INTERNATIONAL STANDARD

ISO 1873-2

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Plastics — Polypropylene (PP) and propylene-copolymer thermoplastics

Part 2 : Preparation of test specimens and determination of properties

Plastiques — Thermoplastiques à base de polypropylène (PP) et de copolymères de propylène —

Partie 2 : Préparation des éprouvettes et détermination des caractéristiques

Reference number
ISO 1873-2 : 1989 (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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 1873-2 was prepared by Technical Committee ISO/TC 61, *Plastics*.

ISO 1873 consists of the following parts, under the general title *Plastics — Polypropylene (PP) and propylene-copolymer thermoplastics*:

— *Part 1: Designation*

— *Part 2: Preparation of test specimens and determination of properties*

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Plastics — Polypropylene (PP) and propylene-copolymer thermoplastics —

Part 2 : Preparation of test specimens and determination of properties

1 Scope

1.1 This part of ISO 1873 specifies procedures for moulding test specimens of polypropylene materials under specified moulding conditions and methods for measuring their properties.[1)]

1.2 No figures are quoted for these properties. Those required for the designation of polypropylene materials for moulding and extrusion are given in ISO 1873-1. Other properties are determined by the appropriate methods referred to in this part of ISO 1873 and values may be obtained from manufacturers' literature. Values should only be compared if the procedures described herein for preparing the test specimens and for determining the properties are followed.

1.3 The values determined in accordance with this part of ISO 1873 will not necessarily be identical to those obtained using specimens of different dimensions and/or prepared by different procedures. They may also be influenced by colorants and other additives. The values obtained for the properties of a moulding depend on the moulding compound, the shape, the test method and the state of anisotropy. The last-mentioned depends on the gating and the moulding conditions, for example temperature, pressure and injection rate. Any subsequent treatment must also be considered, for example conditioning or annealing.

1.4 The thermal history and the internal stresses of the specimens may strongly influence the thermal and mechanical properties and the resistance to environmental stress cracking, but exert less effect on the electrical properties, which depend mainly on the chemical composition of the moulding compound.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 1873. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 1873 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 62 : 1980, *Plastics — Determination of water absorption.*

ISO 75 : 1987, *Plastics and ebonite — Determination of temperature of deflection under load.*

ISO 175 : 1981, *Plastics — Determination of the effects of liquid chemicals, including water.*

ISO 178 : 1975, *Plastics — Determination of flexural properties of rigid plastics.*

ISO 179 : 1982, *Plastics — Determination of Charpy impact strength of rigid materials.*

ISO 180 : 1982, *Plastics — Determination of Izod impact strength of rigid materials.*

ISO 291 : 1977, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 293 : 1986, *Plastics — Compression moulding test specimens of thermoplastic materials.*

ISO 294 : 1975, *Plastics — Injection moulding test specimens of thermoplastic materials.*

ISO 306 : 1987, *Plastics — Thermoplastic materials — Determination of Vicat softening temperature.*

ISO/R 527 : 1966, *Plastics — Determination of tensile properties.*

ISO 537 : 1980, *Plastics — Testing with the torsion pendulum.*

ISO 868 : 1985, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness).*

1) Preferred methods and temperatures in this part of ISO 1873 will become mandatory at the next five-year revision.

ISO 899 : 1981, *Plastics — Determination of tensile creep.*

ISO 974 : 1980, *Plastics — Determination of the brittleness temperature by impact.*

ISO 1133 : 1981, *Plastics — Determination of the melt flow rate of thermoplastics.*

ISO 1183 : 1987, *Plastics — Methods for determining the density and relative density of non-cellular plastics.*

ISO 1628-3 : — [1], *Plastics — Determination of viscosity number and limiting viscosity number — Part 3: Polyethylenes and polypropylenes.*

ISO 1873-1 : 1986, *Plastics — Polypropylene (PP) and propylene-copolymer thermoplastics — Part 1: Designation.*

ISO 2039-1 : 1987, *Plastics — Determination of hardness — Part 1: Ball indentation method.*

ISO 2039-2 : 1987, *Plastics — Determination of hardness — Part 2: Rockwell hardness.*

ISO 2556 : 1974, *Plastics — Determination of the gas transmission rate of films and thin sheets under atmospheric pressure — Manometric method.*

ISO 2818 : 1980, *Plastics — Preparation of test specimens by machining.*

ISO 4577 : 1983, *Plastics — Polypropylene and propylene-copolymers — Determination of thermal oxidative stability in air — Oven method.*

ISO 4582 : 1980, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or artificial light.*

ISO 4607 : 1978, *Plastics — Methods of exposure to natural weathering.*

ISO 4892 : 1981, *Plastics — Methods of exposure to laboratory light sources.*

ISO 6602 : 1985, *Plastics — Determination of flexural creep by three-point loading.*

ISO 9113 : 1986, *Plastics — Polypropylene (PP) and propylene-copolymer thermoplastics — Determination of isotactic index.*

IEC Publication 93 : 1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials.*

IEC Publication 112 : 1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions.*

IEC Publication 243 : 1967, *Recommended methods of test for electric strength of solid insulating materials at power frequencies.*

IEC Publication 250 : 1969, *Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths.*

3 Preparation of test specimens

Two methods of preparation of test specimens are described: method 1, compression moulding, and method 2, injection moulding.

In the case of dispute or disagreement, method 1 shall be taken as the definitive procedure for unfilled polypropylene products and method 2 shall be used for filled products.

3.1 Method 1: compression moulding

Specimens shall be prepared either by stamping or by machining from a compression-moulded sheet (see ISO 2818). Full details of compression moulding of sheet are given in ISO 293, but for polypropylene (as defined in ISO 1873-1) the following additional points shall apply:

Mould: A simple three-plate frame mould as described in ISO 293 is satisfactory for producing small sheets from which test specimens may be cut.

Predrying: No drying is normally necessary.

Moulding temperature: 210 °C ± 5 K is preferred. Other temperatures may have to be used because of the nature of the polymer, generally in the range 180 °C to 230 °C; they shall be reported.

Average cooling rate:

Method B — Standard rate:
15 K·min^{-1} ± 5 K·min^{-1}

Method C — Quench cooling rate:
60 K·min^{-1} ± 30 K·min^{-1}

Method B is preferred but, if a different rate is used because of the requirements of the user, it shall be reported.

Moulding procedure: The contact pressure time shall be 5 min to 10 min and the full-pressure time 2 min to 5 min. The demoulding temperature shall be less than or equal to 40 °C.

3.2 Method 2: injection moulding

The properties of injection-moulded test specimens depend strongly on the equipment and conditions used. At present, because of the very wide range of such parameters, a general approach has been taken.

Apparatus (see also ISO 294): An injection-moulding machine fitted with a reciprocating screw shall be used. The mould shall be a single cavity unless it can be shown that use of a multi-cavity mould yields specimens with properties equivalent to those made from a single cavity.

1) To be published.

The gate diameter shall be at least equal to the specimen thickness. The ratio of the stroke volume to the shot volume shall not exceed 10 : 1 and not be less than 2 : 1.

Moulding procedure: The moulding conditions used shall be as follows:

Mould temperature 60 °C ± 3 K. Temperature measurements shall be made with a surface-type pyrometer or equivalent after cycling conditions have been established.

Melt temperature

225 °C ± 5 K for an MFR > 1 g/10 min

255 °C ± 5 K for an MFR ⩽ 1 g/10 min

The melt temperature is defined as the temperature of a free air shot measured using a needle pyrometer. The specimens produced shall be free from voids, sink marks, flow lines and/or jetting and be visually good in appearance.

If other temperatures have to be used because of the nature of the polymer, they shall be reported, together with the reasons for use.

Machine settings: Follow ISO 294. Typical values are as follows:

Injection pressure: set at a level that does not produce flash, sink marks or voids in the specimens

Average injection velocity: 10 cm/s ± 2 cm/s

Screw forward time: 20 s minimum

Mould open time: 5 s

Cooling time: 50 s minimum

Total cycle time: 60 s minimum

Heat-sensitive polypropylenes may undergo molecular breakdown during moulding; therefore an increase in the melt flow rate to 1,5 times the original value shall be avoided. If the MFR increases by more than 1,5 times the original value, the melt temperature shall be lowered, 10 °C at a time, until the increase in MFR is ⩽ 1,5 times the original value. This adjustment in melt temperature shall be reported. The uniformity of the mouldings shall be checked by weighing. Their masses shall not deviate by more than 1 % from each other.

4 Determination of properties

Test specimens shall be conditioned in accordance with ISO 291, unless otherwise stated in the relevant standard, for at least 7 days at 23 °C ± 2 K before testing. A shortened procedure of 16 h to 24 h may be agreed on by the interested parties, but in cases of dispute the 7-day period shall be used.

The properties shall be determined using the specimens and methods referred to in table 1.

5 Test report

When properties are determined using test specimens prepared in accordance with ISO 293 or ISO 294 and this part of ISO 1873, the following additional information shall be included in the test report:

Compression-moulded specimens (in addition to the information required by ISO 293):

a) the form of the material (powder, granules, pellets, specimen from a moulded part);

b) the moulding temperature;

c) the average cooling rate;

d) details of non-standard test conditions, when used.

Injection-moulded specimens (in addition to the information required by ISO 294):

a) the form of the material (powder, granules, pellets, specimen from a moulded part);

b) the melt temperature;

c) the mould temperature;

d) the machine settings, if significantly different from those given in this part of ISO 1873.

Table 1 — Test methods and conditions[1)]

Property	Units	Test method	Specimen dimensions mm — Method 1: compression-moulded	Specimen dimensions mm — Method 2: injection-moulded	Comments
Mechanical properties					
Tensile stress at yield[2)]	MPa	ISO/R 527	Type 2 (thickness 2)	Type 1 (thickness 4)	Speed C (50 mm/min ± 5 mm/min)
Tensile stress at break[2)]	MPa	ISO/R 527	Type 2 (thickness 2)	Type 1 (thickness 4)	Speed C (50 mm/min ± 5 mm/min)
Tensile elongation at yield[2)]	%	ISO/R 527	Type 2 (thickness 2)	Type 1 (thickness 4)	Speed C (50 mm/min ± 5 mm/min)
Tensile elongation at break[2)]	%	ISO/R 527	Type 2 (thickness 2)	Type 1 (thickness 4)	Speed C (50 mm/min ± 5 mm/min)
Tensile elastic modulus[3)]	MPa	ISO/R 527	Type 2 (thickness 2)	Type 1 (thickness 4)	Speed A (1 mm/min ± 0,5 mm/min)
Flexural modulus at 1 % strain	MPa	ISO 178	80 × 10 × 4	80 × 10 × 4	Test speed: 2 ± 0,5 mm/min
Shear modulus and mechanical loss factor	MPa	ISO 537	60 × 10 × 1	60 × 10 × 1	Method A only
Tensile creep modulus[3)]	MPa	ISO 899	ISO/R 527 type 2 (thickness 2)	ISO/R 527 type 1 (thickness 4)	
Flexural creep modulus[3)]	MPa	ISO 6602	80 × 10 × 4	80 × 10 × 4	
Izod impact resistance[4)] vs temperature	kJ/m²	ISO 180	80 × 10 × 4	80 × 10 × 4	Method ISO 180/1A
Charpy impact resistance[5)] vs temperature	kJ/m²	ISO 179	80 × 10 × 4	80 × 10 × 4	Method ISO 179/1A
Ball indentation hardness	N/mm²	ISO 2039-1	minimum thickness 4	minimum thickness 4	
Rockwell hardness		ISO 2039-2	minimum thickness 4	minimum thickness 4	
Shore A or D hardness		ISO 868	minimum thickness 4	minimum thickness 4	
Thermal properties					
Deflection temperature under load[6)]	°C	ISO 75	110 × 10 × 4	110 × 10 × 4	Method A or B
Vicat softening temperature (VST)	°C	ISO 306	25 × 25 × 4	20 × 10 × 4	Method A (at 50 K/h)
Brittleness temperature	°C	ISO 974	20 × 2,5 × 1,6		
Electrical properties					
Surface resistance	Ω	IEC 93			Measurement voltage 500 V
Volume resistivity	Ω·cm	IEC 93			
Dielectric strength	kV/mm	IEC 243			
Relative permittivity		IEC 250			AC frequency 1 MHz
Dissipation factor		IEC 250			AC frequency 1 MHz
Comparative tracking index		IEC 112			AC frequency 50 Hz
Ageing properties					
Natural weathering		ISO 4607, ISO 4582			
Artificial-light weathering		ISO 4892, ISO 4582			
Oven ageing		ISO 4577			
Raw-material properties					
Viscosity number (VN)	ml/g	ISO 1628-3	Test done on granules or powder		
Melt flow rate (MFR)	g/10 min	ISO 1133	Test done on granules or powder		See also ISO 1873-1
Isotactic index (II)	%	ISO 9113	Test done on granules or powder		See also ISO 1873-1

Table 1 — Test methods and conditions[1] (*concluded*)

Property	Units	Test method	Specimen dimensions mm		Comments
			Method 1: compression-moulded	Method 2: injection-moulded	
Miscellaneous properties					
Density of moulded pieces	g/cm^3	ISO 1183	Pieces from ISO/R 527 specimen		
Water absorption	mg	ISO 62			
Gas transmission rate	$cm^3/(m^2 \cdot d \cdot atm)$	ISO 2556			
Effect of liquid chemicals		ISO 175			

1) Preferred specimens and conditions are given, but some alternatives are indicated in these footnotes. It is intended to make the preferred conditions mandatory at the next revision.

2) Speed C is preferred. Alternative speeds, for example 100 mm/min, may be used but shall be reported.

3) A graph of modulus against time at specified temperatures and stresses is recommended.

4) Method 180/1A is preferred. Method 180/4A is an alternative, but its use shall be reported.

5) Method 179/1A is preferred, with a distance between supports of 60 mm. Methods 179/1C and 2C are alternatives, but their use shall be reported.

6) 110 mm × 10 mm × 4 mm is the preferred specimen size. A 110 mm × 12,7 mm × 4 mm specimen is an alternative, but its use shall be reported.

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