INTERNATIONAL STANDARD

ISO 294-5

Second edition
2011-04-15

Plastics — Injection moulding of test specimens of thermoplastic materials —

Part 5: **Preparation of standard specimens for investigating anisotropy**

Plastiques — Moulage par injection des éprouvettes de matériaux thermoplastiques —

Partie 5: Préparation d'éprouvettes normalisées pour déterminer l'anisotropie

Reference number
ISO 294-5:2011(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

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.

ISO 294-5 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 9, *Thermoplastic materials*.

This second edition cancels and replaces the first edition (ISO 294-5:2001), which has been technically revised. The main change concerns the thickness of the test specimens produced, which is now 2 mm as opposed to 3 mm in the previous edition. In addition, the maximum mould-locking force in 4.2 has been recalculated.

It also cancels and replaces the Amendment ISO 294-5:2001/Amd.1:2004. In addition, it incorporates the Technical Corrigendum ISO 294-5:2001/Cor.1:2003.

ISO 294 consists of the following parts, under the general title *Plastics — Injection moulding of test specimens of thermoplastic materials*:

— *Part 1: General principles, and moulding of multipurpose and bar test specimens*

— *Part 2: Small tensile bars*

— *Part 3: Small plates*

— *Part 4: Determination of moulding shrinkage*

— *Part 5: Preparation of standard specimens for investigating anisotropy*

Introduction

Reinforced and self-reinforcing injection-mouldable thermoplastics are used in a wide variety of applications, some of which can be safety-related. During the injection-moulding process, reinforcement fibres can preferentially align with the flow of the molten material and not across the flow direction. This preferential alignment causes an imbalance in the properties of the moulded thermoplastic so that, in the flow direction, the alignment of the reinforcing fibres causes a higher strength and stiffness than in the cross direction with fewer aligned fibres. This difference in properties is termed anisotropy, and it may result in an injection-moulded component having less than the desired or designed strength. To aid designers in understanding the potential strength of an injection-moulded component, it is desirable to know about the anisotropy of an injection-moulded component.

During the development of this part of ISO 294, it was found that injection-moulded test specimens do not exhibit the same fibre alignment across their thickness, but that the outer layers have fibres preferentially aligned in the mould filling direction while the core has randomly oriented fibres (i.e. no preferential alignment). The ratio of the cross-sectional area of aligned-fibre orientation (i.e. “skin” layer thickness) to that of random-fibre orientation (i.e. “core” thickness) is affected by the specimen thickness and the mould filling rate, i.e. the average injection velocity. Thicker specimens exhibit a lower proportion of aligned fibres than do thinner specimens. Slower mould fill speeds lead to thicker “skin” layers with aligned fibres. As a result, to obtain meaningful data on a particular design of moulding, an investigator should prepare specimens with the maximum anisotropic properties, as this data will best represent the upper and lower bounds of a composite structure. Since the specimen thickness and injection velocity have a significant influence on the final anisotropy, this part of ISO 294 should only be used for determining information that is useful in designing mouldings, and not as a quality control test for the plastic material itself.

Plastics — Injection moulding of test specimens of thermoplastic materials —

Part 5: Preparation of standard specimens for investigating anisotropy

1 Scope

This part of ISO 294 specifies a two-cavity mould (designated the type F ISO mould) for the injection moulding of 80 mm × 90 mm plates with a preferred thickness of 2 mm for single-point data acquisition because 2 mm has been found to provide the maximum anisotropic properties, with only a slight sensitivity to the rate of injection. For the design of plastic parts, this will provide upper and lower bounds for the tensile properties. Matching the plate thickness to a given part thickness is not a suitable criterion because of the effect of mould filling rate and part geometry on anisotropy. Suitable test specimens [ISO 527-2 type 1BA tensile test specimens or type 1 (80 mm × 10 mm) bars] are then machined or die-cut from the plates (see Annex A) and used to obtain information on the anisotropy of thermoplastic parts.

Investigation of the anisotropy of materials is a special procedure intended to provide guidance in the design of mouldings for end-use applications and is not intended as a quality control tool.

In the injection moulding of thermoplastic materials, the flow of molten polymer may influence the orientation of fillers such as fibreglass or the orientation of polymer chains. This can result in anisotropic behaviour. The knowledge of anisotropic behaviour is valuable in designing plastic parts.

For the purposes of this part of ISO 294, the flow direction is defined as the direction from the gate to the far end of the mould cavity, and the cross direction as the direction perpendicular to the flow direction.

The type F mould is not intended to replace the type D mould used to determine the moulding shrinkage of thermoplastics.

2 Normative references

The following referenced documents are indispensable for the application 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 294-1:1996, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens*

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

3 Terms and definitions

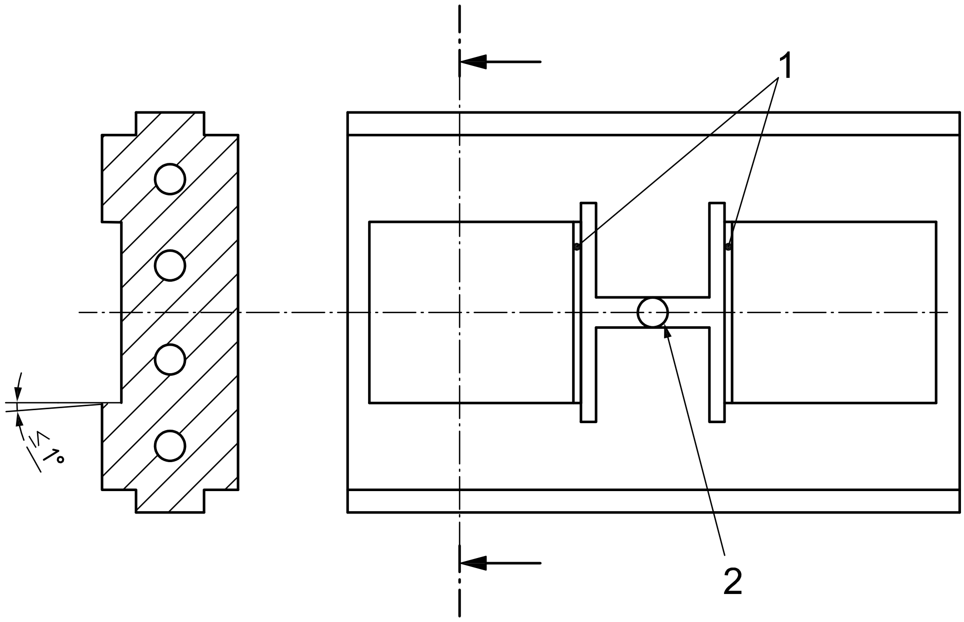
For the purposes of this document, the terms and definitions given in ISO 294-1 apply.

4 Apparatus

4.1 Type F ISO mould

Plates shall be moulded in a two-cavity type F ISO mould (see Figures 1 and 2). The mould dimensions shall be such that the plates produced measure 80 mm × 90 mm (the actual length and width of the mould will vary slightly because of the different shrinkage of different materials).

The preferred thickness is 2 mm but other thicknesses may be used. A thickness of 2 mm is representative of the actual wall thickness of many mouldings and gives a skin-thickness to core-thickness ratio corresponding to the maximum anisotropic properties. Other thicknesses may be used to give different skin-thickness to core-thickness ratios.

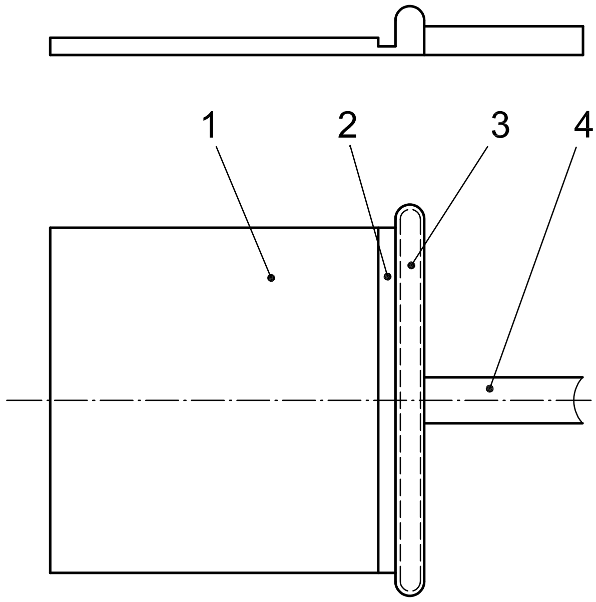


Key

1 gate (projected area $A_P = 15\ 000\ mm^2$)

2 sprue (shot volume $V_S = 30\ 000\ mm^3$)

Figure 1 — Type F ISO mould



All dimensions in millimetres

	1 (cavity)	2 (gate)	3 (flood gate)	4 (runner)
Dimension in direction of flow	90^{+2}_{0} [a]	3,0	6,0	8,0
Dimension normal to flow	80^{+2}_{0} [a]	80	92	12
Depth/height	2,0[b]	1,0[c]	6,0	6,0
End radius[d]	NA	NA	>4,0	NA
Top radius[d]	NA	NA	>3,0	>3,0

[a] The actual length and width will depend on the moulding shrinkage of the injection-moulding material (see 4.1).

[b] 2 mm is the preferred specimen thickness for single-point data acquisition. Cavity depths other than 2 mm may, however, be used to match more closely the thickness of the parts being designed.

[c] The gate height shall be half the cavity depth if a cavity depth other than 2 mm is used.

[d] The radius of the end of the flood gate shall be >4 mm, the radius of the top of the flood gate shall be >3 mm and the intersection of the top and end of the flood gate shall be blended to a smooth transition.

A pressure sensor may be used to monitor the moulding process, but is not required. The sensor, if used, shall be located centrally with respect to the width of the cavity.

If an interchangeable cavity plate of length less than 220 mm is used, it is permissible to use a single flood gate centred on the sprue and no runners.

To obtain correct test specimens, it is essential that the dimensions of the moulded plate be as follows:

length >85 mm;

width >78 mm.

Figure 2 — Details of type F ISO mould

The main constructional details of the mould shall be as shown in Figures 1 and 2 and the mould shall, in addition, meet the following requirements:

a) See ISO 294-1:1996, Subclause 4.1.1.4, item a).

b) See ISO 294-1:1996, Subclause 4.1.1.4, item b).

c) See ISO 294-1:1996, Subclause 4.1.1.4, item c).

d) and e) Not applicable.

f) See ISO 294-1:1996, Subclause 4.1.1, item f).

g) Not applicable (see Figure 2).

h), i) and k) See ISO 294-1:1996, Subclause 4.1.1.4, items h), i) and k).

l) to n) See ISO 294-1:1996, Subclause 4.1.1.4, items l) to n).

4.2 Injection-moulding machine

As specified in ISO 294-1:1996, Subclause 4.2, with the following exception in 4.2.4.

The projected area of each mould cavity A_P is 80 mm × 90 mm = 7 200 mm^2. The total projected area is therefore 14 400 mm^2 + projected area of runners/gates = approx. 15 000 mm^2.

For a maximum mould-locking force F_{max} of 100 metric tons (981 kN) and a value of A_P of 15 000 mm^2, the maximum injection pressure is given by

$$p_{max} = F_{max}/A_P = 981 \text{ kN}/15\,000 \text{ mm}^2 = \text{approx. } 65 \text{ MPa.}$$

5 Procedure

5.1 Conditioning of material

As specified in ISO 294-1:1996, Subclause 5.1.

5.2 Injection moulding

As specified in ISO 294-1:1996, Subclause 5.2, but with the following new text in 5.2.2.

It has been found that the skin-thickness to core-thickness ratio changes with injection velocity. The slower the rate of injection, the thicker the skin (i.e. the thinner the core) and the greater the anisotropic alignment of the fibres. Also, the skin-thickness to core-thickness ratio changes with plate thickness. The thinner the plate, the thicker the skin (i.e. the thinner the core) and the greater the anisotropic alignment of the fibres. In addition, thin plates are less sensitive to changes in the injection velocity. Generally, if the ratio of the tensile modulus in the cross direction to that in the flow direction approaches 0,5, this indicates maximum anisotropy.

For type F ISO mouldings, it may be desirable to use more than one injection velocity. Several injection velocities may be used to acquire data that may be meaningful in the design and production of injection-moulded thermoplastic parts.

6 Report on test-specimen preparation

The report shall include the following information:

a) a reference to this part of ISO 294;

b) the date, time and place of moulding;

c) a full description of the material used (type, designation, manufacturer, trade name, grade, lot number, colour);

d) details of any conditioning of the material carried out prior to moulding;

e) the type of mould used (i.e. type F) and details of the mould (cavity depth, gate size, etc.);

f) details of the injection-moulding machine used (manufacturer, maximum stroke volume, mould-locking force, control systems);

g) the moulding conditions:

— melt temperature T_M, in degrees Celsius,

— mould temperature T_C, in degrees Celsius,

— injection velocity v_I, in millimetres per second,

— injection time t_I, in seconds,

— hold pressure p_H, in megapascals,

— hold time t_H, in seconds,

— cooling time t_C, in seconds,

— cycle time t_T, in seconds,

— mass of the moulding, in grams;

h) any other relevant details (e.g. the number of mouldings initially discarded, the number retained, any post-moulding treatment);

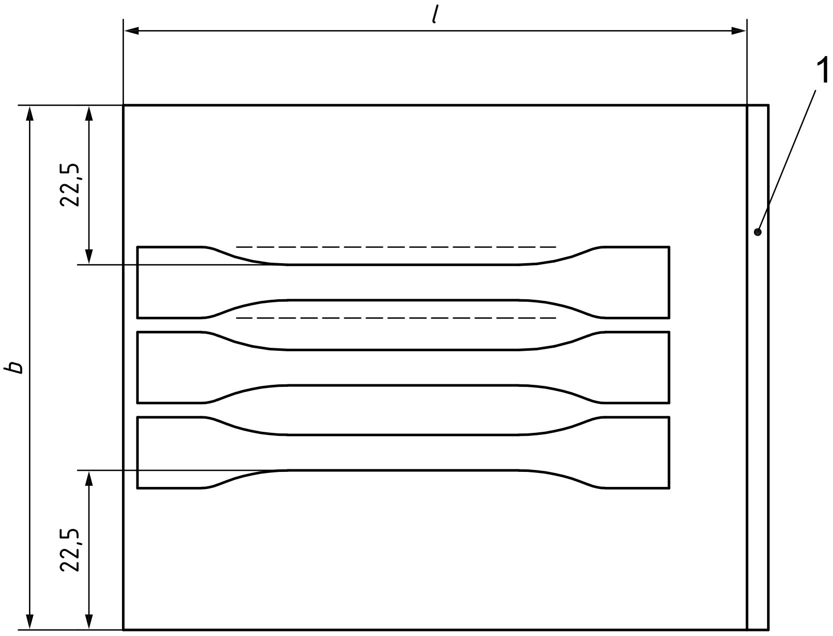
i) the specimen type and the number of specimens obtained from the plate produced, the preparation method used (machined or die-cut) and the locations of the specimens within the plate.

Annex A
(normative)

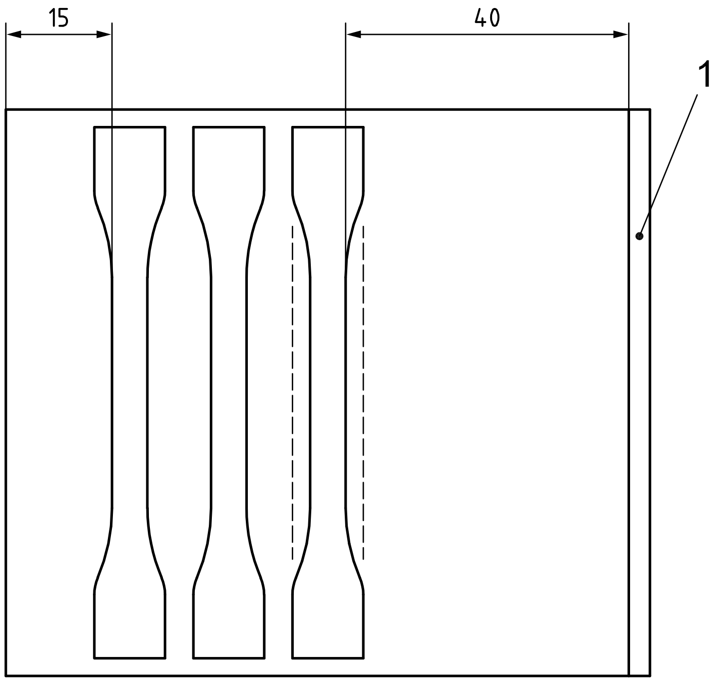
Preparation of test specimens

Type 1BA tensile specimens and type 1 (80 mm × 10 mm) bars shall be machined or die-cut from the moulded plates as shown in Figure A.1. Note that ejector pins, if used, shall be outside the central 50-mm-diameter zone of the plate and shall not contact the narrow, parallel-sided (test) section of the specimens. Specimen surfaces shall be free from nicks, gouges, sink marks, splay and other imperfections. Only three specimens shall be taken from each plate, from the area indicated to avoid effects due to the proximity of the plate edges and the gates. If a pressure transducer is used and is in the area of the test specimens, do not use any specimens which are marked by the transducer.

Dimensions in millimetres



a) Specimens taken in flow direction



b) Specimens taken in crossflow direction

Key

1 gate

Figure A.1 — Positions for obtaining test specimens
(All values are minimum values)

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