# INTERNATIONAL STANDARD

# ISO 13468-1

Second edition
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# Plastics — Determination of the total luminous transmittance of transparent materials —

## Part 1: **Single-beam instrument**

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

*Partie 1: Instrument à faisceau unique*



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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.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 13468-1:1996), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

— the format of figures has been revised;

— the normative references have been revised;

— editorial changes have been applied.

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



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

## Part 1:
## Single-beam instrument



## 1 Scope

This document covers the determination of the total luminous transmittance, in the visible region of the spectrum, of planar transparent and substantially colourless plastics, using a single-beam photometer with a specified CIE Standard light source and photodetector. 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 double-beam spectrophotometer as in ISO 13468-2. This document, however, provides a simple but precise, practical and quick determination. This method is suitable for use not only for analytical purposes but also for quality control.

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 might not 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*

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

ISO 5725-2, *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, *Accuracy (trueness and precision) of measurement methods and results — Part 3: Intermediate measures of the precision of a standard measurement method*

ISO 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO 11664-2, *Colorimetry — Part 2: CIE standard illuminants*

CIE Publication No. 15, *Colorimetry*

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

1) Also published as IEC 60050-845.

## 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/

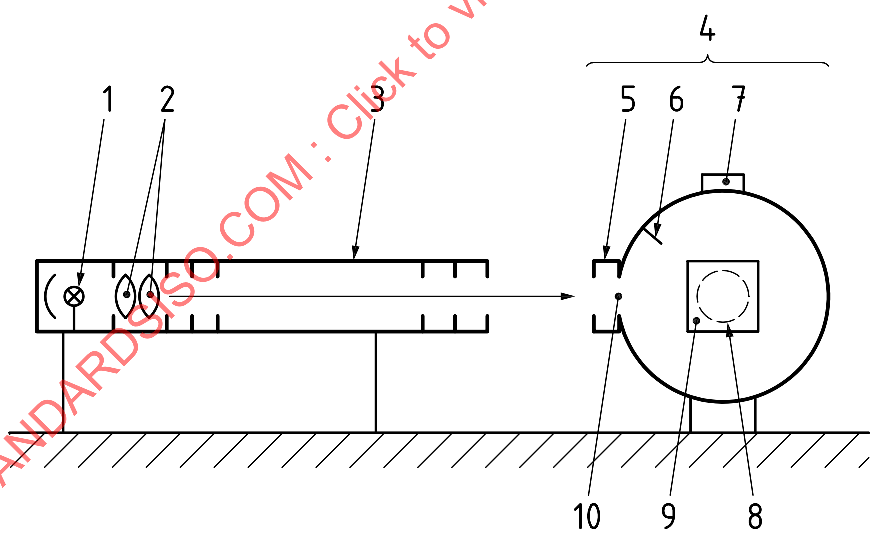
**3.1**
**transparent plastics**
plastics in which the transmission of light is essentially regular and which have a high transmittance in the visible region of the spectrum

Note 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 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 a stabilized light source, an associated optical system, an integrating sphere fitted with ports, and a photometer. Ingress of external light into the integrating sphere shall be prevented. A schematic arrangement of the apparatus is shown in Figure 1.




**Key**

| | | | |
|---|---|---|---|
| 1 | lamp | 6 | baffle |
| 2 | condensing lens | 7 | photodetector |
| 3 | collimator tube | 8 | compensation port |
| 4 | integrating sphere | 9 | light trap |
| 5 | specimen holder | 10 | entrance port |

**Figure 1 — Schematic arrangement of the apparatus**



**4.2** The light source and/or photodetector shall be fitted with filters so that the output of the combined system corresponds to the CIE standard colorimetric observer as specified in ISO 11664-1 and CIE standard illuminant $D_{65}$ as specified in ISO 11664-2. The output of the photodectector shall be proportional, to within 1 %, to the incident flux over the flux range used. The spectrophotometric characteristics of the light source and the photodetector shall be kept constant during measurements on specimens. The measurement conditions shall be such that the specimen temperature does not increase while measurements are made.

**4.3** The light source shall be combined with an optical system to produce a parallel beam of light; the angle which any ray of this beam makes with the axis of the beam shall not exceed 0,087 rad (5°). The beam shall not be vignetted at either port of the sphere.

The diameter of the beam shall be 0,5 to 0,8 times the diameter of the entrance port of the integrating sphere.

**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 it reads zero when the incident flux is zero.

**4.6** The integrating sphere used to collect the transmitted flux 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 A diameter of not less than 150 mm is normally used in the integrating sphere so that specimens of a reasonable size can be used. Other diameters can also be used.

NOTE 2 When the diameter of the integrating sphere is 150 mm and the diameters of the entrance, compensation 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 compensation ports of the integrating sphere shall be circular and of the same size. The entrance port, compensation port and photodetector port shall not lie on a great circle of the sphere.

**4.8** The photodetector shall be fitted with baffles to prevent light falling on it directly from the specimen.

**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 with 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 light trap shall absorb 95 % or more of the light incident on it.

**4.11** The specimen holder shall be such as to hold the specimen rigidly in a plane normal ±2° to the light beam and as closely as possible to the integrating sphere to ensure that all the 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 A thin, flexible film can be clamped around the edge in a double-ring-type holder or a 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.



## 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 and the compensation 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.

**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 equilibrium.

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

**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 on the integrating sphere. The compensation port shall be covered with a light trap.

Adjust the photometer so that the reading $\tau_1$ is 100.

**7.3** Repeat the readings $\tau_1$ and $\tau_2$, making additional readings 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 luminous transmittance $\tau_t$, in percent, using Formula (1):

$$\tau_t = \frac{\tau_2}{\tau_1} \times 100 \tag{1}$$

NOTE Annex A discusses in mathematical terms the effect of the compensation port on the efficiency of the integration sphere.



## 9 Precision

The precision data were determined in 1993 from an interlaboratory trial organized and analysed in accordance with ISO 5725-1, ISO 5725-2 and ISO 5725-3 involving 8 laboratories and 10 samples (see Table 2). No outliers were detected by Grubb's test.

Reproducibility: Precision under conditions in which test results are obtained with the same method on identical test material in different laboratories with different operators using different equipment, and expressed in terms of a reproducibility standard deviation or a reproducibility deviation.

Reproducibility within laboratory: Precision under conditions in which test results are obtained with the same method on identical material in the same laboratory, and with any operator, equipment and/or time of measurement.

NOTE Of the transparent plastics measured in the laboratory trial, the total luminous transmittance obtained for PMMA was the same as the theoretical value and the reproducibility standard deviation was satisfactory.

These results demonstrated that clear-cast PMMA sheet may be used as a reference material for calibration of the apparatus (see Annex A).

## 10 Test report

The test report shall include the following information:

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

b) the type of light source used;

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

d) the total luminous transmittance $\tau_t$ (the average of the three calculated results to the nearest 0,1 %);

**Table 1 — Measurements**

| Reading | Specimen over | | Light trap over compensation port | Quantity measured |
|---|---|---|---|---|
| | entrance port | compensation port | | |
| $\tau_1$ | No | Yes | Yes | Incident light |
| $\tau_2$ | Yes | No | Yes | Total light transmitted by specimen |

**Table 2 — Interlaboratory trials data**

| Transparent plastics | | | Reproducibility-within-laboratory standard deviation, $s_{Rw}$ | Reproducibility standard deviation, $s_R$ |
|---|---|---|---|---|
| | Nominal thickness | $\tau_t$<br>% | % | % |
| PMMA | 2 mm | 92,6 | 0,05 | 0,11 |
| PMMA-I | 2 mm | 92,3 | 0,06 | 0,13 |
| PVC | 2 mm | 87,0 | 0,04 | 0,17 |
| PS | 2 mm | 89,6 | 0,06 | 0,15 |
| MABS | 2 mm | 89,8 | 0,05 | 0,10 |
| PC | 3 mm | 88,3 | 0,04 | 0,23 |
| PP | 50 µm | 92,4 | 0,06 | 0,23 |
| PP($SiO_2$) | 50 µm | 92,1 | 0,04 | 0,24 |
| PE-HD | 30 µm | 90,7 | 0,04 | 0,23 |
| PVDC | 10 µm | 90,3 | 0,08 | 0,22 |

# Annex A
(informative)

## Use of a compensation port to increase the efficiency of an integrating sphere

The efficiency of an integrating sphere depends on the area of the internal surface, the number of ports and the way they are covered.

An error, due to the inefficiency of an integrating sphere when transmittance is measured by a single-beam instrument with an entrance port and an exit port, is inevitable.

A compensation port can be introduced, however, to avoid this error, making it unnecessary to calibrate the instrument with a reference standard.

The total luminous transmittance is calculated as follows (see also Figure A.1):

When a specimen is positioned over the compensation port to modify the incident-flux reading, the luminous flux in the integrating sphere $\Phi_1$, which includes the flux reflected back into the sphere by the specimen $\Phi_c \times \rho'$, is given by Formula (A.1):

$$\Phi_1 = \Phi - (\Phi_e + \Phi_c \times \alpha' + \Phi_c \times \tau') \qquad (A.1)$$

where

- $\Phi$ is the total incident luminous flux;
- $\Phi_e$ is the flux emerging from the entrance;
- $\Phi_c$ is the flux emerging from the compensation port;
- $\tau'$ is the transmittance of the specimen (% transmittance $\tau = \tau' \times 100$);
- $\rho'$ is the reflectance of the specimen;
- $\alpha'$ is the absorptance of the specimen.

Since $\tau' + \rho' + \alpha' = 1$ and assuming $\Phi_e \approx \Phi_c$

$$\Phi_1 = \Phi - 2\Phi_e + \Phi_e \times \rho' \qquad (A.2)$$

When a specimen is placed over the entrance port, the luminous flux in the sphere $\Phi_2$ is given by Formula (A.3):

$$\begin{aligned}\Phi_2 &= \Phi - \left[(\Phi \times \rho' + \Phi \times \alpha') + (\Phi_e \times \tau' \times \alpha' + \Phi_e \times \tau'2) + \Phi_c \times \tau'\right] \\ &= \tau' \times (\Phi - 2\Phi_e + \Phi_e \times \rho')\end{aligned} \qquad (A.3)$$

From Formulae (A.2) and (A.3)

$$\tau' = \frac{\Phi_2}{\Phi_1} = \frac{\tau}{100}$$

Since the terms common to Formulae (A.2) and (A.3) cancel out, the efficiency of the integrating sphere has no influence on the luminous transmittance.