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Extruded sheets of impact-modified polystyrene (PS-I) — Requirements and test methods

Plaques extrudées en polystyrène modifié résistant au choc (PS-I) — Exigences et méthodes d'essai

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Contents

Page

Foreword

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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).

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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 14631:1999), of which it constitutes a minor revision.

The change compared to the previous edition are as follows:

— references to ISO 2897-1 have been replaced by ISO 19063-1.

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.

Extruded sheets of impact-modified polystyrene (PS-I) — Requirements and test methods

1 Scope

This document specifies the requirements and test methods for solid flat extruded sheets of impact-modified polystyrene (PS-I) without fillers and reinforcing materials.

This document applies only to thickness 0,25 mm to 20,0 . It also applies to PS-I sheet in roll form.

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 179-1, *Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test*

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

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

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

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

ISO 1043-1, *Plastics — Symbols and abbreviated terms — Part 1: Basic polymers and their special characteristics*

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

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

ISO 2039-1, *Plastics — Determination of hardness — Part 1: Ball indentation method*

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

ISO 6603-1, *Plastics — Determination of multiaxial impact behaviour of rigid plastics — Part 1: Falling dart method*

ISO 11501, *Plastics — Film and sheeting — Determination of dimensional change on heating*

ISO 19063-1, *Plastics — Impact-resistant polystyrene (PS-I) moulding and extrusion materials — Part 1: Designation system and basis for specifications*

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Material

Sheets shall be made of PS-I extrusion compounds designated by ISO 19063-1 without filler and reinforcing material. Extrusion compounds can contain additives such as processing aids, stabilizers, flame protective agents and colorants. Compounds and additives of unknown identity shall not be used.

NOTE Legal conditions can cause a specific choice of extrusion compounds.

See 5.3.3.

5 Requirements

5.1 Appearance

Sheets shall be substantially free from bubbles, voids, cracks, visible impurities and other defects which would make them unfit for the intended use. Surfaces shall be substantially smooth, if not embossed, and free from grooves, sink marks or damages. Colorants shall be homogeneously distributed throughout the material. Slight colour differences based on extrusion compounds and processing are admissible. Admissible variations in any of the above as well as gloss level specifications, if required, shall be agreed between the interested parties. Sheets shall be examined in accordance with 6.3.

5.2 Dimensional tolerances

5.2.1 Thickness

Within any delivery of sheets, the maximum thickness difference from the nominal,

Δh_1, in millimetres shall fall within the range shown in Formula (1):

$$|\Delta h_1| \leq (0{,}03\ \text{mm} + 0{,}04 \times h_n) \quad (1)$$

where h_n is the nominal sheet thickness in millimetres.

Within any individual sheet, the maximum thickness variation from the average actual value, Δh_2, in millimetres, shall fall within the range shown in Formula (2):

$$|\Delta h_2| \leq (0{,}03\ \text{mm} + 0{,}02 \times h_n) \quad (2)$$

Testing shall be in accordance with 6.4.1.

5.2.2 Length and width

Nominal length, l_n, and nominal width, b_n, of sheets shall be agreed between the interested parties. Unless agreed otherwise, the length is in the direction of extrusion. For any individual sheet selected at random from any delivery, the tolerances of length and width shall be in accordance with Table 1. Testing shall be in accordance with 6.4.2.

Table 1 — Tolerances for length (l) and width (b) of sheet

Dimensions in millimetres

Nominal dimension D_n	Tolerances	
	length	width
$D_n \leq 1\,000$	+3 −1	+2 −1
$D_n > 1\,000$	$+ 3 \times 10^{-3} \times l_n$ −1	$+ 2 \times 10^{-3} \times b_n$ −1

For rolled sheets the minimum length is the nominal length.

5.2.3 Rectangularity

For any individual sheet, selected at random from any delivery, the rectangularity tolerance, expressed as the difference of length of diagonals ($|d_1 - d_2|$, see Figure 1), shall fall within the range shown in Formula (3):

$$|d_1 - d_2| \leq 2 \times 10^{-3} \times \sqrt{l_n^2 + b_n^2} \tag{3}$$

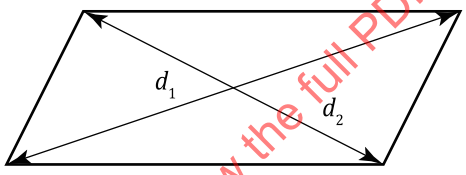

Figure 1 — Difference of length of diagonals ($|d_1 - d_2|$)

Testing shall be in accordance with 6.4.3.

5.2.4 Bow of sheets in rolled form

For sheets in rolled form, a maximum bow of 20 mm in 10 m length is permissible. Testing shall be in accordance with 6.4.4.

5.3 Properties

5.3.1 General

The basic mechanical and thermal properties shall be as described in Table 2. Guide values of other properties of extruded PS-I sheets are given in Annex A, specifically in Tables A.1 and A.2.

5.3.2 Mechanical and thermal properties

Table 2 — Mechanical and thermal properties

Properties	Unit	Minimum requirements for			Test method subclause
		PS-NI[a]	PS-RI[a]	PS-HI[a]	
Mechanical properties					
Tensile stress at yield, σ_Y	MPa	≥20	≥17	≥13	6.6.1
Nominal tensile strain at break, ε_{tB}	%	≥20	≥30	≥35	6.6.2
Modulus of elasticity in tension, E_t	MPa	≥100	≥1 600	≥1 250	6.6.3
Charpy impact strength of notched specimens[b], a_{cU}	kJ/m^2	≥30	≥35	≥40	6.6.4
Charpy impact strength of notched specimens, a_{cN}	kJ/m^2	≥3	≥5	≥7	6.6.5
50 % impact-failure energy, E_{50} at h_n = 4 mm	J	≥10	≥20	≥30	6.6.6
Ball indentation hardness H 358/30	MPa	≥100	≥70	≥60	6.6.7
Thermal properties					
Vicat softening temperature VST B50	°C	75 to 103	70 to 103	65 to 103	6.7.1

[a] ISO 1043-1 symbols: N: normal; R: raised; H: high

[b] Only valid for nominal sheet thickness h_n ≥ 4 mm (see also 6.1.1).

5.3.3 Behaviour after heating

The maximum shrinkage in the direction of extrusion shall not exceed the values given in Table 3 when measured using the method in 6.7.2 and the conditions given in Table 5. The test specimens shall be substantially free from bubbles or cracks after heating.

Table 3 — Maximum shrinkage for thermoforming applications

Nominal thickness h_n	0,25 mm	0,5 mm	1 mm	2 mm	4 mm	8 mm	> 8 mm
Max. shrinkage in the direction of extrusion	35 %	22 %	16 %	12 %	8 %	6 %	not relevant

Intermediate values for other sheet thicknesses can be calculated by interpolation.

5.3.4 Physiological behaviour

Relevant legislation for physiological behaviour shall be taken into consideration.

6 Test methods

6.1 Test specimens

6.1.1 Preparation of test specimens

Representative test specimens shall be cut longitudinally and transversely, evenly distributed over the length and width of the sheet. From a sheet in roll form, a 2 m sample shall be cut from the end of the roll to provide test specimens. Surfaces of the test specimens shall be free from damage and faults in order to avoid notch effects. Should any burrs occur on the test specimens during production these shall be eliminated without damaging the surfaces of the test specimen. If required, the cut edges shall be finished with abrasive paper (grain no. 220 or finer), the direction of abrasion being along the length of the test specimens. If it is necessary to machine the sheet to reduce it to the thickness required, one original surface shall be left intact. In particular, test specimens over 4,2 mm thick intended to be used in the tests described in 6.6.1 to 6.6.6 shall be machined down on one side to a thickness of 4,0 mm ± 0,2 mm in accordance with ISO 2818.

6.1.2 Conditioning

Any production quality control test specimens shall be conditioned for at least 16 h at standard atmosphere (23/50) in accordance with ISO 291. Shorter conditioning times may be used by agreement with the interested parties when it can be shown that there is no significant difference in the results obtained.

6.1.3 Testing

Testing shall be carried out at standard atmosphere (23 °C/50 % RH) in accordance with ISO 291, unless agreed differently between the interested parties or specified in the individual testing standards.

6.2 Delivery condition

Surfaces and cutting edges should be visually examined for bubbles, voids, cracks, notches and swarf.

6.3 Appearance

Where possible, sheets shall be examined for visual defects by transmitted light using a suitable light source. Otherwise, sufficiently bright reflected light should be used. Any defects thus identified shall be compared with the agreed specification (either in written or sample form) and sentenced accordingly.

6.4 Dimensions

6.4.1 Thickness (h)

The thickness, h, shall be measured using suitable calibrated equipment according to Table 4.

Table 4 — Accuracy of equipment

Dimensions in millimetres

Nominal thickness, h_n	Accuracy
$0{,}25 \leq h_n < 1{,}0$	≤ +0,01
$1{,}0 \leq h_n < 10{,}0$	≤ +0,05
$10{,}0 \leq h_n < 20{,}0$	≤ +0,1

6.4.2 Length (l) and width (b)

Length, l, and width, b, shall be measured to the nearest 1 mm using suitable calibrated equipment. Measurement shall be directly on the surface of the sheet and along the cut edge.

6.4.3 Rectangularity

For flat sheets, the rectangularity expressed as the difference of length of the diagonals (according to Figure 1: $|d_1 - d_2|$) shall be measured to the nearest 1 mm using a calibrated ruler or tape measure.

6.4.4 Bow of sheets in rolled form

For sheets in rolled form, the bowing shall be determined after the sheets pulled freely from the rolls and measured against a straight line. The bow shall be measured to the nearest 1 mm using a suitable calibrated equipment.

6.5 Density

Density shall be determined in accordance with ISO 1183-1 and ISO 1183-2.

6.6 Mechanical properties

6.6.1 Tensile stress at yield (σ_Y)

Tensile stress at yield, σ_Y, shall be determined using at least five test specimens type 1B in each direction in accordance with ISO 527-1 and ISO 527-2 using a test speed of 50 mm/min ± 5 mm/min.

6.6.2 Nominal tensile strain at break (ε_{tB})

Nominal tensile strain at break, ε_{tB}, shall be determined using at least five test specimens type 1B in each direction in accordance with ISO 527-1 and ISO 527-2 using a test speed of 50 mm/min ± 5 mm/min. The nominal tensile strain at break shall be stated by the relative displacement of the grips.

6.6.3 Modulus of elasticity in tension (E_t)

Modulus of elasticity in tension, E_t, shall be determined using at least five test specimens type 1B in each direction in accordance with ISO 527-1 and ISO 527-2 using a test speed of 1 mm/min ± 0,2 mm/min.

6.6.4 Charpy impact strength of unnotched specimens (a_{cU})

To determine the influence of surface effects originating in processing conditions, Charpy impact strength of unnotched specimens, a_{cU}, for nominal sheet thicknesses $h \geq 4$ mm shall be determined flatwise in accordance with ISO 179-1/1fU using at least 10 test specimens cut in each direction. If the test specimens were machined down to the required thickness, the impact shall be applied to the machined surface.

6.6.5 Charpy impact strength of notched specimens (a_{cN})

To determine the influence of surface effects originating in processing conditions, Charpy impact strength of notched specimens, a_{cN}, for nominal sheet thicknesses $h_n \geq 4$ mm shall be determined flatwise in accordance with ISO 179-1/1fA using at least 10 double-notched test specimens cut in each direction. If the test specimens were machined down to the required thickness, the impact shall be applied to the machined surface.

6.6.6 Multiaxial impact strength

Multiaxial impact strength shall be determined as 50 % impact-failure energy, E_{50}, in accordance with ISO 6603-1 falling dart method A.

6.6.7 Ball indentation hardness

Ball indentation hardness H 358/30 shall be determined in accordance with ISO 2039-1.

6.7 Thermal properties

6.7.1 Vicat softening temperature

Vicat softening temperature VST B50 shall be determined in accordance with ISO 306. The thickness of the test specimens shall be equal to the thickness of the sheet, except as follows.

a) If the thickness exceeds 6,5 mm, the test specimens shall be reduced in thickness to between 3 mm to 6,5 mm by machining one surface (see ISO 2818), the other surface being left intact. The test surface shall be the intact one.

b) If the thickness of the sheet is less than 3 mm, not more than three pieces shall be stacked together in direct contact to give a total thickness between 3 mm and 6,5 mm and the thickness of the upper (measured) piece shall be at least 1,5 mm. Stacking of pieces of lesser thickness does not always give the same test result.

6.7.2 Determination of shrinkage after heating

Determination of shrinkage after heating shall be done applying the principles of ISO 11501. The principle of test procedure is described as follows.

a) Place a metal container containing a kaolin or talc bed in a circulating-air oven and control the temperature such that the bed is within the specified temperature limits.

b) Measure the initial length between the reference marks on each test specimen in the longitudinal direction.

c) Heat the test specimens for a specified period of time at a specified temperature on the kaolin or talc bed in the circulating-air oven.

d) Measure the distance between the longitudinal reference marks again after cooling, and calculate the change in the lengths.

At least three test specimens shall be cut with dimensions of 100 mm × 100 mm from the centre and both sides of the sheet. The side test specimens shall be taken at least 50 mm from the edge of the sheet. The extrusion direction of the sheet shall be marked on the test specimens at a minimum of two places. The initial length, L_0, in the direction of extrusion shall be measured on the marked places with an accuracy of 0,1 mm after conditioning of the test specimens in accordance with ISO 291. The test specimens shall be covered with kaolin or talc and shall be placed flat on the kaolin or talc bed in a circulating-air oven. The temperature and duration of tests are shown in Table 5.

Table 5 — Thermal treatment of PS-I sheet

Nominal sheet thickness h_n mm	Test temperature °C	Duration of test[a] min
$0{,}25 \le h_n < 1{,}0$	150 ± 2	10 ± 1
$1{,}0 \le h_n < 4{,}0$	150 ± 2	20 ± 1
$4{,}0 \le h_n < 8{,}0$	150 ± 2	30 ± 1
$8{,}0 \le h_n$	150 ± 2	60 ± 1

[a] The heating period until the test temperature is achieved is not included.

After removal of the test specimens from the circulating-air oven and cooling down to room temperature in accordance with ISO 291, the length, L, shall be measured at the marked places. The shrinkage, ΔL, shall be calculated on each marked place using Formula (4):

$$\Delta L = \frac{L - L_0}{L_0} \times 100 \tag{4}$$

where

ΔL is the shrinkage after heating, in percent;

L_0 is the original dimension before heating, in millimetres;

L is the dimension after heating, in millimetres.

The arithmetic average shall be calculated of all ΔL for all test specimens.

If the test specimens show a tendency to curl or become wavy, this deformation can be limited by placing a 3 mm to 4 mm thick glass sheet over the test specimens at a distance of about 3 mm. The glass plate shall rest on spacers (e.g. made from cork) of equal height; weights shall be applied, if necessary, to hold the glass plate in place. The weights and glass plate shall be heated to the appropriate temperature given in Table 5.

Each sample shall be examined after the test to ensure that no excessive cracks or bubbles have developed, as agreed between the interested parties.