INTERNATIONAL STANDARD

ISO 13468-2

Second edition
2021-06

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 13468-2:2021(E)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 5, *Physical-chemical properties,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 13468-2:1999), of which it constitutes a minor revision.

The changes compared to the previous edition are as follows:

— the normative references have been updated.

A list of all parts in the ISO 13468 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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

Part 2: Double-beam instrument

1 Scope

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

This document 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 ISO 13468-1.

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

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

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

CIE Publication No 15, *Colorimetry*

CIE Publication No [1] 17, *International lighting vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE Publication No. 17 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

1) Also published as IEC 60050-845, *International Electrotechnical Vocabulary (IEV) International electrotechnical vocabulary — Chapter 845: Lighting*.

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

Note 1 to entry: 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
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
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;

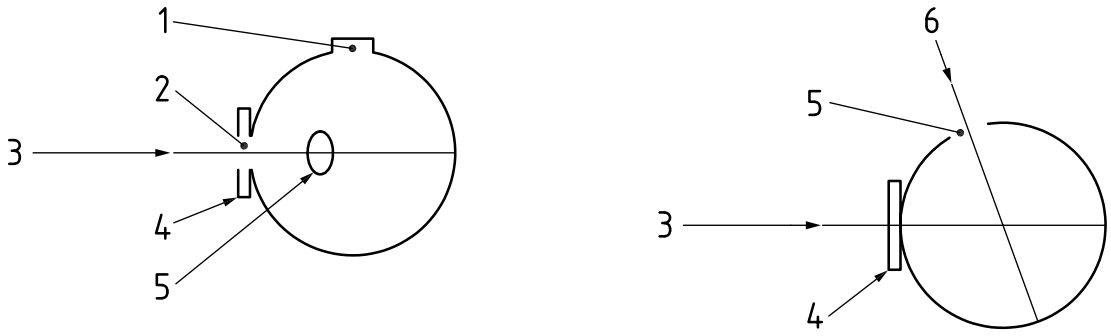
— a monochromator;

— 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 fulfil this requirement, the response of the photodetector shall be sufficiently linear in the visible region of the spectrum and the spectral bandwidth at half power of the monochromator shall be sufficiently small. The measurement conditions shall be such that the specimen temperature does not increase while measurements are made.



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

Key

1	photodetector	4	specimen holder
2	entrance port	5	reference port
3	sample beam	6	reference beam

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 times 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 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. 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 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 CIE Publication No. 15, 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 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 $380\ \text{nm} \leq \lambda \leq 780\ \text{nm}$ in intervals of 5 nm.

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

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 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 ± 2) °C and (50 ± 10) % relative humidity, for a length of time dependent on the specimen thickness and material such that the specimens reach thermal equilibrium.

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

6.2 Set up the test apparatus in an atmosphere maintained at (23 ± 2) °C and (50 ± 10) % 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 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 Formula (1):

$$\tau_t(\lambda) = \frac{\xi_2(\lambda)}{\xi_1(\lambda)} \times 100 \quad (1)$$

Calculate the total luminous transmittance for CIE standard illuminant D_{65}, using Formula (2) with λ = 380 nm, 385 nm, 390 nm, ..., 775 nm, 780 nm:

$$\tau_t = \frac{\sum_{\lambda=380\,nm}^{780\,nm} S(\lambda) \times \tau_t(\lambda) \times V(\lambda)}{\sum_{\lambda=380\,nm}^{780\,nm} S(\lambda) \times V(\lambda)} \quad (2)$$

where

$S(\lambda)$ is the relative spectral power distribution of CIE standard illuminant D_{65} as given in ISO/CIE 11664-2;

$V(\lambda)$ represents the spectral luminous efficiency and is identical to the colour-matching function $\bar{y}(\lambda)$ as given in ISO/CIE 11664-1.

9 Precision

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

10 Test report

The test report shall at least include the following:

a) a reference to this document, i.e. ISO 13468-2:2021;

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

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

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