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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

Reference number
ISO 12017:1995(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.

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 12017 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

Annexes A and B form an integral part of this International Standard.

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

1 Scope

This International Standard 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 as defined in clause 4.

The minimum sheet width is 600 mm.

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

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 140-1:1990, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 1: Requirements for laboratories.*

ISO 140-2:1991, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 2: Determination, verification and application of precision data.*

ISO 140-3:1978, *Acoustics — Measurement of sound insulation in buildings and of building elements — Part 3: Laboratory measurements of airborne sound insulation of building elements.*

ISO 291:1977, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 2818:1994, *Plastics — Preparation of test specimens by machining.*

ISO 2859-0:—[1], *Sampling procedures for inspection by attributes — Part 0: Introduction to the ISO 2859 attribute sampling system.*

ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

ISO 4892-2:1994, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc sources.*

ISO 7823-2:1989, *Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics — Part 2: Melt-calendered extruded sheets.*

ISO 8302:1991, *Thermal insulation — Determination of steady-state thermal resistance and related properties — Guarded hot plate apparatus.*

ISO/CIE 10526:1991, *CIE standard colorimetric illuminants.*

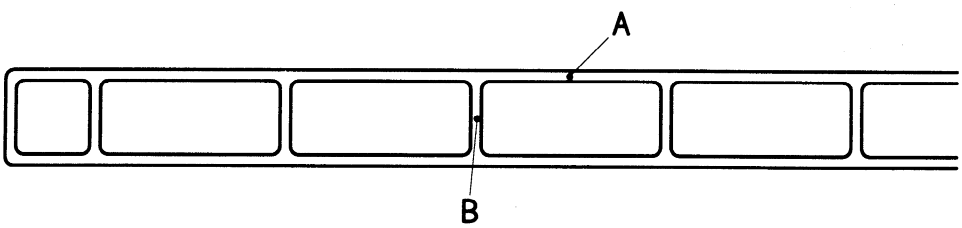
1) To be published.

3 Definitions and abbreviations

For the purposes of this International Standard, the following definitions and abbreviations apply.

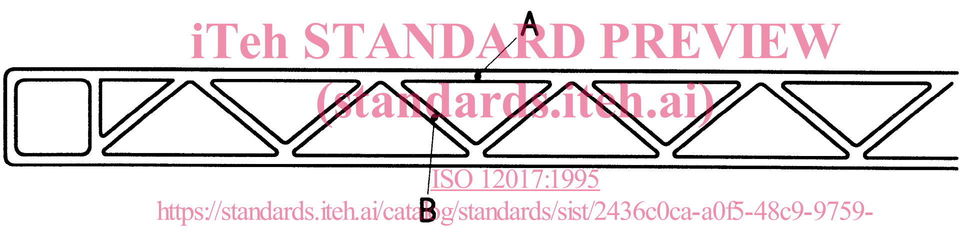
3.1 double-skin sheet (DSS): A sheet having two parallel external skins, differently spaced and jointed by ribs of different shapes (see examples in figures 1 and 2).

3.2 triple-skin sheet (TSS): A sheet having two external and an internal skin which is parallel and properly spaced by ribs from the external one (see an example in figure 3).



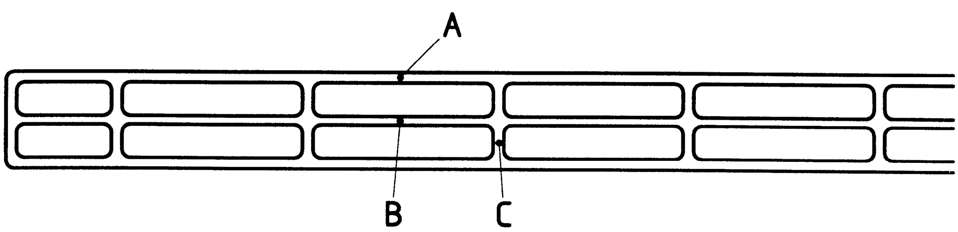
A skin
B rib

Figure 1 — Example of a double-skin sheet



A skin
B rib

Figure 2 — Example of a double-skin sheet



A skin
B internal skin
C rib

Figure 3 — Example of a triple-skin sheet

4 Composition of materials

This International Standard applies to PMMA homopolymers and to copolymers of methyl methacrylate containing at least 80 % (*m/m*) of MMA and not more than 20 % (*m/m*) 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 and examples are shown in figures 4 and 5.

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 2859-0 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 International Standard;

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, ρ_A, in kilograms per square metre, from the equation

$$\rho_A = \frac{m}{W \times 100} \times 10^3$$

where

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

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

Report the value of ρ_A calculated from the above equation 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).

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 1 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).

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.

NOTES

2 Luminous transmittance of DSS and TSS cannot be measured accurately by the method given in ISO 13468-1:—[2], *Plastics — Determination of the total luminous transmittance of transparent materials — Part 1: Single-beam instrument*. Due to the complex geometry of DSS and TSS, it does not necessarily give reliable values.

3 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 report.

6.10 Three-point bending test

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

6.10.1 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 4 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.

6.10.2 Evaluation criterion for the bending test

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

$$P_v \geqslant P_{min}$$

$$\frac{P_v}{H_v} \geqslant S_{min}$$

where

P_v is the load on failure, in newtons;

2) To be published.

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.

6.10.3 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 140-1, ISO 140-2 and ISO 140-3 and 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 report.

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

Materials of this category are e.g. 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 7823-2:1989, annex B, shall be no more than 3 %.

NOTE 5 It is left to the interested parties to agree, depending on the results of the compatibility test, on the conditions under which such materials will be 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 6 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.

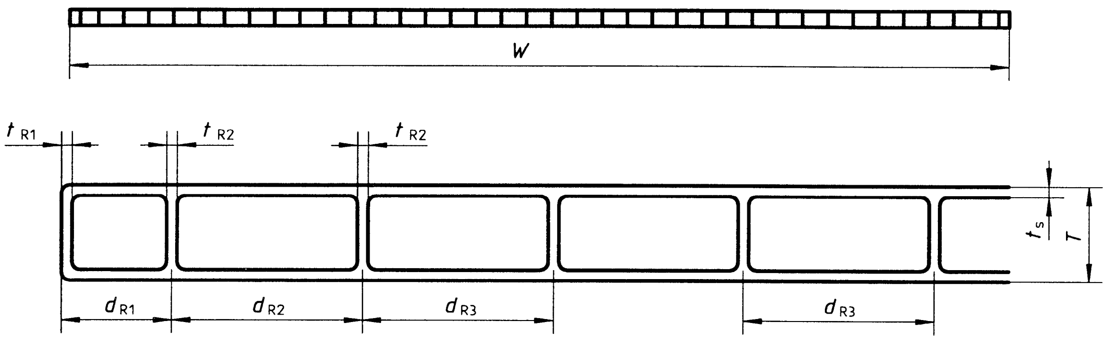
In cases of dispute, condition a specimen at least 300 mm wide and 100 mm long for at least a day in a dessicator at 23 °C ± 1 °C. Then immerse the edges of the specimen at least 50 mm deep in ethyl acetate for 10 min at a temperature of 23 °C ± 1 °C.

Examine the specimen for cracks or crazing after immersion of each edge and report.

7 Condensate formation

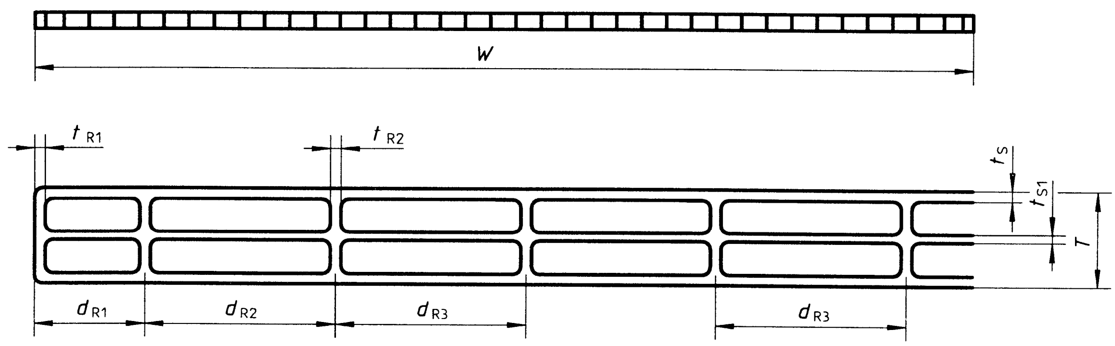
Condensate formation is occasionally observed following changes in the atmospheric conditions (i.e. temperature and humidity). Condensate can form on the external and/or internal surfaces of the DSS or TSS. Condensation first appears in the form of fine droplets which scatter the light and makes the 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 International Standard does not specify a method for the measurement of condensate.



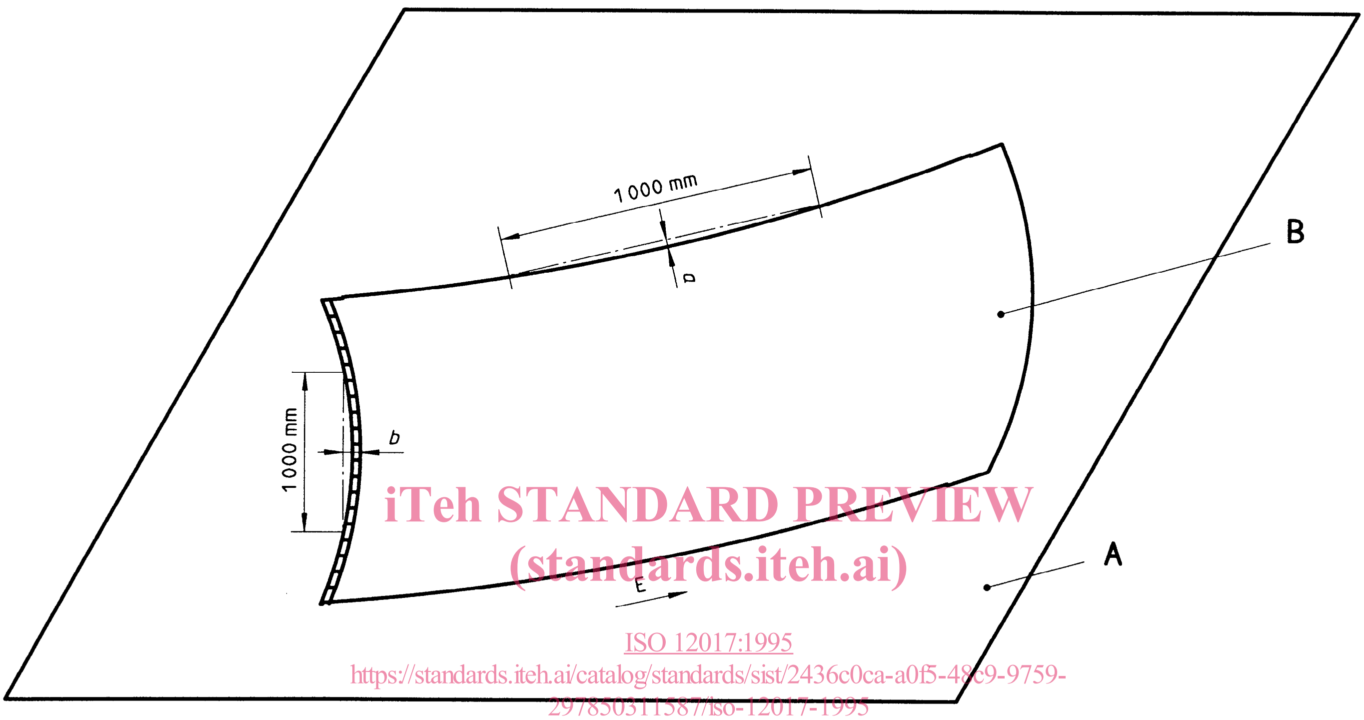
Total thickness	T = 16 mm
Total width	W = 700 mm
Mass per unit area	ρ_A = 5 kg/m^2
Skin thickness	t_S = 1,8 mm
Rib thickness	t_{R1} = 1,7 mm
	t_{R2} = 1,8 mm
Rib spacing	d_{R1} = 20 mm
	d_{R2} = 24 mm
	d_{R3} = 30 mm (main rib spacing)

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	ρ_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



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

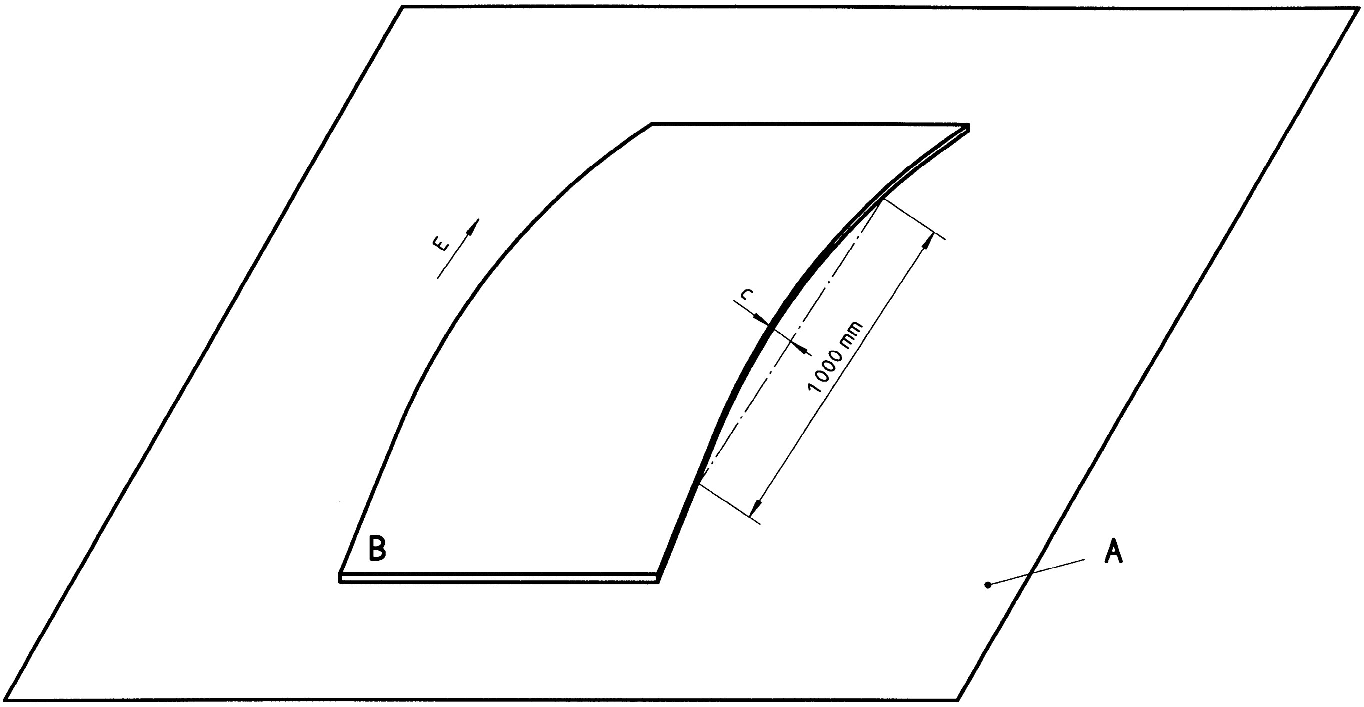
A Horizontal plane surface

a Curvature in extrusion direction

b Curvature perpendicular to extrusion direction

E Extrusion direction

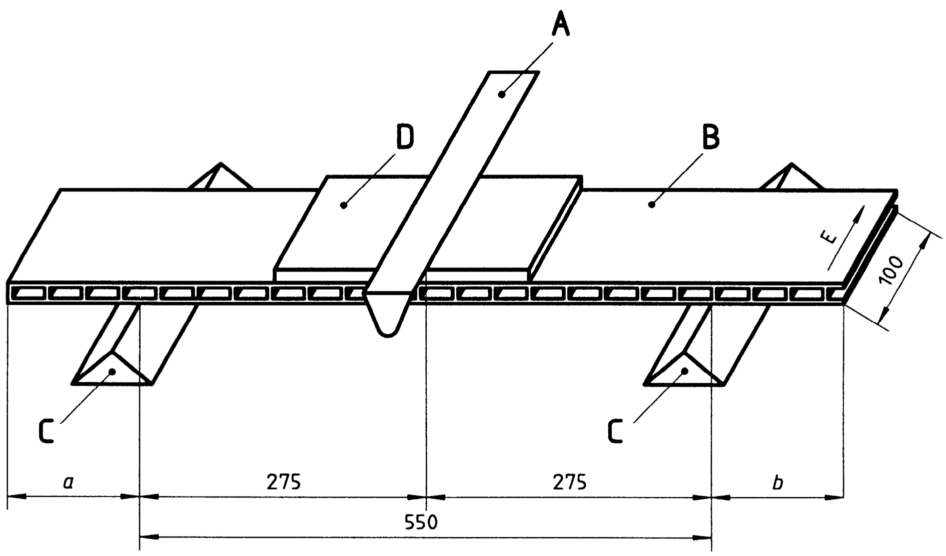
Figure 6 — Curvature of sheet surface



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

Dimensions in millimetres



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