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

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Contents

Page

Foreword ... **iv**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **1**

4 Material ... **1**

5 Requirements ... **2**
5.1 Appearance ... 2
5.2 Dimensional tolerances ... 2
5.2.1 Thickness ... 2
5.2.2 Length and width ... 2
5.2.3 Rectangularity ... 3
5.2.4 Bow of sheets in rolled form ... 3
5.3 Properties ... 3
5.3.1 Mechanical and thermal properties ... 3
5.3.2 Behaviour on heating ... 4
5.3.3 Physiological behaviour ... 4

6 Test methods ... **4**
6.1 Test specimens ... 4
6.1.1 Preparation of test specimens ... 4
6.1.2 Conditioning ... 4
6.1.3 Testing ... 4
6.2 Delivery condition ... 4
6.3 Appearance ... 5
6.4 Dimensions ... 5
6.4.1 Thickness, h ... 5
6.4.2 Length, l, and width, b ... 5
6.4.3 Rectangularity ... 5
6.4.4 Bow of sheets in rolled form ... 5
6.5 Tensile stress at yield, σ_y, and tensile strain at yield, ε_y ... 5
6.6 Modulus of elasticity in tension, E_t ... 5
6.7 Charpy impact strength of notched specimens, a_{cn} ... 5
6.8 Melt mass-flow rate (MFR) ... 6
6.9 Heat resistance ... 6
6.10 Determination of shrinkage on heating ... 6

7 Designation and order specification ... **7**
7.1 Example for sheets ... 7
7.2 Example for sheets in rolled form ... 8

8 Marking ... **8**

Annex A (normative) **Requirements for rectangularity** ... **9**

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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 third edition cancels and replaces the second edition (ISO 15013:2007), which has been technically revised. The main changes compared to the previous edition are as follows.

— The minimum value of tensile strain at yield for PP-H group 1.1 in Table 2 has been changed from ≥ 9 % to ≥ 7 %.

— The mandatory Clause 3 (Terms and definitions clause) has been added and subsequent clauses have been renumbered.

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.

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

1 Scope

This document 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 document applies to PP sheet in rolled form. It applies only to thicknesses of 0,5 mm to 40 mm.

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 1: Non-instrumented impact test*

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

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

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

ISO 1133-1, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method*

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

ISO 4577, *Plastics — Polypropylene and propylene-copolymers — Determination of thermal oxidative stability in air — Oven method*

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

ISO 19069-1, *Plastics — Polypropylene (PP) 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 terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Material

Sheets shall consist of PP extrusion compounds as specified in ISO 19069-1, without fillers or reinforcing materials. The extrusion compounds can contain additives such as processing aids, stabilizers, flame

retardants, impact modifiers and colorants. Compounds and additives of unknown identity shall not be used.

NOTE Legal conditions can necessitate a specific choice of extrusion material (see 5.3.3).

5 Requirements

5.1 Appearance

Sheets shall be substantially free from bubbles, voids, cracks, visible impurities and other defects which makes 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 variations due to variations in the extrusion compound or processing conditions are admissible. The exact extent of variations in any of the above shall be agreed between the interested parties. Sheets shall be examined in accordance with 6.3.

5.2 Dimensional tolerances

5.2.1 Thickness

For any individual sheet, the thickness tolerance with reference to the nominal thickness shall be as given by Formula (1):

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

where

Δh is the tolerance on the thickness, in millimetres;

h_n is the nominal thickness, in millimetres.

Testing shall be in accordance with 6.4.1.

5.2.2 Length and width

The nominal length, l_n, and nominal width, b_n, of sheets shall be as 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 6.4.2.

Table 1 — Tolerances on length and width of sheet

Values in millimetres

Nominal 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.

5.2.3 Rectangularity

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

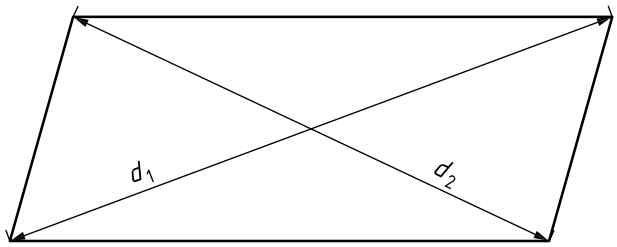

Figure 1 — Difference between lengths of diagonals, $|d_1 - d_2|$

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 a 10 m length is permissible. Testing shall be in accordance with 6.4.4.

5.3 Properties

5.3.1 Mechanical and thermal properties

Requirements for mechanical and thermal properties are given in Table 2.

Table 2 — Mechanical and thermal properties

Property	Unit	Requirements (average values)							Test method subclause
		PP-H			PP-B		PP-R		
		Group 1.1 [a]	Group 1.2	Group 1.3	Group 2.1	Group 2.2	Group 3.1	Group 3.2	
Tensile stress at yield	MPa	≥ 30	≥ 30	≥ 30	≥ 25	≥ 25	≥ 20	≥ 20	6.5
Tensile strain at yield	%	≥ 7	≥ 9	≥ 8	≥ 12	≥ 8	≥ 12	≥ 8	6.5
Modulus of elasticity in tension	MPa	≥ 1 200	≥ 1 200	≥ 1 200	≥ 1 000	≥ 1 100	≥ 700	≥ 800	6.6
Charpy impact strength of notched specimens [b]	kJ/m^2	≥ 6	≥ 6	≥ 4	≥ 15	≥ 15	≥ 15	≥ 15	6.7
MFR (230 °C/2,16 kg)	g/10 min	0,2 to 0,7	0,2 to 1,0	—	0,2 to 0,7	—	0,2 to 0,7	—	6.8
Heat resistance	°C days	150 ≥ 100	150 ≥ 100	150 ≥ 20	150 ≥ 80	150 ≥ 20	140 ≥ 40	140 ≥ 20	6.9

[a] Sheets of group 1.1 shall be manufactured only from extrusion compounds approved by all interested parties.

[b] Only valid for nominal sheet thicknesses h_n ≥ 4 mm.

5.3.2 Behaviour on heating

5.3.2.1 Maximum shrinkage for general applications

For sheets for general applications, the maximum shrinkage in the direction of extrusion shall be less than 3 % after heating. Testing shall be in accordance with 6.10 and Table 5.

5.3.2.2 Maximum shrinkage for thermoforming applications

For sheets 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 6.10 under 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

5.3.3 Physiological behaviour

Relevant legislation concerning 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 from locations evenly distributed over the length and width of the sheet. With sheets in roll form, a 2 m sample shall be cut from the end of the roll to prepare test specimens. The surfaces of the test specimens shall be free from damage and faults in order to avoid notch effects. Should any burrs be formed on the test specimens during preparation, these shall be eliminated without damaging the surfaces of the specimens. If required, the cut edges shall be finished with abrasive paper (grain size 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 6.5 to 6.7 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

All test specimens shall be conditioned for at least 16 h at standard temperature 23 °C as specified in ISO 291. Shorter conditioning times may be used by agreement between 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 temperature 23 °C as specified in ISO 291, unless otherwise agreed between the interested parties or specified in the individual test standards.

6.2 Delivery condition

Sheets shall be visually examined when delivered to ensure freedom from mechanical damage or other obvious defects. Sheets can be inspected by ultrasonic or X-ray methods where required.

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 shall be used. Any defects thus identified shall be compared with the agreed specification (which may be either a written specification or in the form of reference samples) and classified accordingly.

6.4 Dimensions

6.4.1 Thickness, *h*

The thickness, *h*, shall be measured using suitable calibrated equipment meeting the specifications of Table 4.

Table 4 — Error limits of equipment

Values in millimetres

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

6.4.2 Length, *l*, and width, *b*

The length, *l*, and width, *b*, shall be measured to the nearest 1 mm using suitable calibrated equipment. Measurements shall be made directly across the surface of the sheet and along the cut edge.

6.4.3 Rectangularity

For flat sheets, the rectangularity, expressed as the difference between the lengths of the diagonals, $|d_1 - d_2|$, as shown in Figure 1, shall be measured to the nearest 1 mm using a graduated ruler or tape measure.

6.4.4 Bow of sheets in rolled form

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

6.5 Tensile stress at yield, σ_y, and tensile strain at yield, ε_y

The 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 ISO 527-2, using a test speed of 50 mm/min ± 5 mm/min.

6.6 Modulus of elasticity in tension, E_t

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

6.7 Charpy impact strength of notched specimens, a_{cn}

For nominal sheet thicknesses $h_n \geq 4$ mm, the Charpy impact strength of notched specimens, a_{cn}, shall be determined edgewise in accordance with ISO 179-1/1eA or ISO 179-2/1eA, using at least 10 test specimens cut in each direction.

6.8 Melt mass-flow rate (MFR)

The melt mass-flow rate shall be determined in accordance with ISO 1133-1 using a temperature of 230 °C and load of 2,16 kg.

6.9 Heat resistance

The heat resistance shall be determined in accordance with ISO 4577.

6.10 Determination of shrinkage on heating

The shrinkage on heating shall be determined in accordance with the principles of ISO 11501.

Cut at least three test specimens 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. Make one or more pairs of reference marks on the specimens in the extrusion direction. Measure the initial length, L_0, between the pairs of marks with an uncertainty of measurement of 0,1 mm at room temperature. Dust the specimens with kaolin and place them flat on a kaolin bed in a circulating-air oven. The temperature and duration of the test shall be as given in Table 5 and Table 6.

Table 5 — Test conditions for general applications

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

Table 6 — Test conditions for thermoforming applications

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

Remove the tray with the test specimens from the circulating-air oven. Allow to cool down to room temperature. Measure the length, L, of each specimen between the pairs of reference marks. Calculate the shrinkage, ΔL, for each pair of reference marks using Formula (2):

$$\Delta L = \frac{L_0 - L}{L_0} \times 100 \tag{2}$$

where

ΔL is the shrinkage on heating, in percent;

L_0 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.