INTERNATIONAL STANDARD

ISO 14631

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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) — Prescriptions et méthodes d'essai

Reference number
ISO 14631:1999(E)

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 14631 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 11, *Products*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this standard, read “...this European Standard...” to mean “...this International Standard...”.

Annexes A and B of this International Standard are for information only.

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Foreword

The text of EN ISO 14631:1999 has been prepared by Technical Committee CEN/TC 249 "Plastics", the secretariat of which is held by IBN, in collaboration with Technical Committee ISO/TC 61 "Plastics".

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 1999, and conflicting national standards shall be withdrawn at the latest by August 1999.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Annex A and Annex B are informative.

1 Scope

This standard specifies the requirements and test methods for solid flat extruded sheets of impact-modified polystyrene (PS-I[1]) without fillers and reinforcing materials. This standard applies only to thickness 0,25 mm to 20,0 mm in accordance with clause 3. This standard also applies to PS-I sheet in roll form.

2 Normative References

This European standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references subsequent amendments to or revisions of any of these publications apply to this European standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN ISO 179	Plastics – Determination of Charpy impact strength (ISO 179:1993)
EN ISO 291	Plastics – Standard atmospheres for conditioning and testing (ISO 291:1997)
EN ISO 306	Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST) (ISO 306:1994)
EN ISO 527-1	Plastics – Determination of tensile properties – Part 1: General principles (ISO 527-1:1993 including Corr 1:1994)
EN ISO 527-2	Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics (ISO 527-2:1993 including Corr 1:1994)
EN ISO 2039-1	Plastics – Determination of hardness – Part 1: Ball indentation method (ISO 2039-1:1993)
EN ISO 2818	Plastics – Preparation of test specimens by machining (ISO 2818:1994)
EN ISO 6603-1	Plastics – Determination of multiaxial impact behaviour of rigid plastics – Part 1: Falling dart method (ISO 6603-1:1985)
ISO 1043-1	Plastics – Symbols and abbreviated terms – Part 1: Basic polymers and their special characteristics
ISO 1183	Plastics - Methods for determining the density and relative density of non-cellular plastics
ISO 2897-1	Plastics - Impact-resistant polystyrene (PS-I) moulding and extrusion materials - Part 1: Designation system and basis for specification
ISO 11 501	Plastics – Film and sheeting - Determination of dimensional change on heating

1 Abbreviation PS-I see ISO 1043-1

3 Material

Sheets shall be made of PS-I extrusion compounds designated by ISO 2897-1 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 4.3.3).

4 Requirements

4.1 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 5.3.

4.2 Dimensional tolerances

4.2.1 Thickness

Within any delivery of sheets, the maximum thickness difference from the nominal, Δh_1, in millimetres shall fall within the range:

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

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:

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

Testing shall be in accordance with 5.4.1.

4.2.2 Length and width

Nominal length ,l_n ,and nominal width ,b_n ,of sheets shall be agreed between the interested parties. Unless agreed differently, 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 5.4.2.

Table 1: Tolerances for length ,*l*, and width ,*b*, of sheet

Dimensions in millimetres

Nominal dimension D_n	Tolerances	
	length	width
$D_n \leq 1000$	+ 3 - 1	+ 2 - 1
$D_n > 1000$	+ 3 x 10^{-3} x l_n - 1	+ 2 x 10^{-3} x b_n - 1

For rolled sheets the minimum length is the nominal length.

4.2.3 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:

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

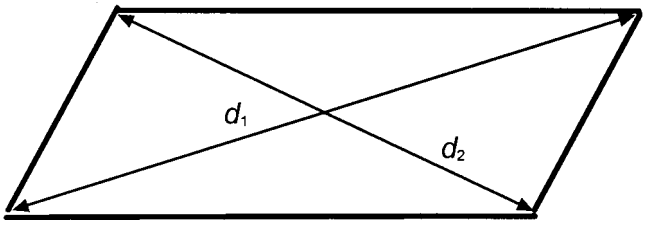


Figure 1: Difference of length of diagonals ($|d_1 - d_2|$)

Testing shall be in accordance with 5.4.3.

4.2.4 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 5.4.4.

4.3 Properties

The basic mechanical and thermal properties shall be as described below. Guide values of other properties of extruded PS-I sheets are given in tables A.1 and A.2 of the informative annex A.

4.3.1 Mechanical and thermal properties

Table 2: Mechanical and thermal properties

Properties	Unit	Minimum requirements for			Test method subclause
		PS-NI*	PS-RI*	PS-HI*	
Mechanical properties					
Tensile stress at yield, σ_Y	MPa	≥ 20	≥ 17	≥ 13	5.6.1
Nominal tensile strain at break, ε_{tB}	%	≥ 20	≥ 30	≥ 35	5.6.2
Modulus of elasticity in tension, E_t	MPa	≥ 2100	≥ 1600	≥ 1250	5.6.3
Charpy impact strength of unnotched specimens, a_{cU}**	kJ/m²	≥ 30	≥ 35	≥ 40	5.6.4
Charpy impact strength of notched specimens, a_{cN}	kJ/m²	≥ 3	≥ 5	≥ 7	5.6.5
50 % impact-failure energy, E_{50} at h_n = 4 mm	J	≥ 10	≥ 20	≥ 30	5.6.6
Ball indentation hardness H 358/30	MPa	≥ 100	≥ 70	≥ 60	5.6.7
Thermal properties					
Vicat softening temperature VST/B/50	°C	75 to 103	70 to 103	65 to 103	5.7.1
* ISO 1043-1 symbols: N: normal; R: raised; H: high ** Only valid for nominal sheet thickness $h_n \geq 4$ mm (see also 5.1.1)					

4.3.2 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 5.7.2 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.

4.3.3 Physiological behaviour

Relevant legislation for physiological behaviour shall be taken into consideration.

5 Test Methods

5.1 Test specimens

5.1.1 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 5.6.1 to 5.6.6 shall be machined down on one side to a thickness of 4,0 ± 0,2 mm in accordance with EN ISO 2818.

5.1.2 Conditioning

Any production quality control test specimens shall be conditioned for at least 16 h at standard atmosphere (23/50) in accordance with EN 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.

5.1.3 Testing

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

5.2 Delivery condition

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

5.3 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.

5.4 Dimensions

5.4.1 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
$0{,}25 \leq h_n < 1{,}0$	$\leq + 0{,}01$
$1{,}0 \leq h_n < 10{,}0$	$\leq + 0{,}05$
$10{,}0 \leq h_n < 20{,}0$	$\leq + 0{,}1$

5.4.2 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.

5.4.3 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.

5.4.4 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.

5.5 Density

Density shall be determined in accordance with ISO 1183.

5.6 Mechanical properties

5.6.1 Tensile stress at yield (σ_Y)

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

5.6.2 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 EN ISO 527-1 and EN 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.

5.6.3 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 wih EN ISO 527-1 and EN ISO 527-2 using a test speed of 1 mm/min ± 0,2 mm/min.

5.6.4 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 $h_n \geq 4$ mm shall be determined flatwise in accordance with EN ISO 179/1fU 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.

5.6.5 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 EN ISO 179/1fA 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.

5.6.6 Multiaxial impact strength

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

5.6.7 Ball indentation hardness

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

5.7 Thermal properties

5.7.1 Vicat softening temperature

Vicat softening temperature VST/B/50 shall be determined in accordance with EN 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 EN 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.

5.7.2 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 x 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_O, 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 EN 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* min
$0,25 \leq h_n < 1,0$	150 ± 2	10 ± 1
$1,0 \leq h_n < 4,0$	150± 2	20 ± 1
$4,0 \leq h_n < 8,0$	150 ± 2	30 ± 1
$8,0 \leq h_n$	150 ± 2	60 ± 1
* 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 EN ISO 291, the length ,L, shall be measured at the marked places. The shrinkage ,ΔL, shall be calculated on each marked place using the equation (4):

$$\Delta L = \frac{L - L_o}{L_o} \times 100 \qquad (4)$$

Where ΔL is the shrinkage after heating, in percent
L_O is the original dimension before heating, in millimetres
L is the dimension after heating, in millimetres

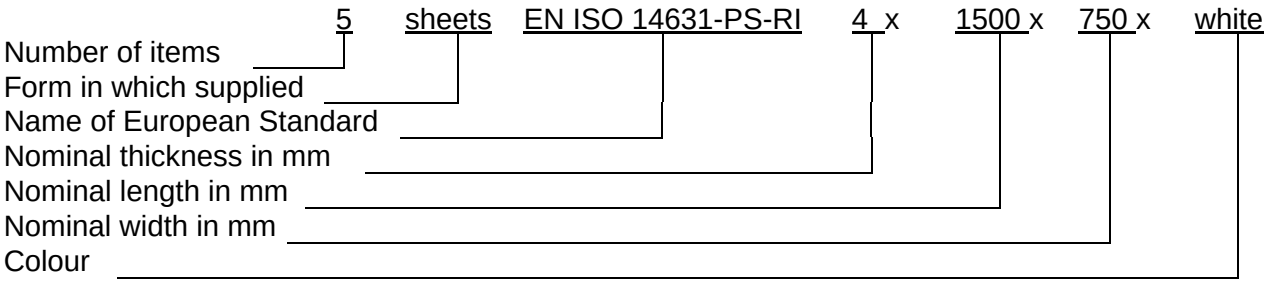
The arithmetic average shall be calculated of all ΔL for all test specimens.

If the test specimens shows 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.

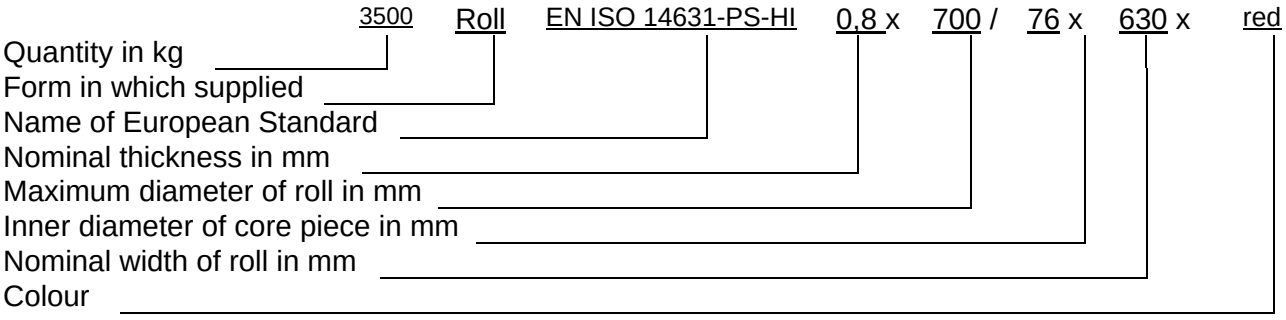
Each sample shall be examined after the test to ensure that no excessive cracks or bubbles have developed, as agreed between the interested parties.

6 Designation

6.1 Example for PS-I-sheets



6.2 Example for PS-I sheets in roll form



7 Marking

Only sheets or rolls that conform to this standard are allowed to be marked with the following information:

- the manufacturer's name, trade mark or identification mark
- the number of this European standard, EN ISO 14 631
- material designation
- date of manufacture/batch number

Annex A (informative)
Additional guide values

Table A.1: Guide values for further properties of PS-I extrusion materials

Properties	Unit	Typical value	Test method
Density, ρ	g/cm³	1,00 to 1,20	ISO 1183
Coefficient of thermal expansion, α (23–80 °C)	10^{-4}/K	approx. 1	ISO 7991
Thermal conductivity, λ, method A	W/mK	approx. 0,17	ISO 8302
Surface resistivity, ρ_S	Ω	approx. 10^{14}	IEC 60093
Volume resistivity, ρ_D	Ω·m	approx. 10^{13}	IEC 60093
Water absorption, W_A ,up to saturation at 23 °C	% weight	< 0,1	ISO 62

Table A.2: Guide values for further mechanical properties of PS-I extrusion materials

Mechanical properties	Unit	PS-NI*	PS-RI*	PS-HI*	Test methods
Charpy impact strength of un-notched specimens, a_{cU} **	kJ/m²	≥ 20	≥ 30	≥ 35	EN ISO 179/1eU
Charpy impact strength of notched specimens, a_{cN} **	kJ/m²	≥ 3	≥ 4	≥ 5	EN ISO 179/1eA
Total penetration energy, E_{tot} at h_n = 4 mm	J	≥ 8	≥ 16	≥ 24	EN ISO 6603-2

* ISO 1043-1 symbols: N: normal; R: raised; H: high
** Only valid for nominal sheet thicknesses h_n ≥ 4 mm (see also 5.1.1), determined edgewise

Annex B (informative)
Bibliography

ISO 62	Plastics – Determination of water absorption
IEC 60093	Methods of test for insulating materials for volume resistivity and surface resistivity of solid electrical insulating materials
EN ISO 179	Plastics – Determination of Charpy impact strength (ISO 179:1993)
ISO 1183	Plastics – Methods for determining the density and relative density of non-cellular plastics
EN ISO 6603-2	Plastics – Determination of multiaxial impact behaviour of rigid plastics – Part 2: Instrumented Puncture Test (ISO 6603-2:1989)
ISO 7991	Glass – Determination of coefficient of mean linear thermal expansion
ISO 8302	Thermal insulation – Determination of steady-state thermal resistance and related properties – Guarded hot plate apparatus

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