INTERNATIONAL STANDARD

ISO 7823-2

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

Part 2:
Melt-calendered extruded sheets

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

Partie 2: Plaques extrudées-calandrées

Reference number
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Foreword

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

This second edition cancels and replaces the first edition (ISO 7823-2:1989), 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: Melt-calendered extruded sheets*

Annexes A and B form an integral part of this part of ISO 7823.

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

Part 2:
Melt-calendered extruded sheets

1 Scope

1.1 This part of ISO 7823 specifies requirements for poly(methyl methacrylate) (PMMA) flat sheets, extruded and melt-calendered from colourless or coloured, transparent, translucent or opaque grades of the materials defined in 3.1.

1.2 The sheet-thickness range covered by this part of ISO 7823 is 1,5 mm to 12 mm.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 7823. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7823 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 62:1980, *Plastics — Determination of water absorption.*

ISO 75-1:1993, *Plastics — Determination of temperature of deflection under load — Part 1: General test method.*

ISO 75-2:1993, *Plastics — Determination of temperature of deflection under load — Part 2: Plastics and ebonite.*

ISO 178:1993, *Plastics — Determination of flexural properties.*

ISO 179:1993, *Plastics — Determination of Charpy impact strength.*

ISO 291:— [1], *Plastics — Standard atmospheres for conditioning and testing.*

ISO 306:1994, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST).*

ISO 489:1983, *Plastics — Determination of the refractive index of transparent plastics.*

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

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

ISO 1133:— [2], *Plastics — Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics.*

ISO 1183:1987, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

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.*

1) To be published. (Revision of ISO 291:1977)
2) To be published. (Revision of ISO 1133:1991)

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

ISO 2859-1:— [3], *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

ISO 4582:— [4], *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, to natural weathering or to artificial light.*

ISO 4607:1978, *Plastics — Methods of exposure to natural weathering.*

ISO 4892-1:1994, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance.*

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

ISO 8257-1:— [5], *Plastics — Poly(methyl methacrylate) (PMMA) moulding and extrusion materials — Part 1: Designation system and basis for specifications.*

ISO 10350:1993, *Plastics — Acquisition and presentation of comparable single-point data.*

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

EN 2155-9:1989, *Aerospace series — Test methods for transparent materials for aircraft glazing — Part 9: Determination of haze.*

3 Definitions

For the purposes of this part of ISO 7823, the following definitions apply.

3.1 homopolymers and copolymers of methyl methacrylate (MMA): PMMA homopolymers and copolymers of MMA containing at least 80 % (*m/m*) of MMA and not more than 20 % (*m/m*) of acrylic ester or other suitable monomers. They 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).

3.2 flat PMMA sheets: Sheets with two plane, substantially parallel surfaces.

4 General requirements

4.1 Protection of surface

Unless otherwise agreed upon by the interested parties, the surfaces of the sheet, as delivered, shall be protected by suitable material, for example kraft paper, secured with a water-soluble or pressure-sensitive adhesive or a polyethylene film, readily removable without contaminating or damaging the surfaces of the sheet.

4.2 Appearance

4.2.1 Surface defects

The sheet shall have a smooth surface. There shall be no surface defects, scratches or marks larger than 5 mm^2 each anywhere in the sheet.

4.2.2 Inclusion defects

There shall be no bubbles, large inclusions, cracks or other defects that could adversely affect the performance of the sheet in its intended application. There shall be no foreign-matter inclusions larger than 4 mm^2 each anywhere in the sheet.

4.2.3 Classification of defects

The areas of defects found in the sheet shall be classified as specified in table 1. Each defect shall be considered separately.

Table 1 — Classification of defects

Classification	Surface defects	Inclusion defects
Negligible	Less than 2 mm^2	Less than 1 mm^2
Acceptable	2 mm^2 to 5 mm^2	1 mm^2 to 4 mm^2

4.2.4 Distribution of defects

4.2.4.1 There shall not be a significant (for the application) amount of fine defects, each of which is defined as negligible in table 1, within 1 m^2 anywhere in the sheet.

3) To be published. (Revision of ISO 2859-1:1989)
4) To be published. (Revision of ISO 4582:1980)
5) To be published. (Revision of ISO 8257-1:1987)

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 between the interested parties.

4.4 Dimensions

4.4.1 Length and width

The length and width of sheets shall be agreed upon by 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

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 1,5 mm to 2,5 mm thick shall be ± 10 %; for sheets 3 mm to 12 mm thick it shall be ± 5 %.

These 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 a 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), but need not be less than 2 mm.

4.4.4 Measurements

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.

5 Basic and other properties

5.1 Basic properties

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

5.2 Other properties

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

6 Test methods

6.1 General

6.1.1 Sampling

The inspection procedure shall be agreed between the interested parties. The sampling inspection procedure of ISO 2859-1 is widely accepted and frequently used. Hence it is recommended for inspection by sampling.

6.1.2 Conditioning and testing atmospheres

Test specimens shall be conditioned (48 h) and tests shall be carried out at 23 °C ± 2 °C and (50 ± 5) % relative humidity in accordance with ISO 291, except for the Vicat softening temperature and the temperature of deflection under load (see 6.6.1 and 6.6.2).

6.1.3 Preparation of specimens

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

6.1.4 Specimen thickness

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

Table 3 — Basic properties of PMMA melt-calendered extruded sheets — Required values

Property	Units	Test method	Required values	Subclause
Tensile strength	MPa	ISO 527-2/1B/5	min. 60	6.5.2
Tensile strain	%	ISO 527-2/1B/5	min. 2	6.5.2
Modulus of elasticity in tension	MPa	ISO 527-2/1B/1	min. 2 900	6.5.2
Charpy impact strength (unnotched)	kJ/m^2	ISO 179/1fU	min. 8	6.5.3
Vicat softening temperature	°C	ISO 306, method B50	min. 88	6.6.1
Dimensional change (shrinkage) at elevated temperature				
Thickness, t (mm)				
$1,5 \leqslant t < 2$	%	Annex B	max. 20	6.6.3
$2 \leqslant t < 2,5$	%	Annex B	max. 18	6.6.3
$2,5 \leqslant t < 3$	%	Annex B	max. 12	6.6.3
$3 \leqslant t \leqslant 6$	%	Annex B	max. 10	6.6.3
$6 < t$	%	Annex B	max. 10	6.6.3
Melt flow rate	g/10 min	ISO 1133, cond. 13 (230 °C/3,8 kg)	0,5 to 3,0	6.9.5
Viscosity number	ml/g	ISO 1628-6	55 to 88	6.9.4
Total luminous transmittance[1)]	%	ISO 13468-1	min. 90	6.8.1
Light transmittance at 420 nm (thickness 3 mm)[1)]				
before exposure to xenon lamp (ISO 4892-2)	%	Annex A	min. 90	6.8.3
after exposure to xenon lamp for 1 000 h (ISO 4892-2)	%	Annex A	min. 88	6.8.3

1) For transparent, colourless materials.

Table 4 — Other properties of PMMA melt-calendered extruded sheets — Typical values

Property	Units	Test method	Typical values	Subclause
Flexural strength	MPa	ISO 178	100 to 115	6.5.1
Rockwell hardness		ISO 2039-2	90 to 95	6.5.4
Coefficient of linear expansion	$°C^{-1}$	ISO 10350, table 2	7×10^{-5}	6.6.4
Temperature of deflection under load	°C	ISO 75-2, method A	80 to 101	6.6.2
Haze	%	EN 2155-9	0,5 to 2,0	6.8.2
Refractive index, n_D^{20}		ISO 489, method A	1,49	6.8.4
Density (colourless sheet)[1)]	g/cm^3	ISO 1183, method A, C or D	1,19	6.9.1
Water absorption	mg	ISO 62, method 1 (24 h, 23 °C)	50 [2)]	6.9.2

1) Coloured sheet may have a higher value.

2) Value reported refers to a square specimen of side 50 mm and thickness 3 mm.

6.2 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 at 6 500 K ± 650 K and a power rating of not less than 40 W.

6.3 Colour

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

6.4 Dimensions

6.4.1 The length and width shall be measured to the nearest 1,0 mm in accordance with 4.4.3, using a calibrated rule.

6.4.2 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.

6.5 Mechanical properties

6.5.1 The flexural properties shall be determined in accordance with ISO 178, using, when possible, a 4 mm thick specimen. The original surface shall be the one placed under tension whenever the specimen has been machined to conform with the specified dimensions. Specimens shall be cut so that they are oriented perpendicular to the extrusion direction. (See also 6.1.4.)

6.5.2 The tensile properties shall be determined in accordance with ISO 527-1 and ISO 527-2, using type 1B specimens. The test speed for tensile strength and for tensile strain at break shall be 5 mm/min and for the modulus of elasticity in tension 1 mm/min. Specimens shall be cut so that they are oriented perpendicular to the extrusion direction. (See also 6.1.4.)

6.5.3 The Charpy impact strength shall be determined in accordance with ISO 179/1fU, using the standard unnotched bar (dimensions of the specimen 80 mm × 10 mm × 4 mm). The pendulum shall strike the surface that is opposite to the original one if the specimen has been machined to the specified dimensions. Specimens shall be cut so that they are oriented perpendicular to the extrusion direction. (See also 6.1.4.)

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

6.6 Thermal properties

6.6.1 The Vicat softening temperature shall be determined in accordance with ISO 306, method B, using the original melt-calendered extruded surface. The rate of heating shall be 50 °C/h ± 5 °C/h. Before the test, the specimens shall be conditioned for 16 h at 80 °C ± 2 °C and cooled to room temperature in a desiccator.

6.6.2 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 extrusion direction. (See also 6.1.4.) Before the test, the specimens shall be conditioned for 16 h at 80 °C ± 2 °C and cooled to room temperature in a desiccator. Measurements shall not be carried out on specimens with thicknesses below 3 mm.

6.6.3 The dimensional change during heating (shrinkage) shall be determined by the method described in annex B.

6.6.4 The coefficient of linear expansion shall be determined in accordance with ISO 10350, table 2.

6.7 Flammability

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

6.8 Optical properties

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

6.8.2 Haze shall be determined in accordance with EN 2155-9.

6.8.3 The light transmittance at 420 nm, before and after exposure for 1 000 h to a xenon lamp in accordance with ISO 4892-1 and ISO 4892-2, shall be determined in accordance with annex A. By agreement between the interested parties, the light transmittance may alternatively be determined after exposure to an open-flame carbon-arc lamp.

6.8.4 The refractive index shall be determined in accordance with ISO 489, method A.

6.9 Other properties

6.9.1 The density shall be determined in accordance with ISO 1183, method A, C or D.

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

6.9.3 The natural-weathering performance shall be determined in accordance with ISO 4607; the resistance to exposure to artificial light shall be determined in accordance with ISO 4892-1 and ISO 4892-2. 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.

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

6.9.5 The melt flow rate shall be determined in accordance with ISO 1133, set of conditions No. 13 (test temperature 230 °C, nominal load 3,8 kg).

Annex A
(normative)

Determination of light transmission 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

Three specimens shall be cut from the sheets and cleaned. The dimensions of the sheet shall be compatible with the spectrophotometer used for the measurement. The measurement shall give the total light transmittance of a surface area of at least 1 cm^2.

A.3 Procedure

The measurement shall be made in the optical axis normal to the specimen.

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

Place the first specimen in the instrument and read the value of the transmittance at the wavelength of 420 nm. Repeat with the other two specimens. Calculate the average value for 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 specimen.

Annex B
(normative)

Determination of dimensional change (shrinkage) at elevated temperature

B.1 Cut three square specimens of side 120 mm ± 2 mm from a sample sheet at positions approximately equally spaced across the width of the sheet. 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 these diameters to the nearest 0,05 mm.

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.

B.2 Place the specimens horizontally on a plane plate on a shelf in an oven maintained at 160 °C ± 2 °C. To avoid the specimens sticking to the plate, cover the plate with a layer of talc. The heating time, depending on the thickness of the sheet, shall be as follows:

Thickness (mm)	**Time** (min)
1,5 to 5	60
> 5	75

B.3 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 measure the two diameters of the circle, parallel and perpendicular to the extrusion direction, again to the nearest 0,05 mm.

B.4 For each specimen, calculate the change in length of each diameter, parallel and perpendicular to the extrusion direction, as a percentage of the initial value. Calculate the average values for the set of three specimens.

B.5 In addition to the average change in each diameter, report the presence of bubbles and cracks, and any other change in appearance of the specimens.