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Plastics — Determination of haze for transparent materials

Plastiques — Détermination du trouble des matériaux transparents

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 14782 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

Plastics — Determination of haze for transparent materials

1 Scope

This International Standard specifies a method for the measurement of haze, an optical property resulting from wide-angle scattering of light, in transparent and substantially colourless plastics. This method is applicable to the measurement of haze values of less than 40 %.

NOTE The haze of abraded or matted transparent plastics can be measured, but the value obtained may be erroneously lower than the true value due to light scattering within a narrow angle.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*.

ISO 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*.

ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*.

ISO 5725-3:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 3: Intermediate measures of the precision of a standard measurement method*.

ISO 7724-2:—[1)], *Paints and varnishes — Colorimetry — Part 2: Colour measurement.*

ISO/CIE 10526:1999, *CIE standard illuminants for colorimetry*.

ISO/CIE 10527:1991, *CIE standard colorimetric observers*.

ISO 13468-1:1996, *Plastics — Determination of the total luminous transmittance of transparent materials — Part 1: Single-beam instrument.*

IEC 60050-845:1987, *International Electrotechnical Vocabulary — Chapter 845: Lighting.*

1) To be published. (Revision of ISO 7724-2:1984)

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 13468-1 and the following term and definition apply.

3.1
haze
percentage of transmitted light, passing through a specimen, which deviates from the incident light by no more than 0,044 rad (2,5°) by forward scattering

4 Principle

Haze is determined using an integrating sphere the efficiency of which is held constant by compensation.

5 Apparatus

5.1 The apparatus shall consist of a stabilized light source, an associated optical system, an integrating sphere with ports, and a photometer comprising a photodetector, signal processor and display unit or recorder (see Figure 1).

5.2 The light source and the photometer shall be used in conjunction with a filter to provide an output corresponding to the photopic standard luminous efficiency $V(\lambda)$ (as defined in IEC 60050-845), which is identical to the colour-matching function $\bar{y}(\lambda)$ specified in ISO/CIE 10527 under CIE standard illuminant D_{65} as specified in ISO/CIE 10526. The output of the photodetector shall be proportional to the incident flux, to within 1 % of the incident flux, over the range used.

The spectral and photometric characteristics of the light source and photometer shall be kept constant during measurements.

5.3 The light source and its associated optical system shall produce a parallel light beam, no ray of which makes an angle of more than 0,05 rad (3°) with the beam axis. This beam shall not be vignetted at either port of the integrating sphere.

5.4 The design of the instrument shall be such that the reading is zero in the absence of the light beam.

5.5 The integrating sphere used to collect the transmitted light may be of any diameter (but preferably no less than 150 mm in order to be able to accommodate large specimens), as long as the total port area does not exceed 3,0 % of the internal reflecting area of the sphere.

5.6 The integrating sphere shall have an entrance port, an exit port, a compensation port and a photodetector port (see Figure 1). The entrance and exit ports shall be centred on the same great circle of the sphere, and there shall be an angle of (3,14 ± 0,03) rad (180° ± 2°) between the centres of the ports. The exit port shall subtend an angle of (0,140 ± 0,002) rad (8° ± 0,1°) at the centre of the entrance port. The exit and compensation ports shall have the same size. The entrance and compensation ports and the photodetector shall not lie on the same great circle of the sphere. The compensation port shall be positioned at an angle of less than 1,57 rad (90°) from the entrance port.

NOTE The compensation port is used to compensate for changes in the efficiency of the integrating sphere, which depends on the area of the inner surface, the number of ports and the way they are covered.

5.7 When the beam is unobstructed by a specimen, its cross-section at the exit port shall be approximately circular, sharply defined and concentric with the exit port, leaving round it an annulus which subtends an angle of (0,023 ± 0,002) rad (1,3° ± 0,1°) at the centre of the entrance port.

NOTE 1 It is important to verify whether the unobstructed-beam diameter and centering at the exit port are maintained, especially if the source aperture and focus are changed.

NOTE 2 The tolerance of ± 0,002 rad (± 0,1°) stated for the angle subtended by the annulus corresponds to an uncertainty of ± 0,6 % in a haze reading. This is relevant to the assessment of the precision of this test method.

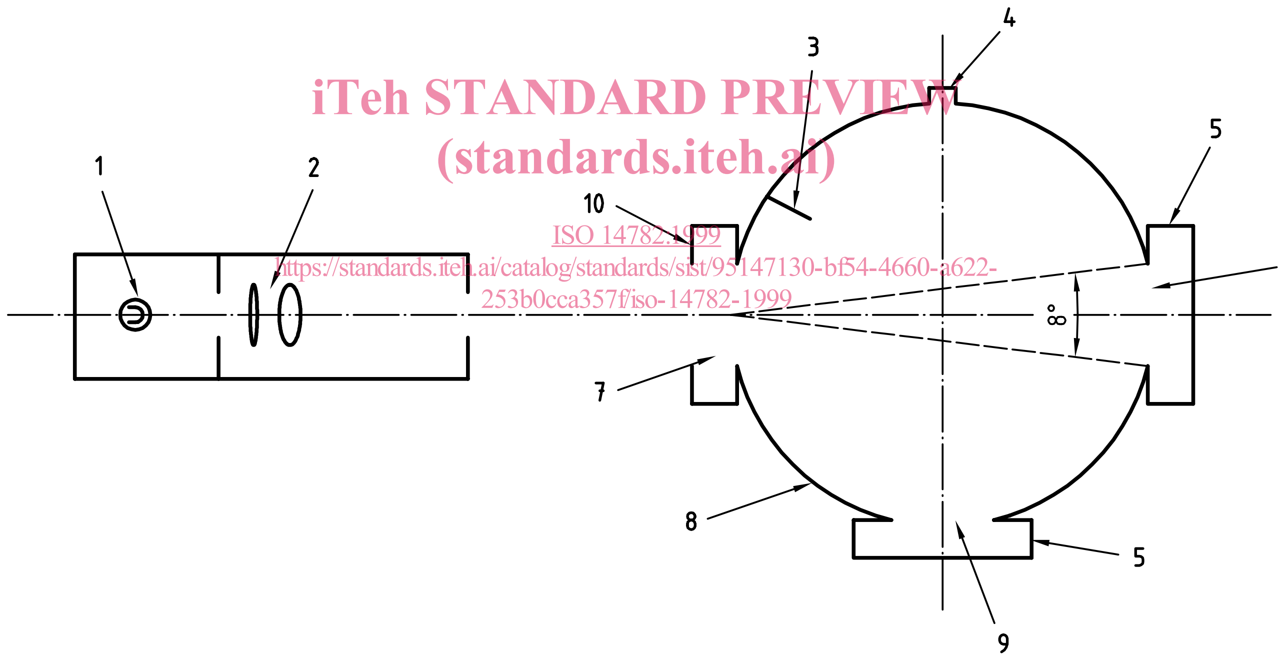
5.8 The position of the photodetector on the integrating sphere shall be at an angle of (1,57 ± 0,26) rad (90° ± 15°) to the entrance port. The photodetector shall be fitted with baffles to prevent light from the specimen falling directly on it.

Light traps shall be provided for the exit and compensation ports to absorb the beam completely when no specimen is present, or the instrument design shall obviate the need for light traps for the exit and compensation ports.

5.9 The tristimulus value Y_{10}, measured in accordance with ISO 7724-2, of the surfaces of the interior of the integrating sphere, the baffles and the white reference (a working reference normally provided by the instrument manufacturer) shall be 90 % or more and shall not vary by more than ± 3 %. When direct measurement of the reflectance of the inner surface of the integrating sphere is difficult, the measurement may be made on a surface prepared from the same material in the same condition as the inner surface.

5.10 The specimen holder shall be designed to hold the specimen rigidly in a plane perpendicular, to within ± 2°, to the light beam and as close as possible to the integrating sphere in order to ensure that all the light passing through the specimen, including scattered light, is collected. The holder shall also be designed so that flexible specimens such as film are kept flat.

It is recommended that thin, flexible film be held round the edge in a double-ring clamp or stuck to the holder by means of double-sided adhesive tape. Double-sided adhesive tape can also be used for thicker specimens which will not fit in the double-ring clamp. The use of a vacuum pump and a vacuum plate to mount the specimen on the holder is also recommended.



Key

1 Lamp	4 Photodetector	7 Entrance port	10 Specimen holder
2 Lens	5 Light trap	8 Integrating sphere	
3 Baffle	6 Exit port	9 Compensation port	

Figure 1 — Schematic arrangement of the apparatus

6 Specimens

6.1 Cut specimens from films, sheets or injection- or compression-moulded articles.

6.2 Specimens shall be free of dust, grease, adhesive from protective materials, scratches, blemishes and other defects, including visibly discernible internal voids and foreign bodies.

6.3 Specimens shall be sufficiently large to cover either the entrance port or, if required, the compensation port of the integrating sphere. A disc of 50 mm diameter or a square with a side of the same length is suggested.

6.4 Unless otherwise specified, prepare three specimens of each sample of a given material.

7 Conditioning

7.1 When conditioning is required, condition the specimens in accordance with ISO 291 at (23 ± 2) °C and (50 ± 10) % relative humidity for no less than 40 h prior to the test.

7.2 When conditioning is required, place the test apparatus in an atmosphere maintained at (23 ± 2) °C and (50 ± 10) % relative humidity.

8 Procedure

8.1 Allow the apparatus sufficient time to reach thermal equilibrium before the measurements are made.

8.2 Mount a specimen in the specimen holder.

8.3 Make the four measurements given in Table 1.

8.4 Measure the thickness of the specimen in three places to an accuracy of 0,02 mm for sheets and 1 µm for films.

8.5 Carry out the procedure on each of the three specimens in turn.

Table 1 — Measurements

	Entrance port	Exit port	Compensation port
τ_1		White reference	Light trap[a]
τ_2	Specimen	White reference	Light trap
τ_3		Light trap	White reference
τ_4	Specimen	Light trap	White reference

[a] See note to clause 9.

9 Expression of results

Calculate the haze, in percent, using the following equation:

$$\text{haze} = \left(\frac{\tau_4}{\tau_2} - \tau_3 \times \frac{\tau_2}{\tau_1} \right) \times 100$$

where

τ_1 is the intensity of the incident light;

τ_2 is the intensity of all the light transmitted by the specimen;

τ_3 is the intensity of the light scattered by the instrument;

τ_4 is the intensity of the light scattered by the instrument and the specimen.

NOTE Haze can also be calculated as the ratio of the diffuse transmittance τ_d to the total luminous transmittance τ_t. To obtain an accurate value of the total luminous transmittance, however, it is necessary, when using a single-beam instrument as in this International Standard, to place a specimen over the compensation port when measuring τ_1 (as specified in ISO 13468-1), in order to compensate for the change in efficiency. Alternatively, an accurate value of the luminous transmittance can be obtained by using a calibrated reference standard to correct the value measured. However, in practice it is sufficient to use the value of τ_1 obtained by placing a light trap over the compensation port instead of a specimen since this makes little difference to the haze value obtained.

An accurate value of the diffuse transmittance τ_d can be obtained from the equation $\tau_d = [\tau_4 - \tau_3(\tau_2/\tau_1)]/\tau_1$, using the accurate value of τ_1 obtained above.

10 Precision

An inter-laboratory trial was conducted to determine the precision of the method. The haze of eight samples was measured by seven laboratories. The data were analysed in 1994 in accordance with ISO 5725-1, ISO 5725-2 and ISO 5725-3.

The test results are given in Table 2.

One outlier was detected using Grubb's test and was excluded.

Table 2 — Inter-laboratory trial data

Values in percent

Test sample	Haze	Within-laboratory reproducibility[a] standard deviation s_{Rw}	Reproducibility[b] standard deviation s_R	Outlier
PMMA	0,30	0,028	0,051	0
PMMA-HI (1)	0,40	0,027	0,078	0
PMMA-HI (2)	0,95	0,032	0,050	0
ABS, transparent (1)	2,88	0,17	0,30	0
ABS, transparent (2)	11,7	0,68	1,25	0
PMMA, matted	31,0	0,19	1,50	0
PE	38,2	0,68	1,14	1
PET/PE	41,8	1,52	2,02	0

[a] The within-laboratory reproducibility is the precision when the test results are obtained with the same method on identical material in the same laboratory, but the operator, the equipment and/or the time of measurement are different.

[b] The reproducibility is the precision when the test results are obtained with the same method on identical test material in different laboratories with different operators using different equipment and expressed as a reproducibility standard deviation.

It can be seen from Table 2 that, when the haze value is less than 1 %, precision is limited by the detector sensitivity. However, haze values of up to 40 % can be measured with reasonable precision using this test method.

NOTE A preliminary inter-laboratory trial was also conducted to compare the difference in values between instruments with a compensation port and those without a compensation port. Twelve specimens having haze values ranging from 0,2 % to 35,3 % were used in this trial, involving eight laboratories. The haze values obtained with the instruments with no compensation port were, on average, 8,9 % lower than those obtained with the instruments with a compensation port. The within-laboratory coefficient of variation, i.e. the within-laboratory reproducibility standard deviation divided by the haze value, was nearly the same for all of the samples tested. However, the reproducibility coefficient of variation, i.e. the reproducibility standard deviation divided by the haze value, for the instruments without a compensation port was, on average, 2,2 times higher than for those with a compensation port. The average coefficient of variation was 9,3 % for the instruments with a compensation port and 13,6 % for those without a compensation port. These results show that the compensation port reduces efficiency differences among instruments. In the inter-laboratory trial proper (the results of which are shown in Table 2), the variation was lower because sample preparation was improved to ensure greater specimen uniformity.