

JIS

JAPANESE INDUSTRIAL STANDARD

Testing Methods for Optical Properties of Plastics

JIS K 7105—1981

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Testing Methods for Optical Properties of Plastics K 7105-1981

1. Scope

This Japanese Industrial Standard specifies the testing methods for optical properties of plastic materials(1).

Note (1) Plastic materials herein mean plastic materials in filmy and platy forms and of formed products.
In the case of the yellowness testing method, plastic materials shall also include those in the form of powder, pellets, filament and liquid.

2. Definitions

The definitions of the main terms used in this standard shall be as specified in JIS K 6900, JIS Z 8105, JIS Z 8113 and JIS Z 8120 and shall also be as specified below:

- (1) light receiving angle The angle formed between the optical axis of the light receiving system and the normal line to the specimen surface.
- (2) specular glossiness The ratio of reflected light flux to incident light flux in specular reflection.
- (3) transfer standard white surface The transfer standard white surface shall be a surface prepared by forming a barium sulfate powder, in which the spectral reflectance factor has been graduated by calibration. The transfer standard white surface shall be used for calibration of working standard white surfaces.
- (4) working standard white surface A durable white surface of known spectral reflectance factor, which is normally used as a standard for comparison in the measurement of spectral reflectance factor.
- (5) glare-proofness The degree in which glare is prevented.
- (6) yellowness The degree in which the hue removes from colorless or white toward yellow, which is expressed as a positive quantity. Consequently, when this is obtained by calculation as a negative value, it means that the hue transfers to the direction of blue.
- (7) yellowing factor A factor used for evaluation of the degree of deterioration of plastic materials exposed to an environment such as light, heat and the like, which is expressed by the difference between the initial yellowness and that obtained after exposure.
- (8) retrogressive reflection The phenomenon in which light is reflected toward the direction of illumination.
- (9) image clarity The property of the surface of a coating which reproduces the image of an object facing the coating surface.
- (10) distinctness of image The degree of distinctness of an image which is transmitted or reflected.

Applicable Standards: See page 6.

3. Classification of Tests

The tests shall be classified as follows:

(1) General Optical Characteristics

- (a) Refractive index
- (b) Glossiness
- (c) Colour
- (d) Colour difference
- (e) Light transmittance and total light reflectance

(2) Special Optical Characteristics

- (a) Optical angular deviation
- (b) Glare-proofness
- (c) Yellowness and yellowing factor
- (d) Haze (cloudiness value)
- (e) Retrogressive reflection property
- (f) Distinctness of image
- (g) Fluorescent colour

4. General Requirements of Test

4.1 Preparation of Specimen and Test Piece The specimens shall be taken from a lot in which all parts can be regarded to have the same quality by a rational method in accordance with JIS Z 9031. Where the specimen taken is a filmy, platy or formed product, it shall be used as it stands as the test piece. Where the specimen taken is in the form of a powder, pellets, filament and liquid, it shall be prepared into a test piece in the form of a filmy, platy and formed product on agreement between the parties concerned. However, in yellowness and yellowing factor tests, the product may be used as it stands as specimen. The number of test pieces used shall be one or more unless otherwise specified.

4.2 Conditioning of Test Piece Test pieces shall be conditioned, before being tested, in a dark place at $23 \pm 2^{\circ}\text{C}$ and $50 \pm 5\%$ relative humidity for 48 hours or longer, as a rule. However, for those test pieces which exhibit reversible changes in hue due to light or heat, they shall be conditioned as specified on agreement between the parties concerned.

4.3 Standard Atmospheric Conditions of Testing Place The standard atmospheric conditions of the testing place shall be the conditions in a room at a temperature of $23 \pm 5^{\circ}\text{C}$ and relative humidity of $50 \pm 20\%$.

4.4 Pretreatment of Test Piece The test pieces shall preliminarily be freed from dust, stains and the like by using a clean, soft cloth and the like with care not to impair their surfaces.

4.5 Handling of Numerical Values of Test Results The test results shall be calculated by either of the methods (1) and (2) mentioned below.

Further, if required, the standard deviation shall be calculated according to method (3).

- (1) Where the Number of Test Pieces Are Specified Test results shall be calculated to the place lower by one place than the figures specified for each test item by averaging the measured values obtained from respective test pieces or the values obtained by calculation, and the average value shall be rounded to the number of figures specified in JIS Z 8401.
- (2) Where the Number of Test Pieces Is Not Specified The results shall be calculated to the place lower by one place than the figures specified for each item by averaging three measured values obtained by measuring at three positions of one test piece or three values obtained by calculation by using such measured values, and the average value shall be rounded to the number of figures specified in JIS Z 8401.
- (3) Where the standard deviation (assumed) is calculated, the value calculated by the following formula shall be rounded into two significant figures in accordance with JIS Z 8401.

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

where S: standard deviation (assumed)

x: each observed value

$\bar{x}$: average value for observed group

n: number of observations

5. Testing Methods for General Optical Characteristics

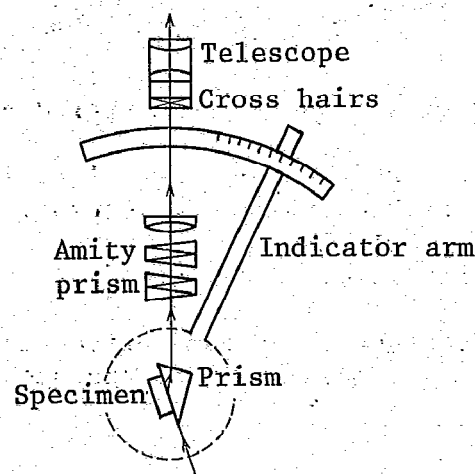
5.1 Refractive Index

5.1.1 Summary The refractive index shall be obtained as the ratio of the velocity of light in the vacuum (practically air) to the velocity of light in the transparent specimen and be expressed by the ratio of the sine of the angle of incidence to the sine of the angle of refraction.

5.1.2 Apparatus

- (1) Abbe Refractometer A refractometer having a measuring range for refractive index of 1.45 to 1.62 and a minimum graduation value of 0.001, capable of thermal insulation of the prism section. The principle of the refractometer is shown in Fig. 1.

Fig. 1. Abbe Refractometer



(2) Constant-Temperature Water Bath A water bath capable of adjusting the temperature to $23 \pm 0.5^\circ\text{C}$. It is preferable to use pure water for the circulating water.

(3) Light Source For the light source, natural light shall be used, as a rule, but, where it is not available, the light of an incandescent lamp having as little yellowness as possible may also be used.

Other light sources may also be used on agreement between the parties concerned.

5.1.3 Preparation of Apparatus The preparation of the apparatus shall be performed as follows:

(1) The refractometer shall be installed in a room capable of obtaining natural light⁽²⁾, a thermometer shall be installed at a specified position of the prism case, and circulating water shall be passed⁽³⁾ from the constant-temperature water bath to adjust the temperature so that the thermometer attached to the refractometer shows 23°C . The prism in the refractometer shall be maintained at this temperature during the test.

Notes (2) No direct sunlight shall be applied to the refractometer.

(3) Care shall be taken so that the circulating water does not leak out and wet the light incidence window or refracted light window of the refractometer. It is preferable, for this purpose, to draw the water by installing a circulation pump at the outlet of the prism case.

(2) After opening the prism case, both prism surfaces and then the surface of the prism-fixing metal shall be lightly wiped with soft sanitary cotton or the like wet with ethyl alcohol or water. This procedure shall be repeated until no running marks remain on the prism surface.

(3) When the refractometer is not in use, the whole apparatus shall be cleaned and preserved in a dry atmosphere with little temperature change. Particularly, the prism surface shall always be maintained in a condition with little moisture⁽⁴⁾, oil, dust or the like.

Note (4) Because the prism is made of heavy flint glass which has low resistance to moisture, the prism surfaces shall not be left wet for a long period.

5.1.4 Test Piece Test pieces shall be prepared as follows:

(1) The dimensions of the test piece shall be 10 mm × 20 mm and the thickness shall be the original thickness.

(2) The number of test pieces shall be 5.

(3) The surface to contact the prism surface and the light receiving surface of the test piece shall be thoroughly polished to smoothness.

5.1.5 Contact Fluid The contact fluid used shall have a refractive index higher than that of the test piece and shall not corrode the test piece. Generally, α -bromonaphthalene, saturated solution of mercury potassium iodide or the like is used.

5.1.6 Measuring Method Measurement shall be performed as follows:

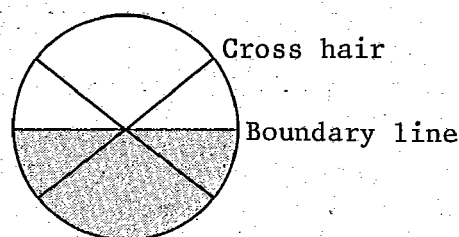
- (1) Clean all the polished surfaces of the test piece, let fall from a glass rod with a rounded end a drop⁽⁵⁾ of a suitable contact fluid onto the center of the test piece surface to be contacted with the prism of the refractometer, open the prism case, and gently push a polished surface of the test piece on the prism, with the surface directed toward the direction of incidence of light of the refractometer. Make the contact so that the fluid film spread all over and the test piece and the prism become perfectly parallel.

Note (5) The contact fluid shall thoroughly spread over the contact surface but shall not ooze out to the edge of the surface of light incidence.

- (2) After turning the eyepiece of the telescope and adjusting the focus to the cross hairs in the visual field as shown in Fig. 2, introduce light into the prism by moving the reflecting mirror, turn the prism to make the boundary line between the light and the dark almost fall on the intersecting point of the cross hairs in the visual field, and let the colour of the boundary line vanish by turning the adjusting knob toward either left or right. Here again, adjust the reflecting mirror to such a position that the colour change of the boundary line can be observed most easily. After equilibrizing the temperature for about 5 minutes, make the boundary line accurately agree with the intersecting point of the cross hairs and read the index of refraction to the four places of decimals.

Further, obtain the mean dispersion to the four places of decimals from the dispersion table appended to the refractometer.

Fig. 2. Prism Visual Field



5.1.7 Expression of Results The refractive index shall be expressed to three places of decimals.

Further, if required, the mean dispersion obtained from the dispersion table shall be attached.

5.2 Glossiness

5.2.1 Summary The light from the standard light source shall be applied to the specimen surface at a specified angle and the regular reflection component shall be measured by a light receptor.

5.2.2 Classification of Glossiness Glossiness shall be classified as follows. Provided that the 60-degree specular glossiness shall be adopted as a standard, but glossiness of the other angles may also be used on agreement between the parties concerned.

- (1) 60-degree specular glossiness
- (2) 45-degree specular glossiness
- (3) 20-degree specular glossiness

5.2.3 Standard Surface for Specular Glossiness As the standard surfaces for specular glossiness, the following standard surface, primary standard surface or secondary standard surface shall be used.

- (1) The standard surface shall be the surface of glass having a refractive index of 1.567, and the corresponding glossiness value shall be expressed as 100 (%).
- (2) The primary standard surface shall be a transparent or black glass surface of known refractive index.
- (3) The secondary standard surface shall be a lustrous plate having high, medium or low glossiness, which has been calibrated based on the primary standard surface.

5.2.4 Apparatus The principle of the glossiness measuring apparatus, hereinafter referred to as the "glossmeter", is shown in Fig. 3. The glossmeter shall have such a construction that, when a light flux of a specified divergence angle is applied to the specimen surface at a specified angle of incidence, the light flux of a specified divergence angle which is reflected just in the opposite direction can be measured by receptor. Further, the apparatus shall meet the requirements of Table 1, and the synthetic sensitivity of the light source, filter and receptor shall satisfy the value of Y of the Luther condition for the standard light C.

Applicable Standards:

- JIS C 7711 Designation Methods for Filament of Incandescent Tungsten Lamps
- JIS K 6900 Glossary of Terms used in Plastic Industry
- JIS Z 8105 Glossary of Colour Terms
- JIS Z 8113 Glossary of Lighting Terms
- JIS Z 8120 Glossary of Optical Terms
- JIS Z 8401 Rules for Rounding Off of Numerical Values
- JIS Z 8722 Methods of Measurement for Colour of Materials Based on the CIE 1931 Standard Colorimetric System
- JIS Z 8902 Xenon Standard White Light Source
- JIS Z 9031 Random Sampling Methods

Fig. 3. Principle of Glossmeter

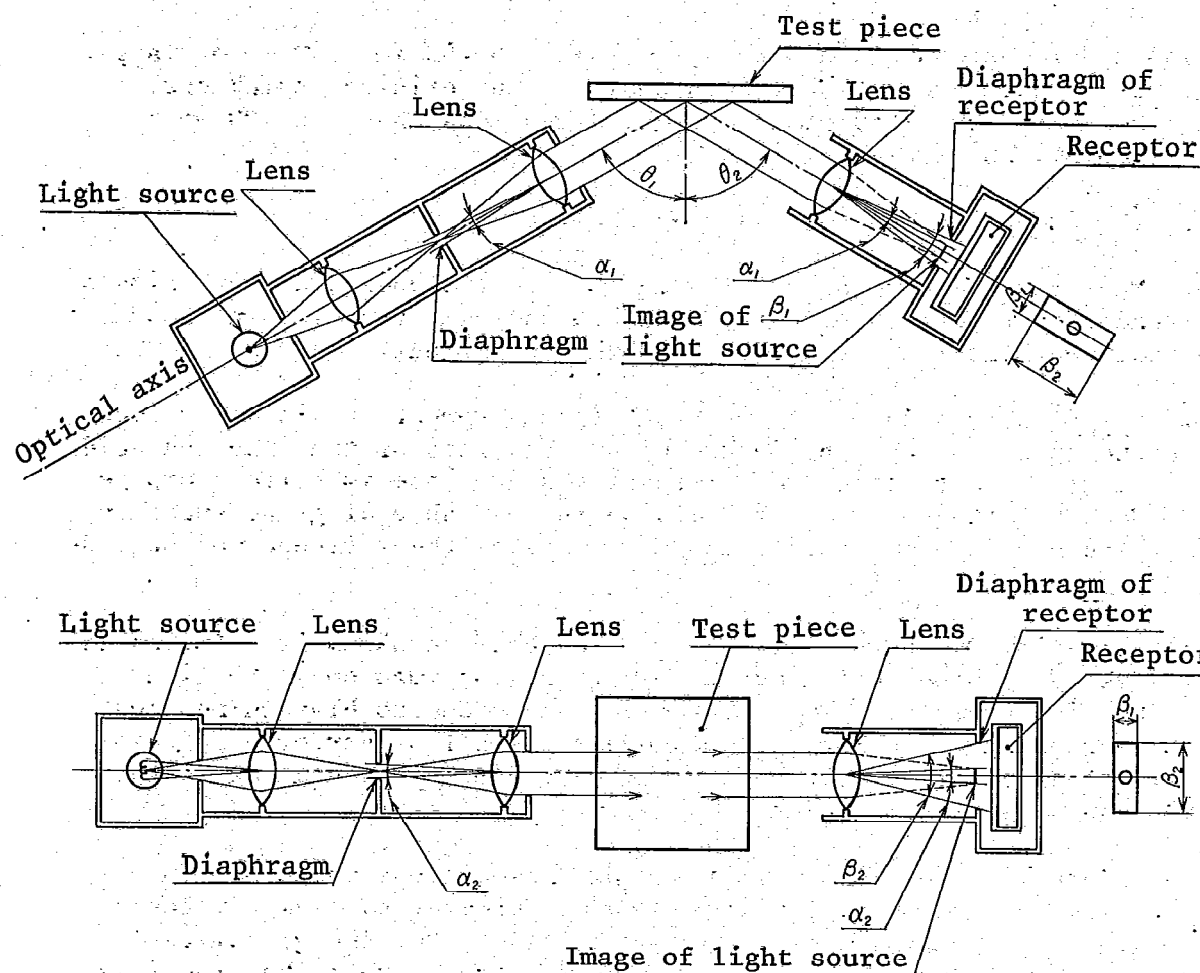


Table 1. Measuring Conditions

Kind of glossiness Measuring condition		60-degree specular glossiness	45-degree specular glossiness	20-degree specular glossiness
Angle of incidence (θ_1)		$60 \pm 0.1^\circ$	$45 \pm 0.1^\circ$	$20 \pm 0.1^\circ$
Light receiving angle (θ_2)		$60 \pm 0.1^\circ$	$45 \pm 0.1^\circ$	$20 \pm 0.1^\circ$
Divergence angle of light source	In plane of incidence (α_1)	$0.75 \pm 0.25^\circ$	$0.75 \pm 0.25^\circ$	$0.75 \pm 0.25^\circ$
	In normal plane (α_2)	$0.75 \pm 0.25^\circ$	$0.75 \pm 0.25^\circ$	$0.75 \pm 0.25^\circ$
Divergence angle of receptor	In plane of incidence (β_1)	$4.4 \pm 0.1^\circ$	$4.4 \pm 0.1^\circ$	$1.8 \pm 0.05^\circ$
	In normal plane (β_2)	$11.7 \pm 0.2^\circ$	$11.7 \pm 0.2^\circ$	$3.6 \pm 0.1^\circ$

5.2.5 Test Piece The test piece shall be as follows:

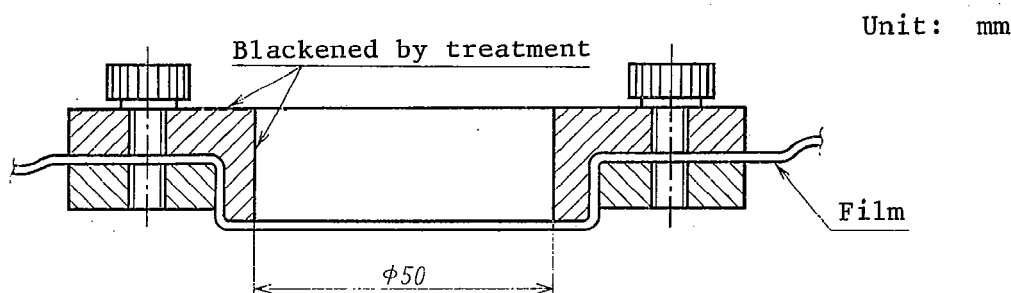
- (1) The dimensions of the test piece shall be 50 mm × 50 mm or larger as a rule, and the thickness shall be the original thickness. However, for filmy products, the dimensions shall be 100 mm × 100 mm, as a rule.
- (2) The number of test pieces used shall be 3.

5.2.6 Measuring Method After the glossmeter is standardized by using a primary standard surface or secondary standard surface, the glossiness of the specimen shall be measured under the following conditions:

- (1) For Platy Products In the case of measurement of platy specimens, the specimen shall be backed with black felt or the like and held firmly by a specimen holder to prevent the specimen from warpage. Measurement shall be performed by further shielding the specimen with a suitable camera obscura to prevent the influence of outside light.
- (2) For Filmy Products For measuring a specimen which is filmy or is likely to bend during measurement, the specimen shall be fixed by, for example, a specimen holder subjected to blackening treatment as shown in Fig. 4. Measurement shall be performed after further shielding the specimen with a camera obscura, as in the case of a platy specimen.

Remark: Where a specimen having a glossiness value of 100 or higher is subjected to measurement by a glossmeter having a maximum graduation of 100, the glossmeter shall be preliminarily adjusted so that the glossiness value of the primary standard surface is $\frac{1}{2}$, and two times the value obtained by measurement of the specimen shall be taken as the glossiness value of the specimen.

Fig. 4. Specimen Holder (Example)



5.2.7 Expression of Results The glossiness shall be expressed, as shown in the following Example, by appending the angle of glossiness in parentheses after the symbol of glossiness G_s and expressing the glossiness value in integer.

In this case, the symbol % may be omitted.

Example: $G_s(60^\circ)=76\%$

5.3 Colour

5.3.1 Summary The characteristics of visible radiation or the aspects of visual perception, according to which the differences in the properties of the colour are recognized depending on the differences in the spectral energy distribution of light, shall be indicated by the tristimulus values and chromaticity coordinates or the hue, lightness and saturation.

5.3.2 Classification of Colour Measuring Methods The measuring methods for colour shall be classified as follows:

- (1) Spectrocolorimetric method
- (2) Stimulus value direct reading method

5.3.3 Apparatus The following spectrophotometer or photoelectric colorimeter shall be used as the measuring apparatus:

- (1) The spectrophotometer used for measurement in the case of the spectrocolorimetric method shall be as specified in 4.2 of JIS Z 8722.
- (2) The photoelectric colorimeter used for measurement in the case of the stimulus value direct reading method shall be as specified in 5.2 of JIS Z 8722.

5.3.4 Test Piece The size of the test piece shall be larger than the size of the test piece fitting window of the measuring apparatus, and the width shall be the original thickness. However, where the specimen is thick and translucent and the loss of light by dispersion by the scattering of light in the direction of thickness is large, a white paint shall be applied on the side surfaces of the test piece.

5.3.5 Measuring Method Measurement shall be performed in accordance with the following:

- (1) The conditions of measurement shall be as follows:
 - (a) In the Case of Reflection Measurement For backing of the test piece, as a rule, black felt or a light trap shall be used. In this case, where the specimen is translucent, an integrating sphere type photometer shall be used.
In the case where the specimen is transparent or translucent, a working standard white surface or, on agreement between the parties concerned, a white enamelled plate or the like may be used. In this case, however, it is desirable to append the tristimulus values of the white plate used.

Remark: In the case where an integrating sphere type photometer is used, measurement shall be performed in accordance with 5.5.3, as appropriate.

- (b) In the Case of Transmission Measurement In the case of transmission measurement, measurement shall be performed in accordance with 4.4 of JIS Z 8722.