INTERNATIONAL STANDARD

ISO 15013

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Extruded sheets of polypropylene (PP) — Requirements and test methods

Plaques extrudées en polypropylène (PP) — Prescriptions et méthodes d'essai

Reference number
ISO 15013:1998(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 15013 was prepared by the European Committee for Standardization (CEN) in collaboration with ISO Technical Committee 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 ...".

Annex A forms an integral part of this International Standard.

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The text of EN ISO 15013:1998 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of an identical text or by endorsement, at the latest by June 1999, and conflicting national standards shall be withdrawn at the latest by June 1999.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 is normative.

1 Scope

This standard specifies the requirements and test methods for solid flat extruded sheets of polypropylene homopolymers (PP- H) and polypropylene copolymers (PP- B and PP- R) without fillers or reinforcing materials. This standard applies only to thicknesses of 0,5 mm to 40 mm. This standard also applies to PP sheet in rolled 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 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)
ISO 1 133	Plastics - Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics
EN ISO 1 873- 1	Plastics - Polypropylene (PP) moulding and extrusion materials Part 1: Designation system and basis for specifications (ISO 1873-1:1995)
EN ISO 2 818	Plastics - Preparation of test specimens by machining (ISO 2818:1994)
ISO 4 577	Plastics - Polypropylene and propylene - copolymers- Determination of thermal oxidative stability in air - Oven method
ISO/ TR 9 080	Thermoplastics pipes for the transport of fluids- Methods of extrapolation of hydrostatic stress rupture data to determine the long - term hydrostatic strength of thermoplastics pipe materials

3 Material

Sheets consist of PP extrusion compounds designated by EN ISO 1 873-1 without fillers or reinforcing materials. Extrusion compounds can contain additives such as processing aids, stabilisers, flame protective agents and colorants.

Compounds and additives of unknown identity shall not be used.

NOTE: Legal requirements 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 and free from sharp grooves, sink marks or damage.
Colorants shall be homogeneously distributed throughout the material. Slight colour differences due to the particular extrusion compound or processing procedure used are admissible. Admissible variations in any of the above 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 individual sheet, referring to the nominal thickness, the tolerance on thickness shall be:

$$|\Delta h| \leq \pm |(0{,}08 \text{ mm} + 0{,}03 \times h_n)| \qquad (1)$$

Where:

Δh is the tolerance on thickness, in millimetres
h_n is the nominal thickness, in millimetres

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 shall be in the direction of extrusion.
For any individual sheet selected at random from any delivery, the tolerances on length and width shall be in accordance with table 1. Testing shall be in accordance with 5.4.2.

Table 1: Tolerances for length and width of sheet

Dimensions in millimetres

Nominal value of dimension, D_n	Tolerances	
	Length	Width
$D_n \leq 500$	+ 2 - 1	+ 2 - 1
$500 < D_n \leq 1\,000$	+ 3 - 1	+ 3 - 1
$1\,000 < D_n \leq 1\,500$	+ 4 - 1	+ 4 - 1
$1\,500 < D_n \leq 2\,000$	+ 6 - 1	+ 4 - 1
$2\,000 < D_n \leq 3\,000$	+ 8 - 1	+ 6 - 1
$3\,000 < D_n \leq 4\,000$	+ 11 - 1	+ 7 - 1

For rolled sheets the minimum length shall be the nominal length.

4.2.3 Rectangularity

For any individual sheet, selected at random from any delivery, the rectangularity tolerance expressed as the difference between the length of the diagonals ($|d_1 - d_2|$, see figure 1) shall be in accordance with table A.1 of annex A (normative).

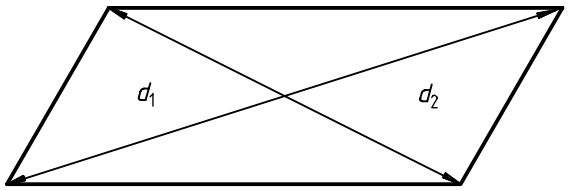

Figure 1: Difference between diagonals ($|d_1 - d_2|$)

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 metres length is permissible. Testing shall be in accordance with 5.4.4.

4.3 Properties

4.3.1 Mechanical and thermal properties

Table 2: Mechanical and thermal properties

Properties	Unit	Requirements (average values)							Test methods subclause
		PP - H sheet group			PP - B sheet group		PP - R sheet group		
		1.1[1)]	1.2	1.3	2.1	2.2	3.1	3.2	
Tensile stress at yield	MPa	≥ 30	≥ 30	≥ 30	≥ 25	≥ 25	≥ 20	≥ 20	5.5
Tensile strain at yield	%	≥ 9	≥ 9	≥ 8	≥ 12	≥ 8	≥ 12	≥ 8	5.5
Modulus of elasticity in tension	MPa	≥1 200	≥1 200	≥1 200	≥1 000	≥1 100	≥ 700	≥800	5.6
Charpy impact strength of notched specimens	kJ/m²	≥ 6	≥ 6	≥ 4	≥ 15	≥ 15	≥ 15	≥ 15	5.7
MFR 190 °C/ 5 kg	g/10 min	0,3 to 0,8	0,3 to 1,2	---	0,3 to 0,8	---	0,3 to 0,8	---	5.8
Heat resistance	°C days	150 ≥ 100	150 ≥ 100	150 ≥ 20	150 ≥ 80	150 ≥ 20	140 ≥ 40	140 ≥ 20	5.9
[1)]Sheets of group 1.1 shall be manufactured from extrusion compounds complying with specific requirements for creep rupture strength defined in accordance with ISO/ TR 9 080 and shall be approved by all interested parties.									

4.3.2 Behaviour after heating

4.3.2.1 Maximum shrinkage for general applications

For general applications, the maximum shrinkage in the direction of extrusion shall be less than three percent after heating. Testing shall be in accordance with 5.10 and table 5.

4.3.2.2 Maximum shrinkage for thermoforming applications

The maximum shrinkage in the direction of extrusion shall not exceed the values given in table 3 when measured using the method in 5.10 and the conditions given in table 6.

Table 3: Maximum shrinkage for thermoforming applications

Nominal thickness, h_n (mm)	0,5	1	2	4	6	8	10	> 10
Maximum shrinkage in the direction of extrusion (%)	60	50	42	34	28	25	22	not applicable

4.3.3 Physiological behaviour

Relevant legislation concerning 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 from locations evenly distributed over the length and width of the sheet.
From a sheet in roll form, a two metre 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 other defects 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 number 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 5.5 to 5.7 shall be machined down on one side to a thickness of 4,0 mm ± 0,2 mm in accordance with EN ISO 2 818.

5.1.2 Conditioning

All test specimens shall be conditioned for at least 16 hours at standard atmosphere (23) in accordance with EN ISO 291. Shorter conditioning times shall be used by agreement between 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) in accordance with EN ISO 291, unless agreed differently between the interested parties or specified differently in the individual testing standards.

5.2 Delivery condition

Sheets should be visually examined when delivered to ensure freedom from mechanical damage or other obvious defects. Sheets can be inspected by means of ultrasonics or X-rays where required.

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 a suitable calibrated equipment according to table 4:

Table 4: Accuracy of equipment

Dimensions in millimetres

Nominal thickness, h_n	Accuracy
$0{,}50 \leq h_n \leq 1{,}00$	$\leq + 0{,}01$
$1{,}00 < h_n \leq 10{,}00$	$\leq + 0{,}05$
$10{,}00 < h_n \leq 40{,}00$	$\leq + 0{,}10$

5.4.2 Length *(l)* and width *(b)*

The length, *l*, and width, *b,* shall be measured to the nearest 1 mm using a suitable calibrated equipment. Measurements shall be made 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 between the 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 bow shall be determined after the sheets have been 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 Tensile stress at yield (σ_y) and tensile strain at yield (ε_y)

Tensile stress at yield, σ_y, and tensile strain at yield, ε_y, shall be determined using at least five type 1B test specimens 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 Modulus of elasticity in tension (E_t)

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

5.7 Charpy impact strength of notched specimens (a_{cn})

Charpy impact strength of notched specimens, a_{cn}, for nominal thicknesses $\geq$ 4 mm shall be determined in accordance with EN ISO 179/ 1eA using at least 10 test specimens in each direction.

5.8 Melt mass-flow rate (*MFR*)

Melt mass-flow rate (*MFR* 190/ 5) shall be determined in accordance with ISO 1 133.

5.9 Heat resistance

Heat resistance shall be determined in accordance with ISO 4 577.

5.10 Determination of shrinkage after heating

At least three test specimens with dimensions of 100 mm x 100 mm shall be cut from the centre and two 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 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 specimens in accordance with EN ISO 291.

The specimens shall be dusted with kaolin and shall be placed flat on a kaolin bed in an oven with air circulation. The temperature and duration of the test are shown in table 5 and table 6.

Table 5: Shrinkage for general applications

Nominal thickness mm	Test temperature °C Sheet groups		Duration of test[1] min
	1.1, 1.2, 1.3, 2.1, 2.2	3.1, 3.2	
$0,5 \leq h_n \leq 2$	150 ± 2	135 ± 2	60 ± 1
$2 < h_n \leq 10$	150 ± 2	135 ± 2	90 ± 1
$10 < h_n \leq 20$	150 ± 2	135 ± 2	120 ± 1
$20 < h_n \leq 40$	150 ± 2	135 ± 2	240 ± 1
[1] The heating period until the test temperature is reached is not included.			

Table 6: Shrinkage for thermoforming applications

Nominal thickness mm	Test temperature °C Sheet groups		Duration of test[1] min
	1.1, 1.2, 1.3, 2.1, 2.2	3.1, 3.2	
$0,5 \leq h_n \leq 1$	170 ± 2	160 ± 2	30 ± 1
$1 < h_n \leq 2$	200 ± 2	185 ± 2	45 ± 1
$2 < h_n \leq 10$	200 ± 2	185 ± 2	60 ± 1
[1] The heating period until the test temperature is reached is not included.			

After removal of the test specimen from the oven and conditioning in accordance with EN ISO 291, the length shall be measured at the marked places.The shrinkage, ΔL, shall be calculated on each marked place using equation (2):

$$\Delta L = \frac{L - L_0}{L_0} \times 100 \qquad (2)$$

Where:

ΔL	is the shrinkage after heating, in percent
L_O	is the initial length in the direction of extrusion before heating, in millimetres
L	is the length in the direction of extrusion after heating, in millimetres

The arithmetic mean shall be calculated of all the values of ΔL for all specimens.

6 Designation

6.1 Example for PP sheets

5 sheets EN ISO 15 013 PP 1.1 - 8 x 2 000 x 1 000 - grey

- Number of items: 5
- Form in which supplied: sheets
- Number of standard: EN ISO 15 013
- Group: PP 1.1
- Nominal thickness in millimetres: 8
- Nominal length in millimetres: 2 000
- Nominal width in millimetres: 1 000
- Colour: grey