INTERNATIONAL STANDARD

ISO 13468-2

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Plastics — Determination of the total luminous transmittance of transparent materials —

Part 2:
Double-beam instrument

Plastiques — Détermination du facteur de transmission du flux lumineux total des matériaux transparents —

Partie 2: Instrument à double faisceau

Reference number
ISO 13468-2:1999(E)

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 13468-2 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties*.

ISO 13468 consists of the following parts, under the general title *Plastics — Determination of the total luminous transmittance of transparent materials*:

— *Part 1: Single-beam instrument*

— *Part 2: Double-beam instrument*

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Plastics — Determination of the total luminous transmittance of transparent materials —

Part 2:
Double-beam instrument

1 Scope

This part of ISO 13468 covers the determination of the total luminous transmittance, in the visible region of the spectrum, of planar transparent and substantially colourless plastics, using a double-beam scanning spectrophotometer. This part of ISO 13468 cannot be used for plastics which contain fluorescent materials.

This part of ISO 13468 is applicable to transparent moulding materials, films and sheets not exceeding 10 mm in thickness.

NOTE 1 Total luminous transmittance can also be determined by a single-beam instrument as in part 1 of this International Standard.

NOTE 2 Substantially colourless plastics include those which are faintly tinted.

NOTE 3 Specimens more than 10 mm thick may be measured provided the instrument can accommodate them, but the results may not be comparable with those obtained using specimens less than 10 mm thick.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13468. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13468 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/CIE 10526:1999, *CIE standard illuminants for colorimetry.*

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

CIE Publication No. 15.2:1986, *Colorimetry.*

CIE Publication No. 17.4:1987, *International lighting vocabulary* [also published as IEC 50(845):1987, *International electrotechnical vocabulary — Chapter 845: Lighting*].

3 Terms and definitions

For the purposes of this part of ISO 13468, the terms and definitions given in CIE Publication No. 17.4 for "transparent medium", "transmittance", "regular transmittance", "radiant flux" and "luminous flux" apply, together with the following:

3.1
transparent plastics
plastics in which the transmission of light is essentially regular and which have a high transmittance in the visible region of the spectrum

NOTE Provided their geometrical shape is suitable, objects will be seen distinctly through plastic which is transparent in the visible region.

3.2
total spectral transmittance
the ratio of the transmitted radiant flux (regular and diffuse) to the incident radiant flux when a parallel beam of monochromatic radiation of a given wavelength passes through a specimen

3.3
total luminous transmittance
the ratio of the transmitted luminous flux to the incident luminous flux when a parallel beam of light passes through a specimen

4 Apparatus

4.1 The apparatus shall consist of the following elements:

— a stabilized light source;

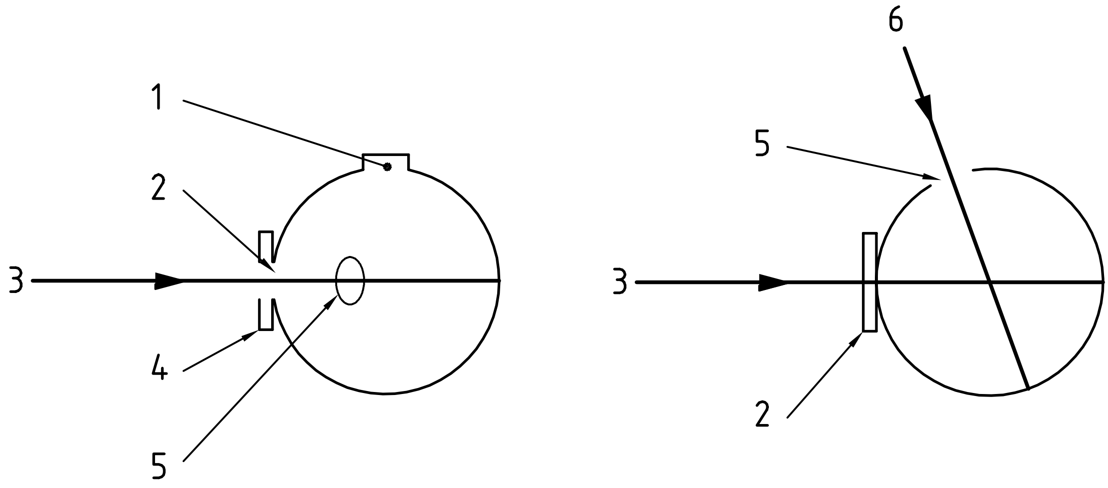
— a monochromator;

— an optical system that forms two parallel beams of monochromatic radiation of equal wavelength λ and approximately equal radiant flux from the output of the monochromator (called the sample and the reference beam);

— and an integrating sphere fitted with ports and a photodetector.

The sample beam enters the sphere through the entrance port. The reference beam enters the sphere through the reference port. The photodetector is mounted on the photodetector port in a manner that allows it to view with equal efficiency all parts of the sphere. Ingress of external light into the integrating sphere shall be prevented. A schematic arrangement of the integrating sphere is shown in Figure 1.

4.2 The value of the total luminous transmittance determined by the instrument shall be accurate to ± 1,0 %. To fulfill this requirement, the response of the photodetector must be sufficiently linear in the visible region of the spectrum and the spectral bandwidth at half power of the monochromator must be sufficiently small. The measurement conditions shall be such that the specimen temperature does not increase while measurements are made.



Key

1 Photodetector
2 Entrance port
3 Sample beam
4 Specimen holder
5 Reference port
6 Reference beam

a) Side view **b) Top view**

Figure 1 — Schematic arrangement of the integrating sphere (baffles not shown)

4.3 The optical system shall produce two parallel beams; the angle which any ray of either of these beams makes with the axis of the beam shall not exceed 0,087 rad (5°). The beams shall not be vignetted at either port of the sphere.

The diameter of each beam shall be 0,5 to 0,8 times the diameter of its respective port.

4.4 Using this instrument, the repeatability standard deviation shall be 0,2 % or less. The within-laboratory reproducibility over long time intervals shall not exceed the repeatability by a factor of more than 3.

4.5 The design of the instrument shall be such that the total spectral transmittance is zero when the radiant flux incident on the specimen is zero.

4.6 The integrating sphere may be of any diameter as long as the total port area does not exceed 3,0 % of the internal area of the sphere.

NOTE 1 It is recommended that the diameter of the integrating sphere is not less than 150 mm so that specimens of a reasonable size can be used.

NOTE 2 When the diameter of the integrating sphere is 150 mm and the diameters of the entrance, reference and photodetector ports are 30 mm, the ratio of the total port area to the internal area of the sphere is 3,0 %.

4.7 The entrance and reference ports of the integrating sphere shall be circular and of the same size (see the note below). The angle between the straight line defined by the centre of the entrance port and the centre of the sphere and the straight line defined by the centre of the reference port and the centre of the sphere shall be less than or equal to 90°. The angle between each of these straight lines and the straight line defined by the centre of the photodetector port and the centre of the sphere shall be 90°.

NOTE The entrance and reference ports may have other shapes provided they give the same total luminous transmittance values.

4.8 The photodetector shall be fitted with baffles to prevent light falling on it directly from the specimen. It shall also be shielded from light reflected from the internal surface of the sphere.

4.9 The surfaces of the interior of the integrating sphere and the baffles shall be of substantially equal luminous reflectance which, determined in accordance to ISO 7724-2, shall be 90 % or more and shall not vary by more than ± 3 %. When direct measurement of the reflectance of the internal surface of an integrating sphere is difficult, the measurement may be carried out instead on a surface prepared from the same material in the same way as the internal surface.

4.10 The apparatus shall be contained in a light-tight box. No radiant flux other than the sample and reference beams may enter the sphere.

4.11 The specimen holder shall be such as to hold the specimen rigidly in a plane normal ± 2° to the sample beam and as close as possible to the entrance port of the integrating sphere to ensure that all light which passes through the specimen, including scattered light, is collected.

The holder shall be designed so that it keeps flexible specimens, such as film, flat.

NOTE It is recommended that thin, flexible film is clamped round the edge in a double-ring-type holder or double-sided adhesive tape is used to stick it to the edge of the holder. The latter method is used for thicker specimens, which cannot be mounted in the double-ring-type holder.

4.12 Errors caused by inter-reflections between the optics and the sample shall be minimized by tilting sensitive components or by applying an anti-reflection coating to them.

4.13 The apparatus shall allow the wavelength λ to be varied over the range 380 nm $\leqslant \lambda \leqslant$ 780 nm in intervals of 5 nm.

NOTE In most cases, a bandwidth of 5 nm will be sufficiently small to fulfill the requirements of subclause 4.2.

4.14 By blocking each of the beams in turn, the radiant flux of each beam can be made equal to zero. The apparatus includes provision for recording the ratio

$$\xi(\lambda) = I_{\text{sam}}(\lambda)/I_{\text{ref}}(\lambda)$$

of two photodetector signals $I_{\text{sam}}(\lambda)$ and $I_{\text{ref}}(\lambda)$ as a function of wavelength λ. $I_{\text{sam}}(\lambda)$ is measured with the reference beam blocked, $I_{\text{ref}}(\lambda)$ with the sample beam blocked.

5 Test specimens

5.1 Specimens shall be cut from film, sheet or injection-moulded or compression-moulded mouldings.

5.2 Specimens shall be free of defects, dust, grease, adhesive from protecting materials, scratches and blemishes, and shall be free from visibly distinct internal voids and particles.

5.3 Specimens shall be large enough to cover the entrance port of the integrating sphere.

NOTE 1 For a 150 mm diameter sphere, a disc of 50 mm or 60 mm in diameter or a square with a side of the same length is recommended.

NOTE 2 Concerning specimen thickness, see note 3 to clause 1.

5.4 Three specimens shall be taken from each sample of a given material unless otherwise specified.

6 Conditioning

6.1 Prior to the test, condition the specimens in accordance with ISO 291, at 23 °C ± 2 °C and (50 ± 5) % relative humidity, for a length of time dependent on the specimen thickness and material such that the specimens reach thermal equlibrium.

NOTE 16 h is usually sufficient for specimens less than 0,025 mm thick. For thicker material, more than 40 h is recommended.

6.2 Set up the test apparatus in an atmosphere maintained at 23 °C ± 2 °C and (50 ± 5) % relative humidity.

7 Procedure

7.1 Allow the apparatus sufficient time to reach thermal equilibrium before making any measurements.

7.2 Make the two readings described in Table 1. The specimen shall be mounted directly over the entrance port of the integrating sphere.

Table 1 — Measurements

Reading	**Specimen over**	
	entrance port	**reference port**
$\xi_1(\lambda)$	No	No
$\xi_2(\lambda)$	Yes	No

Repeat the measurements of $\xi_1(\lambda)$ and $\xi_2(\lambda)$ at intervals of 5 nm to give a total of 81 spectral $\xi_1(\lambda)$-values and 81 spectral $\xi_2(\lambda)$-values at λ = 380 nm, 385 nm, 390 nm, ..., 775 nm, 780 nm.

Concerning the use of abridged or truncated data, CIE Publication No. 15.2:1986 applies.

7.3 Repeat the readings $\xi_1(\lambda)$ and $\xi_2(\lambda)$ with the specimen in positions selected to determine uniformity.

7.4 Measure the thickness of the specimen in three places to an accuracy of 0,02 mm for sheet and 1 µm for film.

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

8 Expression of results

Calculate the total spectral transmittance, $\tau_t(\lambda)$, in percent, using the following equation:

$$\tau_t(\lambda) = \frac{\xi_2(\lambda)}{\xi_1(\lambda)} \times 100$$

Calculate the total luminous transmittance for CIE standard illuminant D_{65}, using the following equation with λ = 380 nm, 385 nm, 390 nm, ..., 775 nm, 780 nm:

$$\tau_t = \frac{\sum_{\lambda = 380\,\text{nm}}^{780\,\text{nm}} S(\lambda) \times \tau_t(\lambda) \times V(\lambda)}{\sum_{\lambda = 380\,\text{nm}}^{780\,\text{nm}} S(\lambda) \times V(\lambda)}$$

where

$S(\lambda)$ is the relative spectral power distribution of CIE standard illuminant D_{65} as given in Table 1 in ISO/CIE 10526:1999;

$V(\lambda)$ represents the spectral luminous efficiency and is identical to the colour-matching function $\bar{y}(\lambda)$ as given in Table 1 in ISO/CIE 10527:1991.

9 Precision

The precision of this test method is not known because inter-laboratory data are not available yet. As soon as inter-laboratory data are obtained, a precision statement in accordance with ISO 5725-1, 2 and 3 will be added at the next revision.

10 Test report

The test report shall include the following:

a) all details necessary for identification of the test specimens and the source of the specimens;

b) the thickness of the specimens (the average of the three measurements);

c) the total luminous transmittance τ_t for CIE standard illuminant D_{65} (the average of the three calculated results to the nearest 0,1 %).

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