INTERNATIONAL STANDARD

ISO 7823-2

Third edition
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Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics —

Part 2: Extruded sheets

Plastiques — Plaques en poly(méthacrylate de méthyle) — Types, dimensions et caractéristiques —

Partie 2: Plaques extrudées

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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.

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The main task of technical committees is to prepare International Standards. 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.

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.

ISO 7823-2 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*.

This third edition cancels and replaces the second edition (ISO 7823-2:1996), which has been technically revised.

ISO 7823 consists of the following parts, under the general title *Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics*:

— *Part 1: Cast sheets*

— *Part 2: Extruded sheets*

— *Part 3: Continuous cast sheets*

Plastics — Poly(methyl methacrylate) sheets — Types, dimensions and characteristics —

Part 2: Extruded sheets

1 Scope

This part of ISO 7823 specifies requirements for flat poly(methyl methacrylate) (PMMA) sheets extruded from colourless or coloured, transparent, translucent or opaque materials as defined in 3.1.

The thickness range of the sheets covered by this part of ISO 7823 is 1,5 mm to 20 mm.

2 Normative references

The following referenced documents are indispensable for the application 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 62:1999, *Plastics — Determination of water absorption*

ISO 75-1:—[1)], *Plastics — Determination of temperature of deflection under load — Part 1: General test method*

ISO 75-2:—[2)], *Plastics — Determination of temperature of deflection under load — Part 2: Plastics, ebonite and long-fibre-reinforced composites*

ISO 178:2001, *Plastics — Determination of flexural properties*

ISO 179-1:2000, *Plastics — Determination of Charpy impact properties — Part 1: Non-instrumented impact test*

ISO 291:1997, *Plastics — Standard atmospheres for conditioning and testing*

ISO 306:—[3)], *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)*

ISO 489:1999, *Plastics — Determination of refractive index*

ISO 527-1:1993, *Plastics — Determination of tensile properties — Part 1: General principles*

1) To be published. (Revision of ISO 75-1:1993)

2) To be published. (Revision of ISO 75-2:1993)

3) To be published. (Revision of ISO 306:1994)

ISO 527-2:1993, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 877:1994, *Plastics — Methods of exposure to direct weathering, to weathering using glass-filtered daylight, and to intensified weathering by daylight using Fresnel mirrors*

ISO 1133:—[4], *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics*

ISO 1183-1:—[5], *Plastics — Methods for determining the density of non-cellular plastics — Part 1: Immersion method, liquid pyknometer method and titration method*

ISO 1183-2:—[5], *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

ISO 1628-6:1990, *Plastics — Determination of viscosity number and limiting viscosity number — Part 6: Methyl methacrylate polymers*

ISO 2039-2:1987, *Plastics — Determination of hardness — Part 2: Rockwell hardness*

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

ISO 2859-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 4582:1998, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources*

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

ISO 4892-4:1994, *Plastics — Methods of exposure to laboratory light sources — Part 4: Open-flame carbon-arc lamps*

ISO 8257-1:1998, *Plastics — Poly(methyl methacrylate) (PMMA) moulding and extrusion materials — Part 1: Designation system and basis for specifications*

ISO 11359-2:1999, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 13468-1:1996, *Plastics — Determination of the total luminous transmittance of transparent materials — Part 1: Single-beam instrument*

ISO 14782:1999, *Plastics — Determination of haze for transparent materials*

3 Terms and definitions

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

3.1
homopolymers and copolymers of methyl methacrylate (MMA)
PMMA homopolymers and copolymers of MMA 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

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4) To be published. (Revision of ISO 1133:1997)

5) To be published. (Revision in parts of ISO 1183:1987)

NOTE 1 They may include both unmodified materials and materials containing lubricants, processing aids, UV absorbers, pigments and colorants. They do not include PMMA modified with elastomers (see ISO 8257-1).

NOTE 2 The use of additives will be governed by national environmental legislation and regulations.

3.2
flat PMMA sheets
sheets with two plane, substantially parallel surfaces

4 General requirements

4.1 Protective coverings

Unless otherwise agreed upon by the interested parties, the surfaces of the sheet, as delivered, shall be protected by suitable materials, for example kraft paper secured with a water-soluble or pressure-sensitive adhesive, or a polyethylene film, which are readily removable without causing surface contamination or damage.

4.2 Appearance

4.2.1 Surface defects

The sheet shall have a smooth surface. There shall be no scratches, marks or other surface defects larger than 4 mm^2 each anywhere in the sheet.

4.2.2 Inclusion defects

There shall be no bubbles, foreign-matter inclusions, cracks or other defects that could adversely affect the performance of the sheet in its intended application. In the case of inclusions, there shall also be none which are larger than 2 mm^2 each anywhere in the sheet.

4.2.3 Classification of defects

The area of any defect found in the sheets shall be classified as specified in Table 1. Each defect shall be considered separately.

Table 1 — Classification of defects

Classification	Area of surface defect	Area of inclusion defect
Negligible	Less than 2 mm^2	Less than 1 mm^2
Acceptable	2 mm^2 to 4 mm^2	1 mm^2 to 2 mm^2

4.2.4 Distribution of defects

4.2.4.1 There shall not be a significant number (for the application) of small defects, each of which is defined as negligible in Table 1, within 1 m^2 anywhere in the sheet. What constitutes a significant number shall be agreed between the interested parties.

4.2.4.2 No defect defined as acceptable in Table 1 shall be within 500 mm of another acceptable defect anywhere in or on the sheet.

4.3 Colour

The colour distribution shall be homogeneous, unless otherwise specified. Variations in colour shall be agreed upon between the interested parties.

4.4 Dimensions

4.4.1 Length and width

The length and width of the sheet shall be agreed upon between the interested parties. For cut sheets, the tolerances for each sheet shall be as specified in Table 2.

Table 2 — Tolerances on length and width of cut sheets

Length or width mm	Tolerance mm
Up to 1 000	$^{+3}_{0}$
From 1 001 to 2 000	$^{+6}_{0}$
From 2 001 to 3 000	$^{+9}_{0}$
3 001 and over	$^{+0,3\ \%}_{0}$

4.4.2 Thickness

The thickness tolerance for sheets in the range from 1,5 mm to less than 3 mm shall be $\pm$ 10 %; for sheets from 3 mm to 20 mm thick, it shall be $\pm$ 5 %.

The tolerances apply within each sheet and from sheet to sheet.

4.4.3 Deviation of shape from rectangular

The difference Δl between the lengths of the two diagonals of the rectangular sheet, expressed in millimetres, shall be less than $3{,}5 \times 10^{-3} \times b$ (where b is the width, in millimetres, of the sheet, measured perpendicular to the direction of extrusion) down to a lower limit of 2 mm (i.e. with shorter widths, the difference Δl does not have to be less than 2 mm).

4.4.4 Conditions of measurement

Measurements of dimensions shall be made at room temperature, except that, in cases of dispute, measurements shall be made under standard conditions, as specified in ISO 291. For measurements made under ambient conditions, due allowance shall be made for dimensional changes due to the differences in temperature and relative humidity between test locations.

4.5 Basic and other properties

4.5.1 Basic properties

The basic mechanical, thermal and optical properties of sheets shall be as specified in Table 3.

4.5.2 Other properties

Other properties of sheets shall be agreed upon between the interested parties. Examples of, and test methods for, such properties are presented in Table 4.

Table 3 — Basic properties of PMMA extruded sheets — Required values

Property	Unit	Test method	Required value	Subclause
Tensile strength	MPa	ISO 527-2/1B/5	min. 60	5.5.2
Tensile strain	%	ISO 527-2/1B/5	min. 2	5.5.2
Modulus of elasticity in tension	MPa	ISO 527-2/1B/1	min. 2 900	5.5.2
Charpy impact strength (unnotched)	kJ/m^2	ISO 179-1/1fU	min. 8	5.5.3
Vicat softening temperature	°C	ISO 306:—, method B50	min. 88	5.6.1
Dimensional change on heating (shrinkage):				
Thickness, t (mm)				
$1{,}5 \leqslant t < 2$	%	Annex B	max. 15	5.6.3
$2 \leqslant t < 3$	%	Annex B	max. 12	5.6.3
$3 \leqslant t \leqslant 20$	%	Annex B	max. 7	5.6.3
Total luminous transmittance:[a]				
Thickness, t (mm)				
$t < 12$	%	ISO 13468-1	min. 91	5.8.1
$12 \leqslant t < 20$	%	ISO 13468-1	min. 90	5.8.1
Light transmittance at 420 nm (thickness 3 mm)[a]				
— before exposure to xenon lamp	%	Annex A	min. 90	5.8.3
— after exposure to xenon lamp for 1 000 h (ISO 4892-2:1994, method A)	%	Annex A	min. 88	5.8.3

[a] For transparent, colourless material.

Table 4 — Other properties of PMMA extruded sheets — Typical values

Property	Unit	Test method	Typical value	Subclause
Flexural strength	MPa	ISO 178	100 to 115	5.5.1
Rockwell hardness		ISO 2039-2	90 to 95	5.5.4
Linear expansion coefficient	K^{-1}	ISO 11359-2	7×10^{-5}	5.6.4
Temperature of deflection under load	°C	ISO 75-2/A	80 to 101	5.6.2
Melt mass-flow rate	g/10 min	ISO 1133:— (230 °C/3,8 kg)	0,5 to 3,0	5.9.5
Viscosity number	ml/g	ISO 1628-6	55 to 88	5.9.4
Haze[a]	%	ISO 14782	0,5 to 2	5.8.2
Refractive index, n_D^{23}		ISO 489:1999, method A	1,49	5.8.4
Density [a, b]	g/cm^3	ISO 1183-1:—, method A or C, or ISO 1183-2	1,19	5.9.1
Water absorption	%	ISO 62:1999, method 1 (24 h, 23 °C)	0,5[c]	5.9.2

[a] For transparent, colourless material.

[b] Coloured sheets may have a higher value.

[c] Value reported refers to a square specimen of edge 50 mm and thickness 3 mm.

5 Test methods

5.1 General

5.1.1 Sampling

The sampling procedure shall be agreed upon between the interested parties. The sampling procedure given in ISO 2859-1 is widely accepted and frequently used. Hence it is recommended.

5.1.2 Conditioning and testing atmospheres

Conditioning of specimens (48 h) and tests shall be carried out in accordance with ISO 291 at 23 °C ± 2 °C and (50 ± 5) % relative humidity, except for the Vicat softening temperature and the temperature of deflection under load (see 5.6.1 and 5.6.2).

5.1.3 Preparation of test specimens

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

When it is necessary to machine the sheet to the thickness required for a particular test method, one original surface shall be left intact.

5.1.4 Specimen thickness

When the sheet has a thickness less than that required for the specimens in a particular test method, specimens having the thickness of the sheet shall be used.

5.2 Appearance

Defects and their distribution shall be evaluated by inspecting the sheet illuminated by daylight or by a daylight-type fluorescent lamp with a colour temperature of 6 500 K ± 650 K and a power rating of not less than 40 W.

5.3 Colour

Colour differences between a reference material (standard) and the test sample shall be determined by methods agreed upon by the interested parties.

5.4 Dimensions

5.4.1 The length and width shall be measured to the nearest 1,0 mm, in accordance with 4.4.4, using a graduated rule.

5.4.2 The thickness shall be measured to the nearest 0,05 mm, in accordance with 4.4.4, using a calibrated micrometer or dial gauge, or an ultrasonic probe. Measurements shall be carried out at not less than 100 mm from the sheet edge.

5.5 Mechanical properties

5.5.1 The flexural properties shall be determined in accordance with ISO 178, using, when possible, a 4-mm-thick specimen. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 5.1.4). The original surface shall be put under tension whenever the specimen has been machined to the specified dimensions.

5.5.2 The tensile properties shall be determined in accordance with ISO 527-1 and ISO 527-2, using type 1B specimens. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 5.1.4). The test speed for tensile strength and for tensile strain at break shall be 5 mm/min ± 1 mm/min and for the modulus of elasticity in tension 1 mm/min ± 0,2 mm/min.

5.5.3 The Charpy impact strength shall be determined in accordance with ISO 179-1/1fU, using the standard unnotched bar (dimensions of the specimen 80 mm × 10 mm × 4 mm). Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 5.1.4). The pendulum shall strike the surface that is opposite to the original one if the specimen has been machined to the specified dimensions.

5.5.4 The Rockwell hardness shall be determined in accordance with ISO 2039-2, scale M, on the original extruded surface.

5.6 Thermal properties

5.6.1 The Vicat softening temperature shall be determined in accordance with ISO 306:—, method B50, using the original extruded surface. The rate of heating shall be 50 °C/h ± 5 °C/h. Before the test, the specimens shall be conditioned for 24 h at 80 °C ± 2 °C and cooled to room temperature in a desiccator.

5.6.2 The temperature of deflection under load shall be determined in accordance with ISO 75-1:— and ISO 75-2:—, method A. Specimens shall be cut so that they are oriented perpendicular to the machine direction (see also 5.1.4). Before the test, the specimens shall be conditioned for 16 h to 24 h at 80 °C ± 2 °C and cooled to room temperature in a desiccator. Measurements shall not be carried out on specimens with a thickness below 3 mm.

5.6.3 The dimensional change on heating (shrinkage) shall be determined by the method described in Annex B.

5.6.4 The linear expansion coefficient shall be determined in accordance with ISO 11359-2.

5.7 Flammability

The flammability and burning properties shall be determined in accordance with national fire regulations.

5.8 Optical properties

5.8.1 The total luminous transmittance shall be determined using illuminant D_{65} in accordance with ISO 13468-1.

5.8.2 Haze shall be determined in accordance with ISO 14782.

5.8.3 The light transmittance at 420 nm, before and after exposure for 1 000 h to a xenon lamp in accordance with ISO 4892-2:1994, method A, shall be determined in accordance with Annex A. By agreement between the interested parties, the light transmittance may alternatively be determined after exposure to a carbon-arc lamp (see ISO 4892-4).

5.8.4 The refractive index shall be determined in accordance with ISO 489:1999, method A.

5.9 Other properties

5.9.1 The density shall be determined in accordance with ISO 1183-1:—, method A or C, or ISO 1183-2.

5.9.2 The water absorption shall be determined in accordance with ISO 62:1999, method 1 (24 h at 23 °C).

5.9.3 The natural-weathering performance shall be determined in accordance with ISO 877; the resistance to exposure to artificial light shall be determined in accordance with ISO 4892-2:1994, method A. Changes in colour and properties after exposure shall be determined in accordance with ISO 4582. The details of these tests shall be agreed upon between the interested parties.

5.9.4 The viscosity number shall be determined in accordance with ISO 1628-6.

5.9.5 The melt mass-flow rate shall be determined in accordance with ISO 1133:—, using a test temperature of 230 °C and a nominal load of 3,8 kg.

6 Retest and rejection

If any failure occurs, the material may be retested by agreement between the interested parties.

Annex A
(normative)

Determination of light transmittance at 420 nm

A.1 Apparatus

The instrument used for this determination is a spectrophotometer.

The light source of the spectrophotometer shall produce a continuous light spectrum in the range of wavelengths between 330 nm and 780 nm (tungsten lamp).

The wavelength accuracy shall be ± 3 nm and the reproducibility ± 2 nm.

A.2 Specimens

Cut three specimens from the sheet and clean them. The dimensions of the sheet shall be compatible with the spectrophotomer utilized for the measurements. The measurements shall give the total transmittance of a surface area of at least 1 cm^2.

A.3 Procedure

The optical axis in which the measurements are made shall be normal to the specimen.

Before the measurements, calibrate the spectrophotometer in accordance with the manufacturer's instructions.

Place the specimen in the instrument and read the value of the transmittance at 420 nm. Calculate the average transmittance of the three specimens.

A.4 Test report

The test report shall include the following:

a) the average light transmittance at 420 nm;

b) the thickness of the specimens.

Annex B
(normative)

Determination of dimensional change on heating (shrinkage)

B.1 Specimens

Cut three square specimens of side 100 mm ± 2 mm from the sample sheet at positions approximately equally spaced across the width of the sample.

Dry the specimens at 70 °C ± 2 °C for 48 h and then allow them to cool to room temperature (18 °C to 28 °C; in cases of dispute 23 °C ± 2 °C) in a desiccator. For the purposes of on-line quality control testing, this drying stage may be omitted, but in cases of dispute it is required.

Mark on each specimen the extrusion direction and then mark with a pair of compasses a circle measuring 100 mm ± 1 mm across. Mark on the circle two diameters, one perpendicular and the other parallel to the extrusion direction. Measure the lengths of these diameters to the nearest 0,05 mm.

B.2 Heating procedure

Place the specimens horizontally on a plate on a shelf in an oven maintained at 160 °C ± 2 °C. Take suitable precautions to avoid the specimens sticking to the plate: for example, cover the plate with a layer of talc. The heating time, which depends on the thickness of the sheet, shall be as given in Table B.1.

Table B.1 — Heating time

Thickness mm	Time min
1,5 to 5	60
> 5	75

NOTE When the specimen warps on heating and its dimensions are difficult to measure, warping can be reduced by sprinkling a light covering of talc over an aluminium sheet of for example 0,5 mm thickness, placing the specimen on the sheet and placing a frame-like spacer, which is somewhat larger and thicker than the specimen, around the specimen, leaving room for the specimen to expand. Then sprinkle a light covering of talc over the specimen, place a second aluminium sheet over the specimen and spacer, and fasten the two aluminium sheets together lightly with clips.

B.3 Cooling procedure

Allow the specimens to cool to room temperature (18 °C to 28 °C; in cases of dispute 23 °C ± 2 °C) in the desiccator and remeasure the lengths of the two diameters, again to the nearest 0,05 mm.

B.4 Calculation

For each specimen, calculate the change in length of each diameter as a percentage of the initial value. Calculate the average values for the set of three specimens.

B.5 Test report

The test report shall include the following:

a) the results of the individual determinations and their average value, as indicated in Clause B.4;

b) report the presence of bubbles or cracks, and any other change in appearance of the specimens.

ICS 83.140.10

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