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# Plastics — Poly(methyl methacrylate) double- and triple-skin sheets — Test methods

*Plastiques — Plaques de poly(méthacrylate de méthyle) à double et triple paroi — Méthodes d'essai*



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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 11, *Products,* 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 12017:1995), of which it constitutes a minor revision.

The changes compared to the previous edition are as follows:

— the normative reference clause (Clause 2) has been updated.

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 — Poly(methyl methacrylate) double- and triple-skin sheets — Test methods



## 1 Scope

This document specifies the test methods for quality control of poly(methyl methacrylate) (PMMA) extruded double- and triple-skin flat sheets, obtained from colourless and coloured transparent, translucent and opaque grades of materials.

The minimum sheet width is 600 mm.

The main applications of these sheets are in building and agriculture (greenhouses).

## 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 2818, *Plastics — Preparation of test specimens by machining*

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc sources*

ISO 7823-2:2003, *Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics — Part 2: Melt-calendered extruded sheets*

ISO 8302, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus*

ISO 10140-2, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 2: Measurement of airborne sound insulation*

ISO 10140-5, *Acoustics — Laboratory measurement of sound insulation of building elements — Part 5: Requirements for test facilities and equipment*

ISO 12999-1, *Acoustics — Determination and application of measurement uncertainties in building acoustics — Part 1: Sound insulation*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

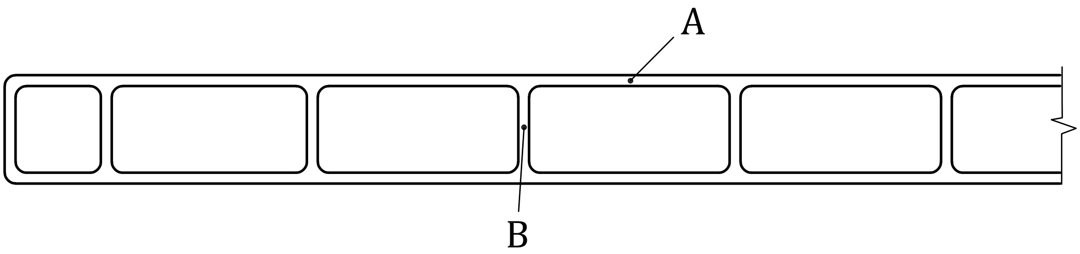
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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

**3.1**
**double-skin sheet**
**DSS**
sheet having two parallel external skins, differently spaced and jointed by ribs of different shapes

Note 1 to entry: See Figures 1 and 2.

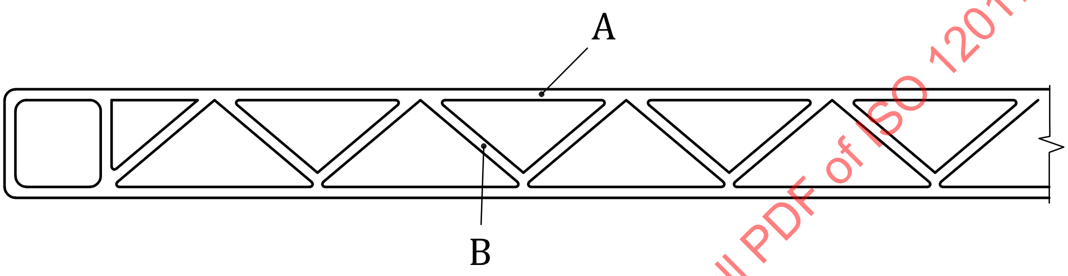



**Key**

A skin

B rib

**Figure 1 — Example of a double-skin sheet**




**Key**

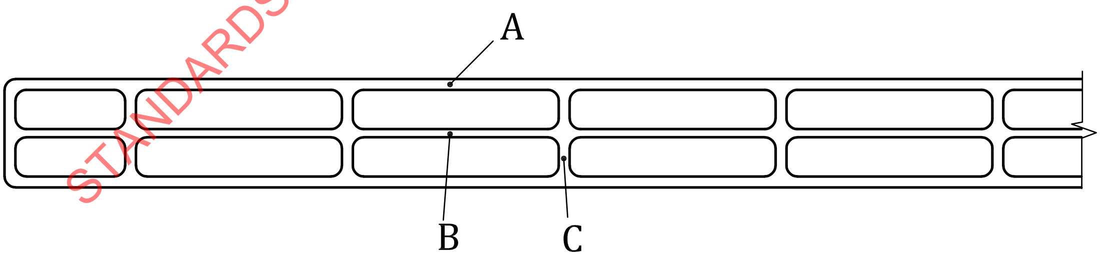
A skin

B rib

**Figure 2 — Example of a double-skin sheet**

**3.2**
**triple-skin sheet**
**TSS**
sheet having two external and an internal skin which is parallel and properly spaced by ribs from the external one

Note 1 to entry: See Figure 3.




**Key**

A skin

B internal skin

C rib

**Figure 3 — Example of a triple-skin sheet**



## 4 Composition of materials

This document applies to PMMA homopolymers and to copolymers of methyl methacrylate containing at least a mass fraction of 80 % of MMA and not more than a mass fraction of 20 % of acrylic ester or other suitable monomers.

Such materials may be unmodified or may contain lubricants, processing aids, UV absorbers, pigments and colorants.

## 5 Characteristics

### 5.1 Main characteristics of DSS and TSS

#### 5.1.1 Total thickness.

#### 5.1.2 Total width.

#### 5.1.3 Skin thickness.

#### 5.1.4 Mass per unit area.

#### 5.1.5 Rib thickness.

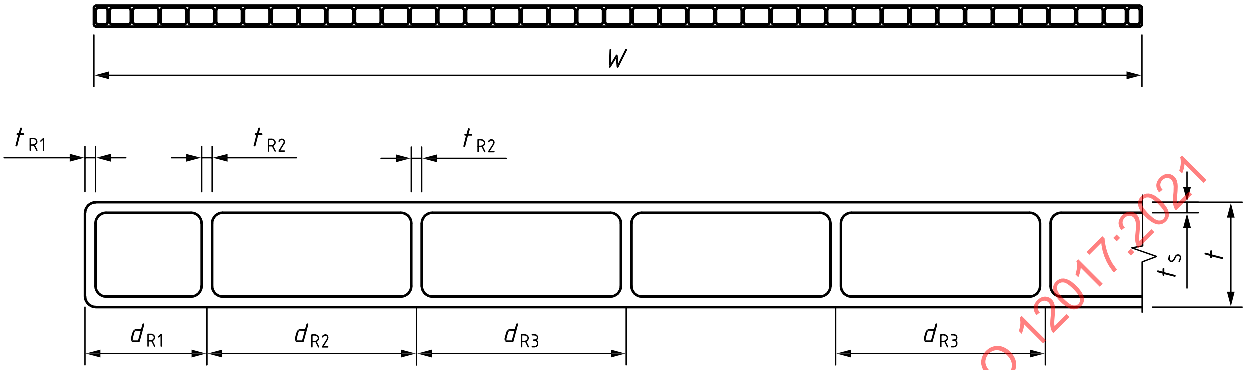
#### 5.1.6 Rib geometry (spacing, angle).



## 5.2 Profile

The profile of a sheet is defined collectively by the characteristics specified in 5.1. Examples are shown in Figures 4 and 5.

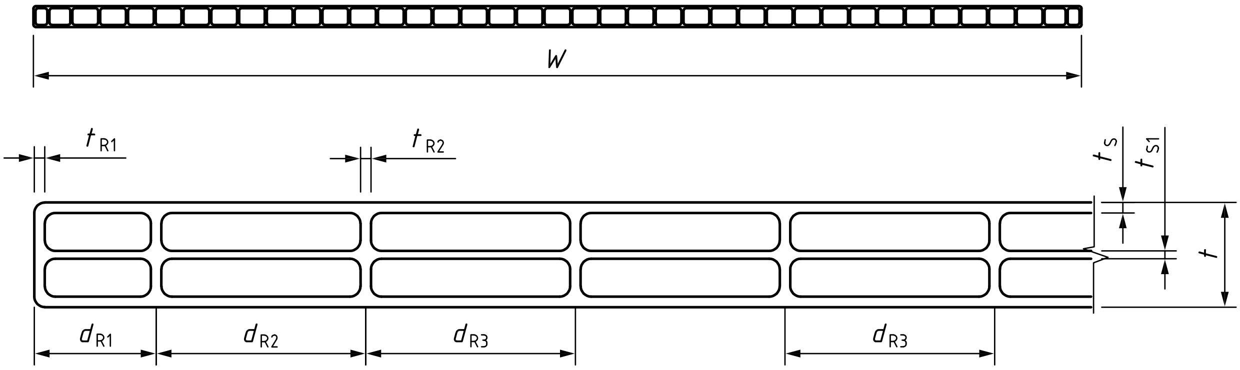



| | |
|---|---|
| Total thickness | $T$ = 16 mm |
| Total width | $W$ = 700 mm |
| Mass per unit area | $\rho_A$ = 5 kg/m$^2$ |
| Skin thickness | $t_S$ = 1,8 mm |
| Rib thickness | $t_{R1}$ = 1,7 mm |
| | $t_{R2}$ = 1,8 mm |
| Rib spacing | $d_{R1}$ = 20 mm |
| | $d_{R2}$ = 24 mm |
| | $d_{R3}$ = 30 mm (main rib spacing) |

**Figure 4 — Examples of typical dimensions and mass per unit area of DSS**






| | |
|---|---|
| Total thickness | $T$ = 16 mm |
| Total width | $W$ = 980 mm |
| Mass per unit area | $\rho_A$ = 5 kg/m$^2$ |
| Skin thickness | $t_S$ = 1,5 mm |
| Internal skin thickness | $t_{S1}$ = 1,2 mm |
| Rib thickness | $t_{R1}$ = 1,6 mm |
| | $t_{R2}$ = 1,5 mm |
| Rib spacing | $d_{R1}$ = 20 mm |
| | $d_{R2}$ = 24 mm |
| | $d_{R3}$ = 32 mm (main rib spacing) |

**Figure 5 — Examples of typical dimensions and mass per unit area of TSS**



## 5.3 Other characteristics of DSS and TSS

### 5.3.1 Curvature.

### 5.3.2 Curvature of edge in extrusion direction.

### 5.3.3 Optical properties.

### 5.3.4 Thermal resistance.

### 5.3.5 Bending properties.

### 5.3.6 Sound insulation.

### 5.3.7 Fire resistance.

### 5.3.8 Weatherability.

### 5.3.9 Chemical resistance to gaskets and sealants.

### 5.3.10 Internal stress.

### 5.3.11 Condensate formation.

# 6 Test methods

## 6.1 General

### 6.1.1 Test conditions

Make all measurements under the standard conditions of 23 °C ± 2 °C and (50 ± 5) % relative humidity (refer to ISO 291). For measurements made under local ambient conditions, due allowance shall be made for dimensional changes due to the differences in temperature and relative humidity.

### 6.1.2 Sampling

The sampling procedure shall be agreed upon between the interested parties. The procedures described in ISO 28590 and ISO 2859-1 are widely accepted and frequently used. Hence these are recommended for sampling.

The test report shall include the following information:

a) a reference to this document, i.e. ISO 12017:2021;

b) all details necessary to identify the sample used for the tests.

### 6.1.3 Preparation of test specimens

Specimens shall be prepared in accordance with the procedures described in ISO 2818, wherever applicable.

## 6.2 Thickness measurements

### 6.2.1 Total thickness

Measure the total thickness, to the nearest 0,1 mm, at 200 mm intervals over the whole extrusion width, beginning at the central point of the edge cell. Calculate the average of the measurements.

### 6.2.2 Minimum skin thickness

Measure the thickness of the outer skins, to the nearest 0,1 mm, at the point of minimum thickness.

Do not report the thickness of the inner skin of a TSS; however, check to ensure that the inner skin is intact.

### 6.2.3 Minimum rib thickness

Measure the rib thickness, to the nearest 0,1 mm, at the thinnest point of the thinnest rib.

### 6.2.4 Test report

The test report shall include the following measurements, accurate to 0,1 mm:

a) the average total thickness, minimum thickness and maximum thickness;

b) the minimum outer-skin thickness;

c) the minimum rib thickness.

## 6.3 Width and length measurements

Measure the extrusion width, the cut width (if necessary) and the sheet length in the extrusion direction to the nearest 0,1 mm.

Report the width and the length measured.

## 6.4 Rib geometry

Report the nominal values of the rib spacing, the rib angles and any other relevant rib-geometry parameters.

## 6.5 Mass per unit area

Weigh, to the nearest 1 g, strips with a width corresponding to the extrusion width and 100 mm in length.

Calculate the mass per unit area, $\rho_A$, in kilograms per square metre, using Formula (1):

$$\rho_A = \frac{m}{W \times 100} \times 10^3 \quad (1)$$

where

$m$ is the mass, in grams, of the specimen;

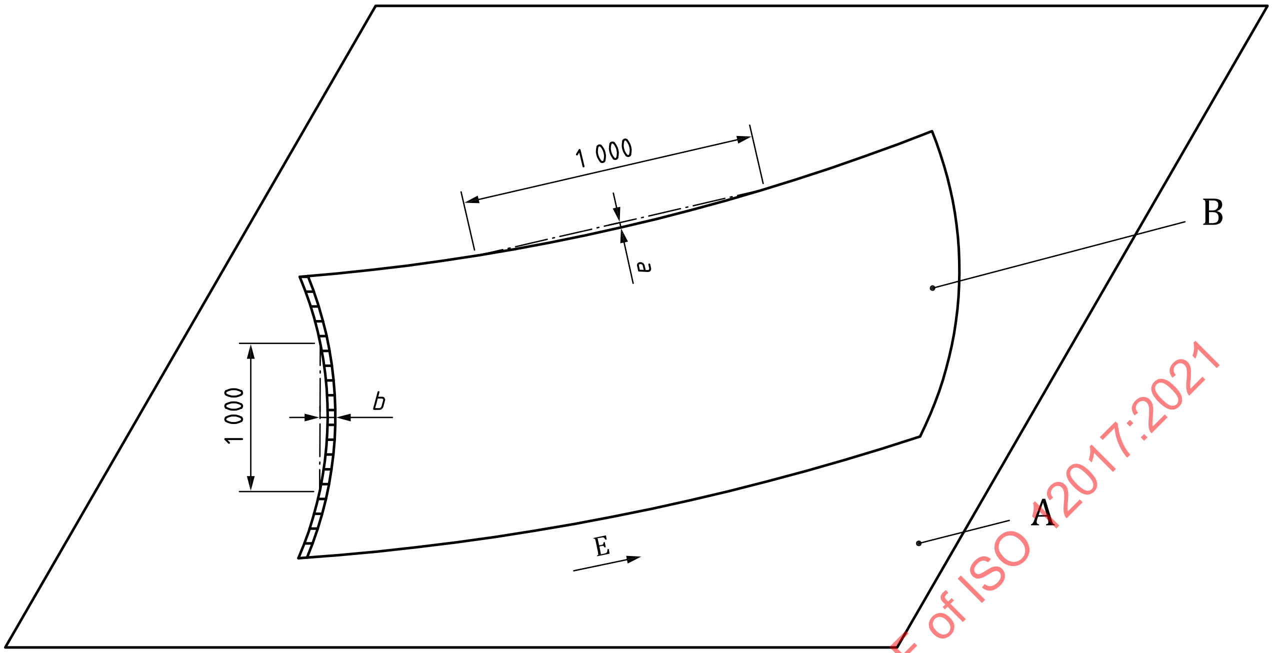
$W$ is the width, in millimetres, of the specimen.

Report the value of $\rho_A$ calculated from Formula (1) to the nearest 0,01 kg/m$^2$.

## 6.6 Curvature of sheet surface

Measure the curvature on a full-size sheet, using a 1 000-mm-long straight edge (see Figure 6).

Dimensions in millimetres




**Key**

B double- or triple-skin sheet in vertical position, resting on A

A horizontal plane surface

*a* curvature in extrusion direction

*b* curvature perpendicular to extrusion direction

E extrusion direction

**Figure 6 — Curvature of sheet surface**



Place the specimen, in the vertical position (extrusion direction horizontal), on a plane horizontal surface, and hold it upright. Place the straight edge against the concave surface of the sheet and measure the maximum distance *a* between the sheet surface and the straight edge (1 000 mm secant line of the curvature) in the extrusion direction. Similarly, measure the maximum curvature *b* at the cut ends (perpendicular to the extrusion direction). If the width is less than 1 000 mm, measure the curvature *b* over the full width.

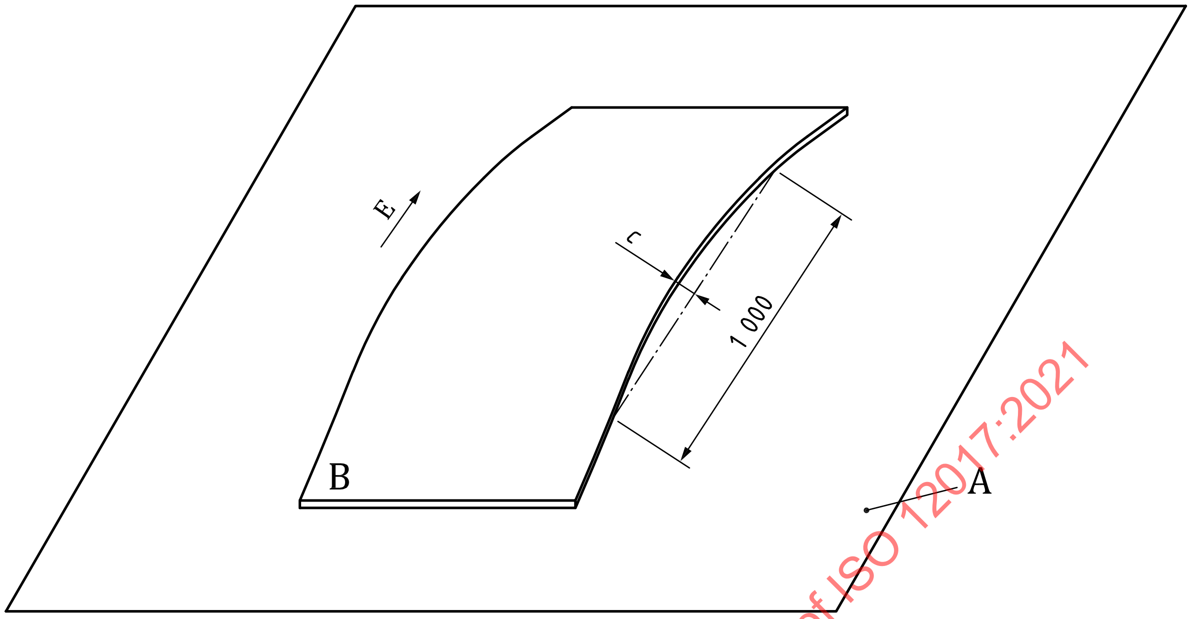
Report the distances measured.

NOTE The sheet is normally longer than 1 000 mm.

## 6.7 Curvature of edge in extrusion direction

Measure the edge curvature on a full-size sheet at the side edges, using a 1 000-mm-long straight edge (see Figure 7).

Dimensions in millimetres




**Key**

B double- or triple-skin sheet in horizontal position, resting on A

A horizontal plane surface

*c* curvature of edge in extrusion direction

E extrusion direction

**Figure 7 — Curvature of edge in extrusion direction**

Place the test sheet in the horizontal position on a plane horizontal surface so that the sheet lies concave side down. Measure the maximum distance *c* between a side edge of the sheet and the straight edge.

Report the distance measured.

## 6.8 Optical properties

### 6.8.1 Luminous transmittance

Measure the luminous transmittance by the method described in Annex A.

NOTE 1 Luminous transmittance of DSS and TSS cannot be measured accurately by the method given in ISO 13468-1. Due to the complex geometry of DSS and TSS, it does not necessarily give reliable values.

NOTE 2 A spectrometer does not give reproducible results either.

### 6.8.2 Colour

The method used for the determination of colour and colour variations shall be agreed on between the interested parties.

### 6.8.3 Appearance

Any defects shall be evaluated by inspecting the sheet under daylight or a daylight-type fluorescent lamp with a colour temperature of 6 500 K ± 650 K and rated at not less than 40 W.



Examples of defects are:

a) bubbles;

b) cracks;

c) crazing.

#### 6.8.4 Test report

The test report shall include the following information, when measured:

a) the luminous transmittance;

b) the colour and colour variation;

c) details of any defects in appearance.

### 6.9 Thermal resistance

Measure the thermal resistance in accordance with ISO 8302 and include the results in a test report.

### 6.10 Three-point bending test

#### 6.10.1 General

The bending test is an important criterion in assessing sheet quality and judging the consistency of the extrusion process.

#### 6.10.2 Procedure

Use specimens 100 mm long in the extrusion direction.

If the extrusion width is between 600 mm and 800 mm, use the whole width for the specimens. If the extrusion width is greater than 800 mm, cut the specimen to 800 mm, taking it from any part of the total width.

Carry out the test using a dynamometer (preferably instrumented) in the following way (see Figure 8):

Place the specimen symmetrically on two supports (edge radius 5 mm) spaced at 550 mm.

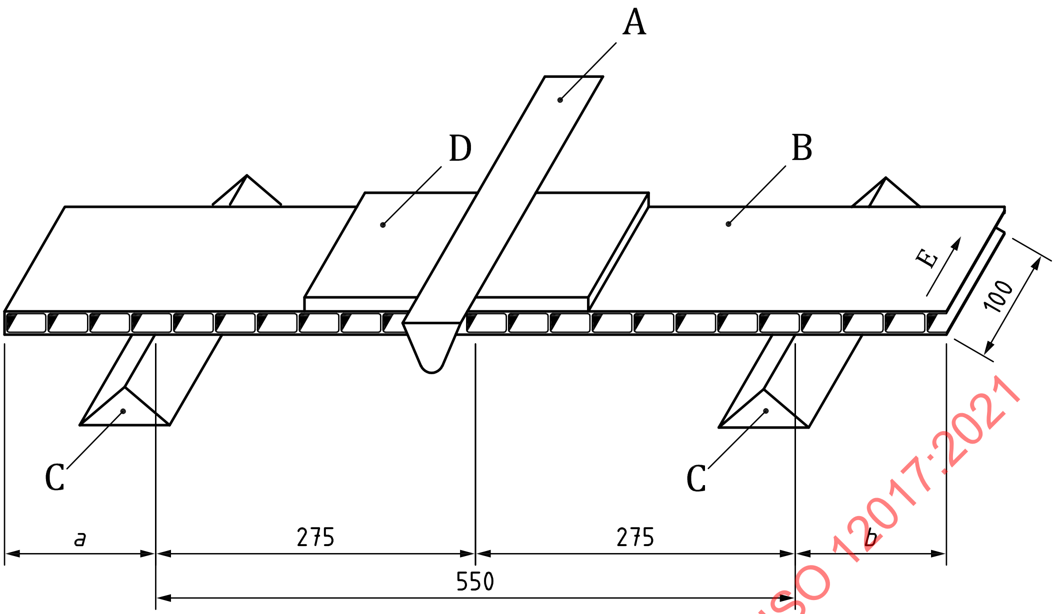
Apply the load at the centre of the specimen, evenly over its entire length (100 mm), using a loading edge (radius 5 mm) pressing against a rubber mat (250 mm × 100 mm × 20 mm, nominal Shore A hardness 70) placed on the specimen.

NOTE The rubber mat is necessary in order to distribute the load over a larger surface area and hence avoid the skin in contact with the loading edge breaking.

Start up the dynamometer, using a rate of advancement of the loading edge of 100 mm/min ± 5 mm/min.

The load is measured by the dynamometer while the deflection is measured to the nearest 0,1 mm by a control gauge.

Continue the test until the specimen fails, either as a result of fracture or by slipping through the supports.




**Key**

A loading edge (edge radius 5 mm)

B double- or triple-skin sheet specimen (max. width 800 mm)

C supports (edge radius 5 mm)

D rubber mat

E extrusion direction

$a = b = [(\text{width} - 550)/2]$ mm

**Figure 8 — Three-point bending test**



### 6.10.3 Evaluation criterion for the bending test

The load-bearing capacity of the specimen is deemed sufficient when the following conditions are satisfied:

$$P_v \geq P_{min} \quad (2)$$

$$\frac{P_v}{H_v} \geq S_{min} \quad (3)$$

where

| | |
|---|---|
| $P_v$ | is the load on failure, in newtons; |
| $P_{min}$ | is the required value of $P_v$, in newtons; |
| $H_v$ | is the deflection on failure, in millimetres; |
| $S_{min}$ | is the required value of $P_v/H_v$. |

### 6.10.4 Test report

Report the values of $P_v$ and $P_v/H_v$, plus the dimensions of the specimen.

### 6.11 Sound insulation

Carry out the test in accordance with ISO 12999-1, ISO 10140-2 and ISO 10140-5 and include the results in a test report.

### 6.12 Fire resistance

Assess fire behaviour as specified in relevant national standards.

### 6.13 Weathering test

Carry out weather-resistance tests as specified in ISO 4892-2, using a filtered xenon lamp ($\lambda_c$ = 300 nm) at a black-panel temperature of 65 °C and with a wet/dry cycle of 18 min/102 min; the period of exposure shall be 3 000 h.

Use a specimen measuring 64 mm × 40 mm.

Examine for the presence of defects (e.g. cracks, crazing or yellowing) at the end of the exposure period and include the results in a report.

### 6.14 Chemical resistance to (compatibility with) materials in contact with DSS or TSS

NOTE Materials of this category are, for example, gaskets, sealants, etc.

#### 6.14.1 Procedure

Carry out the bending test specified in Annex B to qualify such materials as being inert with respect DSS or TSS (i.e. not producing crazing under stress).

Cut specimens from solid extruded sheets 4 mm thick consisting of the same material as the DSS or TSS with which compatibility is to be established. The longer side of the specimen shall be parallel to the extrusion direction. The shrinkage of specimens in the extrusion direction, determined in accordance with ISO 7823-2:2003, Annex B, shall be no more than 3 %.

NOTE It is left to the interested parties to agree, depending on the results of the compatibility test, on the conditions under which such materials are permitted to come in contact with DSS or TSS.

#### 6.14.2 Test report

The test report shall include the following information:

a) the temperature used (23 °C or 50 °C);

b) whether the crazing time was longer or shorter than 24 h;

c) the stress limit;

d) whether the corrosive agent or other material was found to be compatible or not.

### 6.15 Evaluation of internal stress

This test gives an indication of the level of internal stress within the material. A specimen is immersed for 10 min in ethyl acetate and subsequently examined for the appearance of cracks or crazing. This is only suitable as a qualification test for freshly extruded material. During prolonged storage or in use, the DSS or TSS absorbs an undefined amount of water. This increased undefined water content causes irregularities in the described test. If the stress conditions following prolonged storage or use are to be investigated, then the procedure and the specimen conditioning shall be agreed on between the interested parties.

NOTE Previous experience has shown that the internal stress is highest in the edge zones.



The specimen used shall be of full width and 100 mm in length.

Immerse each edge of the specimen, one after the other, over the whole length (100 mm), at least 50 mm deep into analytical-grade ethyl acetate for 10 min.

In cases of dispute, condition a specimen at least 300 mm wide and 100 mm long for at least a day in a dessicator at 23 °C ± 1 °C. Then, immerse the edges of the specimen at least 50 mm deep in ethyl acetate for 10 min at a temperature of 23 °C ± 1 °C.

Examine the specimen for cracks or crazing after immersion of each edge and include the findings in a test report.

## 7 Condensate formation

Condensate formation is occasionally observed following changes in the atmospheric conditions (i.e. temperature and humidity). Condensate can form on the external and/or internal surfaces of the DSS or TSS. Condensation first appears in the form of fine droplets which scatter the light and makes the fogged areas appear white. This fogging reduces light transmission, but has virtually no effect on the other properties of the DSS or TSS (including heat insulation). The formation of condensate in this way is not a property of the DSS or TSS, but depends solely on the physical conditions (temperature, humidity, dew point) at the surface of the DSS or TSS.

For these reasons, this document does not specify a method for the measurement of condensate.



# Annex A
(normative)

# Determination of luminous transmittance of PMMA double- and triple-skin sheets

## A.1 Overview

This annex specifies a method for the determination of the luminous transmittance of transparent, clear or coloured, non-selectively transmitting PMMA multiple-skin ribbed sheets. The luminous transmittance is determined using parallel light, incident normally on the specimen, from CIE standard illuminant A as specified in ISO 11664-2.

The method is applicable to PMMA multiple-skin sheets of thickness equal to or less than 40 mm.

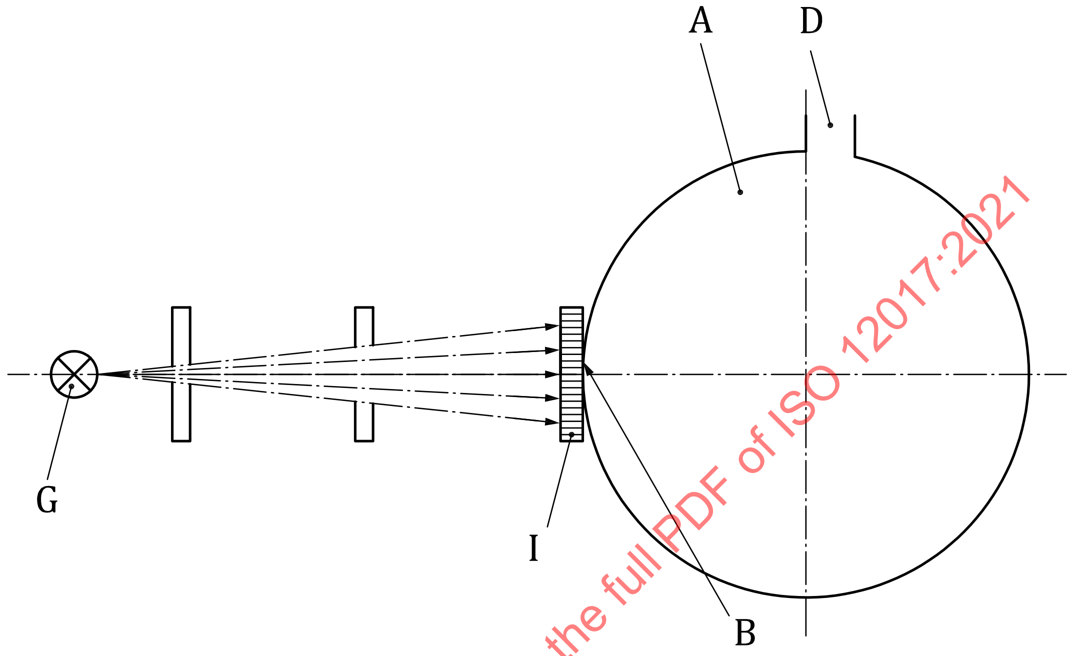
NOTE 1 Diffused incident light, such as the illumination from an overcast sky, does not necessarily give reproducible values of luminous transmittance. However, illumination by normally incident, parallel light is acceptable for this test. The measured values will indicate the achievable maximum.

NOTE 2 PMMA multiple-skin sheets are available in the following grades: clear, transparent white, and non-selectively transmitting shades of grey, brown and bronze. Hence, the luminous transmittance obtained with illuminant A ($\tau_A$) is the same in practice as that obtained with illuminant C ($\tau_C$) and with illuminant $D_{65}$ ($\tau_{D65}$).

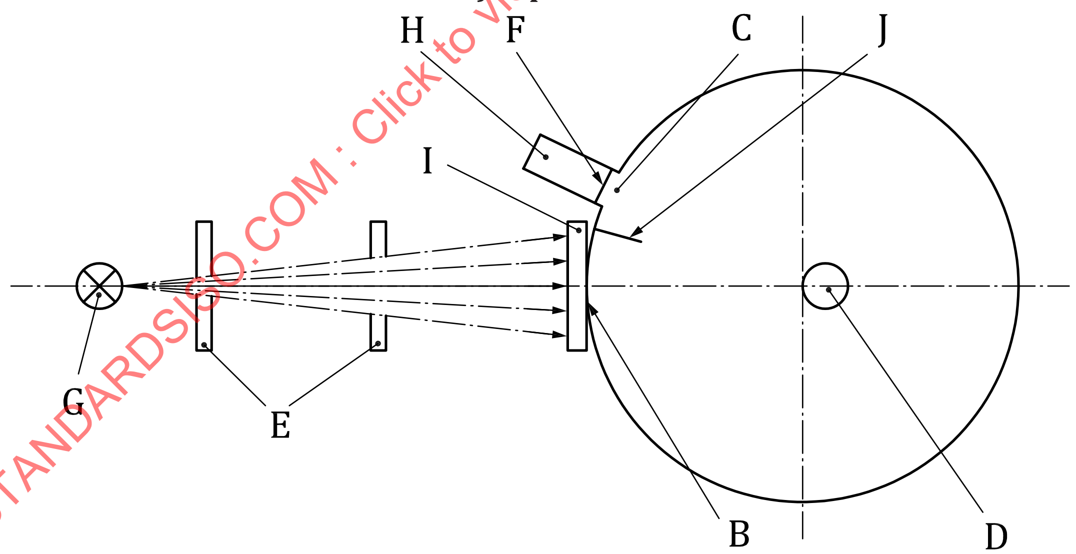
NOTE 3 This method has been found to be a satisfactory way of measuring the daylight-transmitting properties of DSS and TSS.

## A.2 Apparatus

See Figure A.1.




**a) Top view**




**b) Vertical section**

**Key**

A integrating sphere, diameter $d_S$

B entrance port (specimen opening), diameter $d_L$

C photodetector aperture, diameter $d_M$

D compensation port, diameter $d_R$

E collimators

F frosted-glass panel

G light source

H photodetector

I test specimen

J baffle plate

**Figure A.1 — Integrating sphere for measuring light transmittance $\tau_A$ (determination of $E_x$) (not to scale)**

### A.2.1 Light source

**A.2.1.1** A gas-filled lamp with a distribution temperature $T_D$ of 2 856 K is used to produce illuminant A. The manufacturer or calibration authority may specify the electrical conditions under which the required distribution temperature is obtained. The power supply shall be stabilized. Voltage fluctuations shall not exceed ±0,1 %.

**A.2.1.2** The light incident on the specimen shall be an essentially parallel beam normal to the specimen surface. In order to guarantee a sufficiently parallel beam of incident light, the light source and the entrance port of the integrating sphere shall be at least 5 m apart unless optical aids are used to ensure that the light beam incident on the specimen is parallel.

**A.2.1.3** The area illuminated on the surface of the specimen shall be circular in shape and concentric with the photodetector aperture.

The diameter, $D$, in centimetres, of the illuminated area shall be given by Formula (A.1):

$$D = 10 + 10T \tag{A.1}$$

where $T$ is the thickness, in centimetres, of the sheet.

**A.2.1.4** Within the illuminated area, the illuminance may vary by up to 1 %.

**A.2.1.5** To avoid light-scattering effects, several collimators with circular apertures shall be located between the light source and the integrating sphere (see Figure A.1).

### A.2.2 Integrating sphere

#### A.2.2.1 General

The integrating sphere collects the transmitted light emerging from the specimen into the space behind it and measures the mean luminance.

#### A.2.2.2 Sphere diameter and diameter of entrance port

In order for accurate measurements to be possible, the sphere diameter $d_S$ shall be much larger than the diameter of the light entrance port $d_L$. For the same reasons, the latter shall be much larger than the rib spacing in the sheet under investigation. The following diameters shall be used for rib spacings up to 35 mm and sheet thicknesses up to 40 mm:

— sphere diameter $d_S \geq 1\ 000$ mm;

— entrance port diameter $d_L = 100$ mm.

#### A.2.2.3 Compensation port

The diameter $d_R$ of the compensation port shall be equal to that of the entrance port $d_L$.

#### A.2.2.4 Photodetector aperture

The diameter $d_M$ of the photodetector aperture depends on the instrument used. This aperture shall be covered with a light-diffusing panel coated on the inside with a material having a reflectance similar to that of the inside wall of the sphere (see A.2.2.6).

