mine Safety Sign

JIS R 6253-Waterproof Abrasive Papers

JIS Z 0237-Testing Methods of Pressure Sensitive Adhesive Tapes and Sheets

JIS Z 8105-Glossary of Colour Terms

JIS Z 8703-Standard Atmospheric Conditions for Testing

JIS Z 8721-Specification of Colours According to their Three Attributes

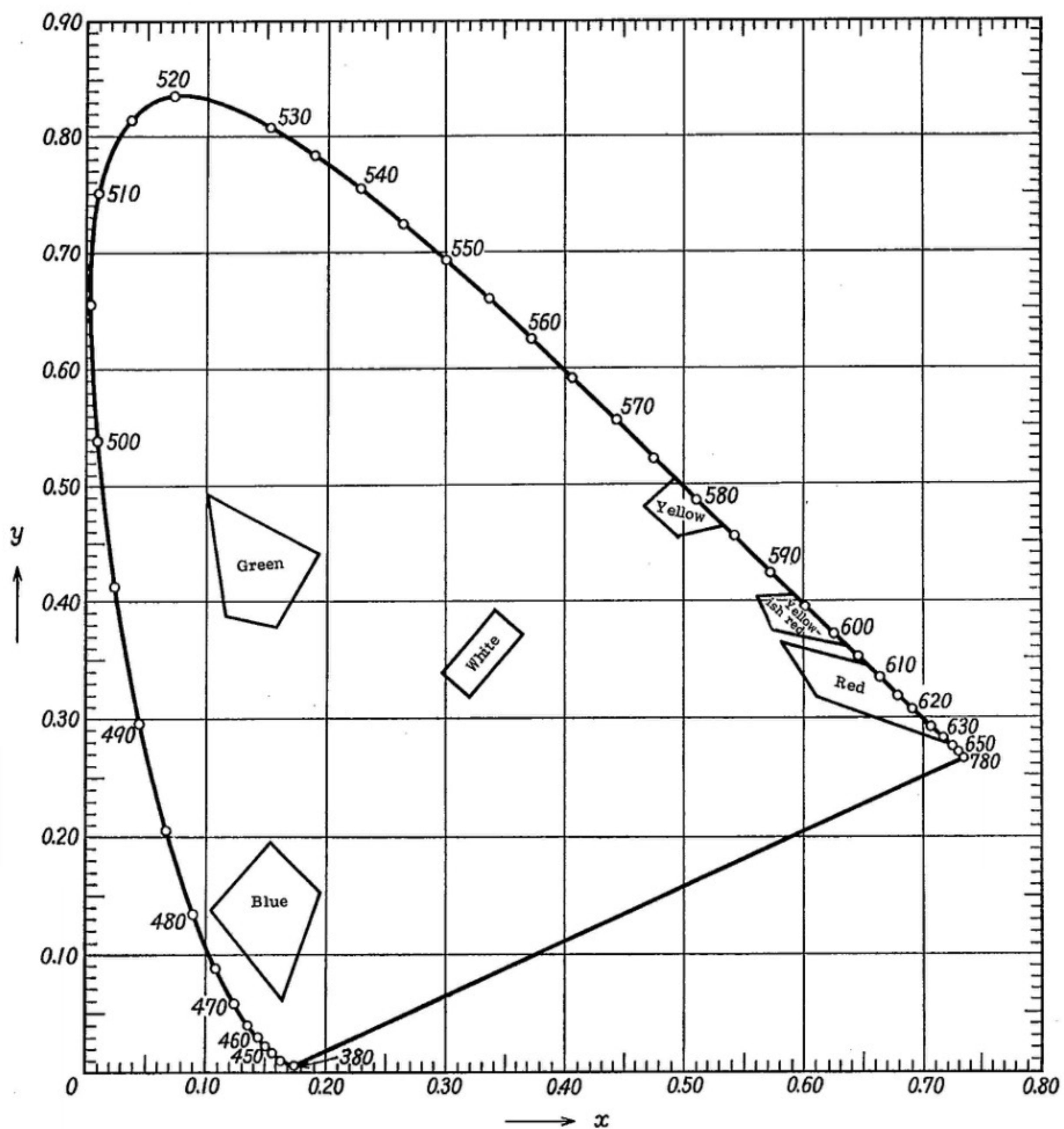
JIS Z 8722-Methods of Measurement for Colour of Reflecting or Transmitting Objects

JIS Z 8741-Method of Measurement for Specular Glossiness





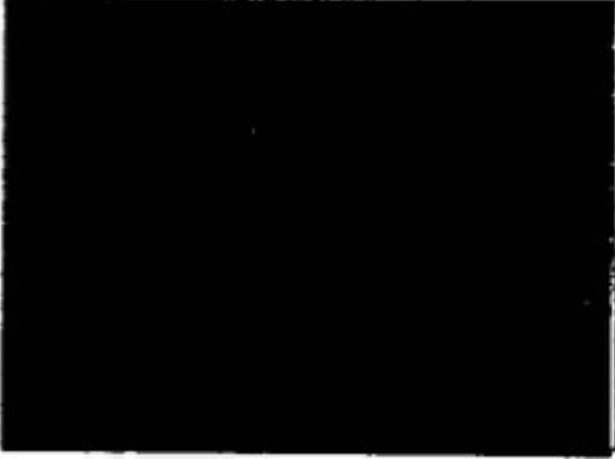

JIS Z 9105-Reflective Safety Signs



Attached Figure. Ranges of Chromaticity Coordinates



Reference: The reference colour samples shall be as follows:

Colour	Reference colour sample	Colour	Reference colour sample
White		Yellowish red	
Yellow		Green	
Red		Blue	



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