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Extruded sheets of polyethylene (PE-HD) — Requirements and test methods

Plaques extrudées en polyéthylène (PE-HD) — Exigences et méthodes d'essai

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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 second edition cancels and replaces the first edition (ISO 14632:1998), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the range of MFR values for PE HD sheet group 1 in Table 2 has been changed to cover the wider PE 100 grade of extruded PE HD sheets.

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 polyethylene (PE-HD) — Requirements and test methods

1 Scope

This document specifies the requirements and test methods for solid flat extruded sheets of polyethylene homopolymers (PE-HD) without fillers or reinforcing materials.

This document is applicable only to thicknesses of 0,5 mm to 40 mm. It also applies to PE-HD sheet in rolled 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 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 527-1, *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 1133-1, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 1: Standard method*

ISO 1133-2, *Plastics — Determination of the melt mass-flow rate (MFR) and melt volume-flow rate (MVR) of thermoplastics — Part 2: Method for materials sensitive to time-temperature history and/or moisture*

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 1183-3, *Plastics — Methods for determining the density of non-cellular plastics — Part 3: Gas pyknometer method*

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

ISO 9080, *Plastics piping and ducting systems — Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*

ISO 17855-1, *Plastics — Polyethylene (PE) 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 consist of PE extrusion compounds designated by ISO 17855-1 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 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 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 6.3.

5.2 Dimensional tolerances

5.2.1 Thickness

Within any individual sheet, referring to the nominal thickness, the tolerance on thickness shall be as shown in Formula (1):

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

where

Δh is the tolerance on 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

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 6.4.2.

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.

5.2.3 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.

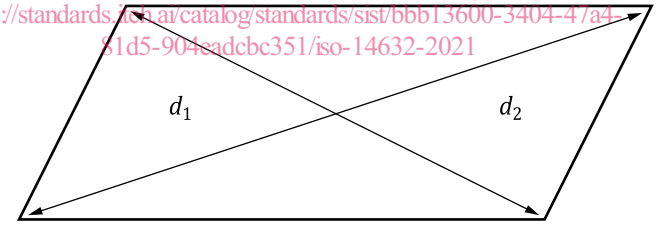

Figure 1 — Difference between diagonals ($|d_1 - d_2|$)

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 Mechanical and thermal properties

The properties of sheets shall meet the requirements specified in Table 2.

Table 2 — Mechanical and thermal properties

Properties	Unit	Requirements (average values) PE-HD sheet group				Test method subclause
		1[a]	2	3	4	
Density	g/cm^3	0,95 to 0,965	0,94 to 0,96	0,95 to 0,96	≥0,96	6.5
Tensile stress at yield	MPa	≥20	≥15	≥20	≥25	6.6
Tensile strain at yield	%	≥10	≥8	≥8	≥8	6.6
Modulus of elasticity in tension	MPa	≥700	≥700	≥900	≥1 200	6.7
Charpy impact strength of notched specimens	kJ/ m^2	≥10	≥6	≥10	≥15	6.8
MFR 190 °C / 5 kg	g/10 min	0,2 to 0,7	0,1 to 2,0	0,1 to 2,0	0,1 to 2,0	6.9

[a] Sheets of group 1 shall be manufactured from extrusion compounds (black, UV-stabilized with >2 % carbon black) complying with specific requirements for creep rupture strength defined in accordance with ISO 9080 and shall be approved by all interested parties.

5.3.2 Behaviour after heating

5.3.2.1 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 6.10 and Table 5.

5.3.2.2 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 6.10 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 (%)	75	70	60	50	40	35	30	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.

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 6.6 to 6.8 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 hours in accordance with 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.

6.1.3 Testing

Testing shall be carried out in accordance with ISO 291, unless agreed differently between the interested parties or specified differently in the individual testing standards.

6.2 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.

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 a suitable calibrated equipment according to Table 4.

Table 4 — Accuracy of equipment

Dimensions in millimetres

Nominal thickness, h_n	Accuracy
$0{,}50 \leq h_n \leq 1{,}00$	≤ +0,01
$1{,}00 < h_n \leq 10{,}00$	≤ +0,05
$10{,}00 < h_n \leq 40{,}00$	≤ +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 a suitable calibrated equipment. Measurements shall be made 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 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.

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 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, ISO 1183-2 and ISO 1183-3.

6.6 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 ISO 527-1 and ISO 527-2 using a test speed of 50 mm/min ± 5 mm/min.

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

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

Charpy impact strength of notched specimens, a_{cn}, for nominal thicknesses ≥4 mm shall be determined in accordance with ISO 179-1 and ISO 179-2 using at least 10 test specimens in each direction.

6.9 Melt mass-flow rate (*MFR*)

Melt mass-flow rate (*MFR* 190/ 5) shall be determined in accordance with ISO 1133-1 and ISO 1133-2.

6.10 Determination of shrinkage after heating

At least three test specimens with dimensions of 100 mm × 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_0, 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 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, h_n mm	Test temperature °C	Duration of test[a] min
$0,5 \le h_n \le 2$	110 ± 2	60 ± 1
$2 < h_n \le 10$	110 ± 2	90 ± 1
$10 < h_n \le 20$	110 ± 2	120 ± 1
$20 < h_n \le 40$	110 ± 2	240 ± 1

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