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Fibre-reinforced plastics — Methods of producing test plates —

Part 11: Injection moulding of BMC and other long-fibre moulding compounds — Small plates

Plastiques renforcés de fibres — Méthodes de fabrication de plaques d'essai —

Partie 11: Moulage par injection de BMC et d'autres mélanges à mouler à longues fibres — Plaques de petites dimensions

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Contents

Page

Foreword ... iv
Introduction ... v
1 Scope ... 1
2 Normative references ... 1
3 Terms and definitions ... 1
4 Apparatus ... 1
5 Procedure ... 4
6 Report on test-specimen preparation ... 6
Annex A (informative) Recommended applications for small-plate test specimens or parts thereof ... 7
Annex B (informative) Weld lines ... 8
Annex C (informative) Marking of test specimens ... 9
Bibliography ... 11

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 1268-11 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

Together with the other parts (see below), this part of ISO 1268 cancels and replaces ISO 1268:1974, which has been technically revised.

ISO 1268 consists of the following parts, under the general title *Fibre-reinforced plastics — Methods of producing test plates*:

— *Part 1: General conditions*

— *Part 2: Contact and spray-up moulding*

— *Part 3: Wet compression moulding*

— *Part 4: Moulding of prepregs*

— *Part 5: Filament winding*

— *Part 6: Pultrusion moulding*

— *Part 7: Resin transfer moulding*

— *Part 8: Compression moulding of SMC and BMC*

— *Part 9: Moulding of GMT/STC*

— *Part 10: Injection moulding of BMC and other long-fibre moulding compounds — General principles and moulding of multipurpose test specimens*

— *Part 11: Injection moulding of BMC and other long-fibre moulding compounds — Small plates*

Introduction

Many factors in the injection-moulding process can influence the properties of moulded test specimens and hence the measured values obtained when the specimens are used in a test method. The thermal and mechanical properties of such specimens are in fact strongly dependent on the conditions of the moulding process used to prepare the specimens. Exact definition of each of the main parameters of the moulding process is a basic requirement for reproducible and comparable operating conditions.

It is important in defining moulding conditions to consider any influence the conditions may have on the properties to be determined. Thermosets may show differences in orientation and length of anisotropic fillers such as long fibres and in curing. Residual (“frozen-in”) stresses in the moulded test specimens may also influence properties. Due to the crosslinking of thermosets, molecular orientation is of less influence on mechanical properties than it is for thermoplastics. Each of these phenomena must be controlled to avoid fluctuation of the numerical values of the measured properties.

The principles described in this part of ISO 1268 are the same as those in ISO 10724-2. Only a few details of the moulds have changed, as has specimen thickness, because of the use of long-fibre reinforcements. It is therefore possible to compare the properties of long-fibre moulding compounds with those of thermosetting powder moulding compounds (PMCs) and thermoplastics.

Fibre-reinforced plastics — Methods of producing test plates —

Part 11:
Injection moulding of BMC and other long-fibre moulding compounds — Small plates

1 Scope

This part of ISO 1268 specifies two two-cavity moulds, designated the type D1 and type D2 ISO moulds, for the injection moulding of small plates measuring 60 mm × 60 mm with preferred thicknesses of 2 mm (type D1) or 4 mm (type D2) which can be used for a variety of tests (see Annex A). The moulds may additionally be fitted with inserts for studying the effects of weld lines on the mechanical properties (see Annex B).

This part of ISO 1268 is intended to be read in conjunction with ISO 1268-1.

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 472, *Plastics — Vocabulary*

ISO 1268-1, *Fibre-reinforced plastics — Methods of producing test plates — Part 1: General conditions*

ISO 1268-10:2005, *Fibre-reinforced plastics — Methods of producing test plates — Part 10: Injection moulding of BMC and other long-fibre moulding compounds — General principles and moulding of multipurpose test specimens*

ISO 2577, *Plastics — Thermosetting moulding materials — Determination of shrinkage*

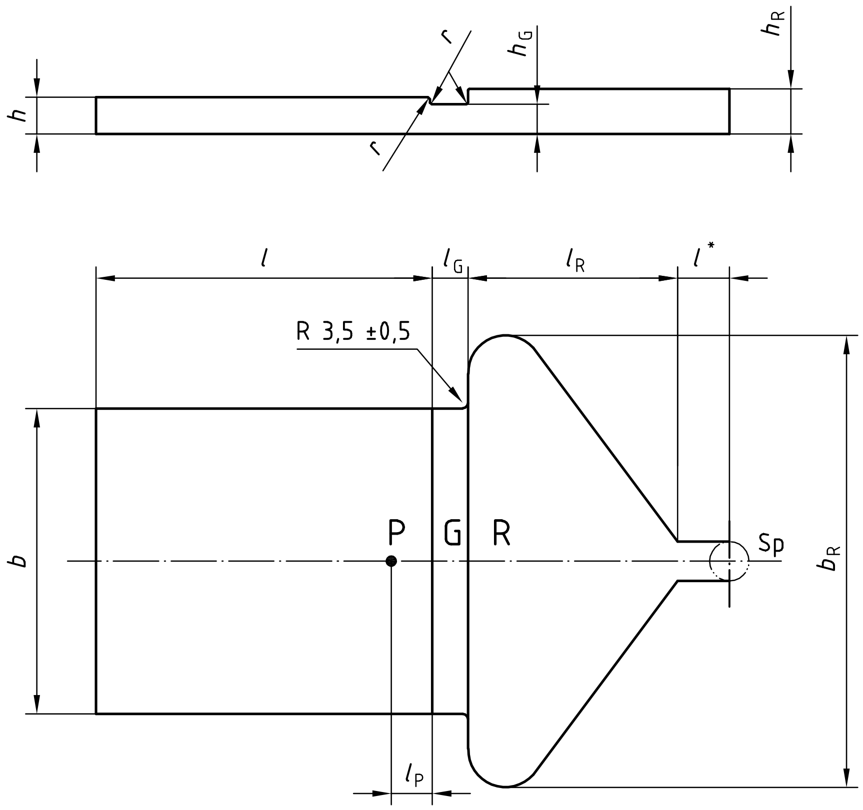
3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and ISO 1268-10 apply.

4 Apparatus

4.1 Type D1 and D2 ISO moulds

Type D1 and D2 moulds are two-cavity moulds (see Figure 2) intended for the preparation of plates measuring 60 mm × 60 mm. The plates produced using these moulds shall have the dimensions given in Figure 1.



Key

Sp sprue
G gate
R runner
P pressure sensor

		Dimensions in mm			Dimensions in mm
l	length of plate	60 ± 2 [a]	h_G	height of gate	$(0{,}75 \pm 0{,}05) \times h$ [b,c]
b	width of plate	60 ± 2 [a]	l_R	length of runner	25 to 30 [d]
h	thickness of plate:		b_R	width of runner at gate	$\geqslant (b + 6)$
	type D1 mould	$2{,}0 \pm 0{,}1$	h_R	depth of runner at gate	$= h$
	type D2 mould	$4{,}0 \pm 0{,}1$ [a]	l^*	unspecified distance	—
l_G	length of gate	$4{,}0 \pm 0{,}1$ [b]	l_p	distance of pressure sensor from gate	5 ± 2 [e]

a These dimensions are for the preferred test specimen used in ISO 6603.

b See Note 1 to Subclause 4.1.

c See Note 2 to Subclause 4.1.

d See Note 3 to Subclause 4.1.

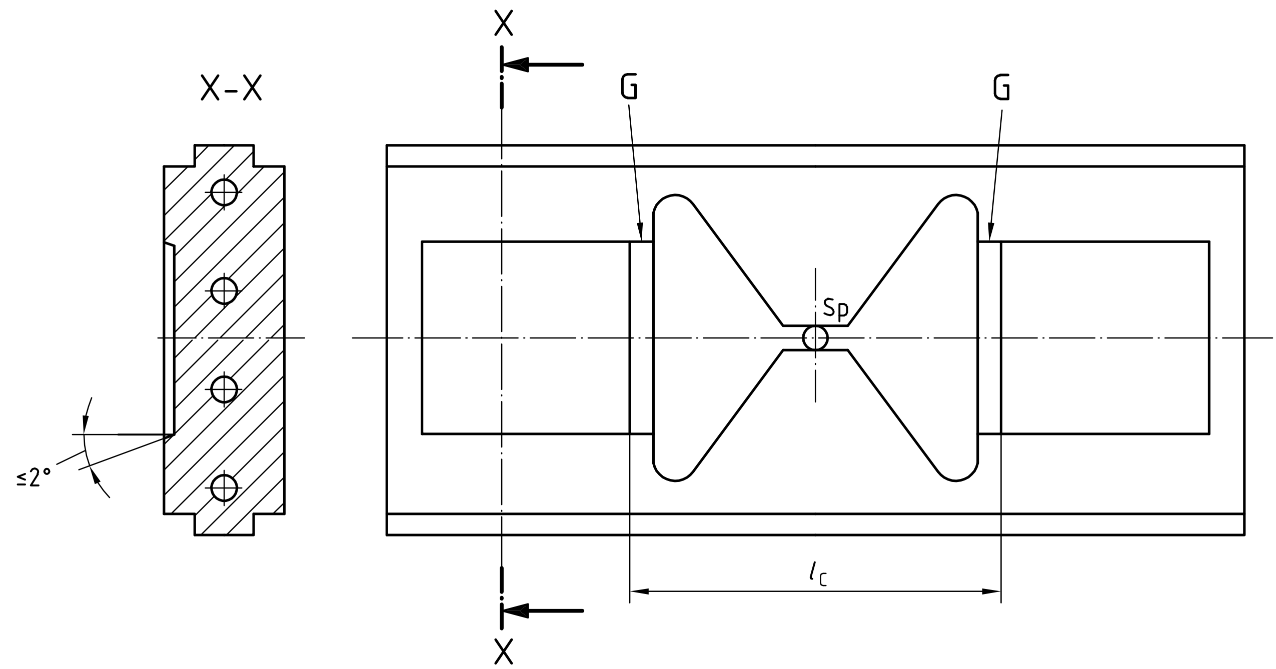
e The position of the pressure sensor shall be further limited by the following conditions:

$l_p + r_p \leqslant 10$

$l_p - r_p \geqslant 0$

where r_p is the radius of the sensor.

Figure 1 — Details of type D1 and D2 ISO moulds



Key

Sp sprue

G gate

l_C is the distance between the lines along which the test specimens are cut from the runners (see Note 4 to Subclause 4.1)

moulding volume $V_M \approx$ 30 000 mm^3 (at 2 mm thickness)

projected area $A_p \approx$ 11 000 mm^2

Figure 2 — Cavity plate for type D1 and D2 ISO moulds

The main constructional details of type D1 and D2 ISO moulds shall be as shown in Figures 1 and 2 and shall meet the following requirements:

a) The sprue diameter on the nozzle side shall be at least (4,5 ± 0,5) mm.

b) The cavities shall be one-end gated as shown in Figure 2.

c) The draft angle of the runners shall be (13 ± 3)°. The cavity shall have a draft angle not greater than 2°.

d) The dimensions of the cavities shall be such that the dimensions of the test specimens produced conform to the requirements given in the relevant test standard. To allow for different degrees of mould shrinkage, the dimensions of the cavities shall be chosen so that they are between the nominal value and the upper limit of the dimensions specified for the specimen concerned.

   The main dimensions, in millimetres, of the cavities shall be as follows (see also Figure 1):

   — length: 60 to 62;

   — width: 60 to 62;

   — depth: type D1 mould 2,0 to 2,1;

     type D2 mould 4,0 to 4,1.

e) Ejector pins shall be located outside the test area of the specimen, i.e. in the area of the runner.

f) The heating system for the mould plates shall be designed so that, under operating conditions, the difference in temperature between any point on the surface of a cavity and either plate is less than 3 °C.

g) Interchangeable cavity plates and gate inserts are recommended to permit rapid changes in production from one type of test specimen to another. Such changes are facilitated by using shot capacities V_S which are as similar as possible.

h) Figure 1 shows the position of a pressure sensor P within the cavity, which is mandatory for the measurement of moulding shrinkage only (see ISO 2577). Such a sensor may be useful, however, in controlling the injection period with any ISO mould [see ISO 1268-10:2005, Subclause 4.1.4, item k)]. The pressure sensor shall be flush with the cavity surface in order to avoid interference of the material flow.

i) To ensure that cavity plates are interchangeable between different ISO moulds, it is important to note the constructional details given in ISO 1268-10:2005, Subclause 4.1.4, item l), in particular that the width of the mould plates may be affected by the minimum distance required between the connection points for the heating channels.

j) To make it easer to check that all the specimens from a mould are identical, it is recommended that the individual cavities be marked, but outside the test area of the specimen. This can be done very simply by engraving suitable symbols on the heads of the ejector pins, thus avoiding any damage to the surface of the cavity plate. Another option is shown in Annex C.

k) Surface imperfections can influence the results, especially those of mechanical tests. Therefore, where appropriate, the surfaces of the mould cavities shall be highly polished. The direction of polishing shall correspond to the direction in which the test specimen will be placed under load when it is tested.

NOTE 1 The height and length of the gate strongly influence the process of curing of the plasticized material as it flows into the cavity, and hence the moulding shrinkage (see ISO 2577). The dimensions of the gate are therefore defined with tight tolerances.

NOTE 2 Gates which are severely limited in height have a great influence on the orientation of the material within the cavity, even at large distances from the gate. The change in height at the gate has therefore been fixed at a value which facilitates subsequent measurement of the moulding shrinkage (see ISO 2577).

NOTE 3 Separating the test specimens from the runner has to be done immediately after removal from the mould cavity. Otherwise, the plates will be irreversibly distorted due to the fact that the shrinkage of the runner and gate is different from that of the plate.

NOTE 4 The distance l_C between the lines along which the test specimens are cut from the runners is given by $l_C = 2(l_G + l_R + l^*)$ (see Figure 2). Taking this distance as 80 mm gives the advantage that the same cutting device can be used to cut 80 mm × 10 mm × 4 mm bars from the central sections of multipurpose test specimens [see ISO 1268-10:2005, Subclause 4.1.3 and Subclause 4.1.4, item l)].

4.2 Injection-moulding machine

For the reproducible preparation of test specimens capable of giving comparable results, only reciprocating-screw injection-moulding machines equipped with all the necessary devices for the control of the moulding conditions shall be used.

The minimum mould-locking force F_M for type D1 and type D2 ISO moulds is given by $F_M \geqslant 11\,000 \times p_{max} \times 10^{-3}$, i.e. 880 kN for a maximum pressure on the material of 80 MPa.

5 Procedure

5.1 Conditioning of material

Prior to moulding, condition the moulding compound as required in the relevant material standard or, in the absence of such information, as recommended by the manufacturer.

Avoid exposing materials to an atmosphere at a temperature significantly below the temperature of the workshop to avoid condensation of moisture on to the material.

5.2 Injection moulding

5.2.1 Set the machine to the conditions specified in the relevant material standard or, in the absence of such information, agreed between the interested parties.

5.2.2 For many moulding compounds, the most suitable range for the injection velocity v_I is (150 ± 50) mm/s when using a type D1 or D2 ISO mould.

For a given value of the injection velocity v_I, the injection time t_I is inversely proportional to the number of cavities n in the mould [see Equation (3) in 3.19 of ISO 1268-10:2005]. Any changes in the injection velocity during the injection period should therefore be kept as small as possible.

5.2.3 A convenient way of determining the hold pressure p_H, a parameter which is frequently not specified, is by the following procedure:

Starting from zero, gradually increase the pressure on the material until the mouldings are free from sink marks, voids and other visible faults and have minimum flash. Use this pressure as the hold pressure.

This procedure can be used for most injection-moulding presses.

5.2.4 Ensure that the hold pressure is maintained constant until the material in the gate region has cured, i.e. until the mass of the moulding has reached an upper limiting value under these conditions.

5.2.5 Discard the mouldings until the machine has reached steady-state operation. Then record the operating conditions and begin test specimen collection.

During the moulding process, maintain the steady-state conditions by suitable means, e.g. by checking the mass of the moulding m_M.

5.2.6 In the event of any change in material, empty the machine and clean it thoroughly. Discard at least 10 mouldings made using the new material before beginning test specimen collection again.

5.3 Measurement of mould temperature

Determine the mould temperature T_C after the system has attained thermal equilibrium and immediately after opening the mould. Measure the temperature of the mould-cavity surface at several points on each side of the mould cavity using a surface thermometer. Between each pair of readings, cycle the mould for a minimum of 10 cycles before continuing with the next measurement. Record each measurement and calculate the mould temperature as the average of all the measurements.

5.4 Measurement of the material temperature

5.4.1 Measure the material temperature T_M by one of the following methods:

5.4.2 After thermal equilibrium has been attained, inject a free shot of at least 30 cm^3 into a non-metallic container of a suitable size and immediately insert the probe of a preheated rapid-response needle thermometer into the centre of the plasticized material, moving it about gently until the reading of the thermometer has reached a maximum.

Ensure that the preheating temperature is close to the material temperature. Confirm this by using the same injection conditions for free shots as those to be used to mould the specimens, allowing the appropriate cycle time to elapse between each free shot.

5.4.3 Alternatively, the material temperature may be measured by means of a suitable temperature sensor, provided the result obtained can be shown to be the same as that obtained using the free-shot method. The sensor shall cause only low heat losses and shall respond rapidly to material temperature changes. Mount the sensor in a suitable place, such as in the nozzle of the injection-moulding machine. In case of doubt, use the method described in 5.4.2.

5.5 Post-moulding treatment of test specimens

Once removed from the mould, allow the test specimens to cool gradually and at the same rate to room temperature in order to avoid any differences in the history of individual test specimens.

NOTE Experience has shown that at least a part of this cooling time can have a significant influence on the degree of curing of bulk moulding compounds.

6 Report on test-specimen preparation

The report shall include the following information:

a) a reference to this part of ISO 1268;

b) the date, time and place the specimens were moulded;

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

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

e) the type of specimen produced, the relevant standard and the gate size and location;

f) details of the injection-moulding machine used (manufacturer, shot capacity, mould-locking force, control systems);

g) the moulding conditions:

- material temperature T_{M} (see 3.2 in ISO 1268-10:2005), in degrees Celsius,
- mould temperature T_{C} (see 3.1 in ISO 1268-10:2005), in degrees Celsius,
- injection velocity v_{I} (see 3.19 in ISO 1268-10:2005), in millimetres per second,
- injection time t_{I} (see 3.8 in ISO 1268-10:2005), in seconds,
- hold pressure p_{H} (see 3.5 in ISO 1268-10:2005), in megapascals,
- maximum pressure on the material p_{max} (see 3.4 in ISO 1268-10:2005), if a pressure sensor is installed, in megapascals,
- hold time t_{H} (see 3.10 in ISO 1268-10:2005), in seconds,
- cure time t_{CR} (see 3.9 in ISO 1268-10:2005), in seconds,
- cycle time t_{T} (see 3.7 in ISO 1268-10:2005), in seconds,
- mass of the moulding m_{M} (see 3.20 in ISO 1268-10:2005), in grams;

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

Annex A
(informative)

Recommended applications for small-plate test specimens or parts thereof

The type D2 ISO mould is recommended for the preparation of test specimens for use in determining multiaxial impact properties as described in ISO 6603 (see Note 1 to this annex), in determining moulding shrinkage as described in ISO 2577, in preparing specimens of coloured plastics (see Note 2), in studying the anisotropy of mechanical and thermal properties (see Note 3) and, with the mould fitted with gate inserts, in studying the effects of weld lines (see Annex B).

The type D1 ISO mould is especially suitable for producing test specimens for use in determining electrical properties (see Note 4), water absorption (see Note 5) and dynamic mechanical properties (see Note 6).

NOTE 1 It is proposed that multiaxial impact strength be included with the mechanical properties in ISO 10350-2[9] and ISO 11403-1[11]. The recommended specimen thickness is 4 mm.

NOTE 2 Plate specimens produced from coloured or natural materials are suitable for use in determining optical and mechanical properties in order to study the influence of weathering in accordance with e.g. ISO 4892-2[4].

NOTE 3 Type 4 tensile specimens as specified in ISO 8256[8], taken at different positions and orientated in different directions from the plate mouldings by machining in accordance with ISO 2818[3], are suitable for use in studying the anisotropy of mechanical properties by tensile and tensile-impact testing as described in ISO 527-2[2] and ISO 8256[8], respectively. Moreover, the anisotropy of thermal properties, especially the coefficient of linear thermal expansion, may be studied in analogous fashion by using parallel-sided test specimens (e.g. 10 mm wide) taken at different positions and in different directions as described above (see also reference [12]).

NOTE 4 ISO 10350-2[9] recommends the measurement of the following electrical properties: relative permittivity, dissipation factor, volume resistivity and surface resistivity using plate specimens 2 mm thick and electric strength using 2-mm-thick and 4-mm-thick plates.

NOTE 5 ISO 10350-2[9] recommends the measurement of water absorption as described in ISO 62[1] using a test specimen ⩾ 1 mm thick in order to be able to determine the saturation values within a reasonable test time.

NOTE 6 ISO 6721-2[7] describes the determination of the complex shear modulus using a torsion pendulum and specimens preferably with a thickness of 2 mm. These can be taken from plates produced by a type D1 ISO mould.

Annex B
(informative)

Weld lines

The effects of weld lines on mechanical properties can be studied by fitting suitable inserts in the mould cavities (see Figure B.1).

Figure B.1 shows the use of a multiple insert (hatched) which generates weld lines (shown by continuous lines) from opposed material flows, each weld line representing a flow path of a different length.

The opposed material flows shown in Figure B.1 represent one basic type of weld-line formation. Only symmetrical arrangements of the two-cavity mould should be used.

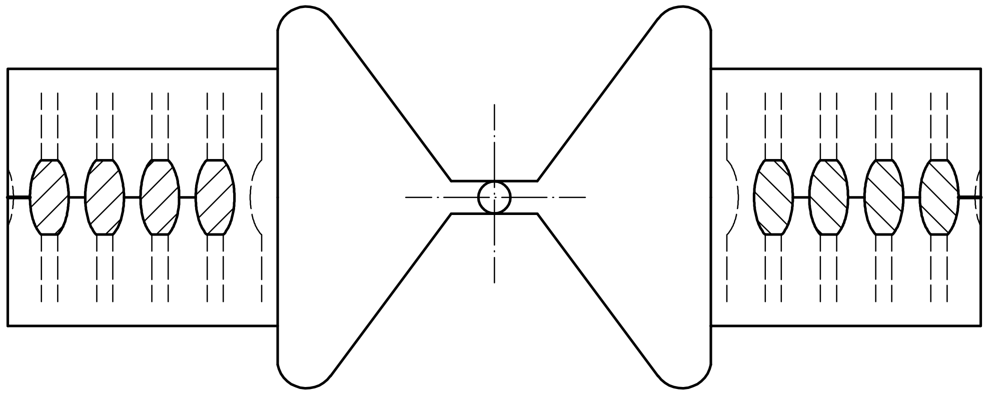


Figure B.1 — Moulding produced using multiple inserts (hatched), showing the locations from where tensile specimens can be taken (dashed lines)

Annex C
(informative)

Marking of test specimens

The purpose of marking test specimens is to enable the following to be determined (even if the runners have been cut off from the mouldings):

— the original positions of the two mouldings in the cavities;

— which side is the top and which is the bottom of the two test specimens (because it may be important for the results of e.g. multi-axial impact properties if the top or underside is located in the tensile-stress area during loading);

— the orientation, as well as which side is the top and which is the bottom, of e.g. 60 mm × 10 mm × 2 mm or 60 mm × 10 mm × 4 mm bars which have been taken from the mouldings either parallel (p) or normal (n) to the material flow direction (e.g. to study the influence of filler or reinforcement orientation on certain mechanical properties).

The markings used, and their positions in the mould cavities, should preferably be as follows [see Figure C.1 and ISO 1268-10:2005, Subclause 4.1.4, item m)]:

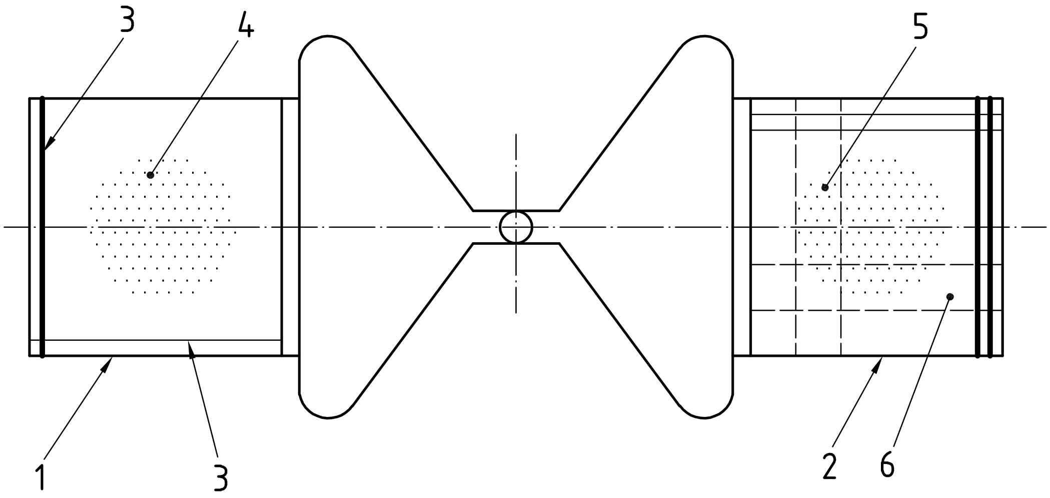
— lines parallel and close to the edges of the cavities should be used instead of numbers: two single lines (along two different edges perpendicular to each other) should be used to indicate cavity "1" and two pairs of parallel lines (also along two different edges perpendicular to each other) to indicate cavity "2";

— the lines should be outside the test area of the specimens (see Figure C.1);

— the lines running in the material flow direction should be disposed asymmetrically with respect to the centre of the mould plate so that these lines run along the same edge (e.g. the left-hand edge) of their cavity when viewed in the flow direction;

— the width of the lines running parallel to the flow direction should be significantly smaller than the width of those running normal to the flow direction (which means that thin lines on a bar taken from a moulding will always indicate that it has been taken normal to the flow direction and broad lines will indicate that it has been taken parallel to the flow direction, thus precluding any confusion);

— the lines should be just visible (e.g. not very deeply "engraved") to avoid any damage to the mould cavity surface and to avoid the moulding sticking when removed.



Key

1 cavity 1

2 cavity 2

3 marking line

4 test area (∅ 50 mm)

5 “n”-specimen

6 “p”-specimen

Figure C.1 — Positions of the markings for cavities “1” and “2”

Bibliography

[1] ISO 62, *Plastics — Determination of water absorption*

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

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

[4] ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc sources*

[5] ISO 6603-1, *Plastics — Determination of puncture impact behaviour of rigid plastics — Part 1: Non-instrumented impact testing*

[6] ISO 6603-2, *Plastics — Determination of puncture impact behaviour of rigid plastics — Part 2: Instrumented impact testing*

[7] ISO 6721-2, *Plastics — Determination of dynamic mechanical properties — Part 2: Torsion-pendulum method*

[8] ISO 8256, *Plastics — Determination of tensile-impact strength*

[9] ISO 10350-2, *Plastics — Acquisition and presentation of comparable single-point data — Part 2: Long-fibre-reinforced plastics*

[10] ISO 10724-2, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 2: Small plates*

[11] ISO 11403-1, *Plastics — Acquisition and presentation of comparable multipoint data — Part 1: Mechanical properties*

[12] ISO 11403-2, *Plastics — Acquisition and presentation of comparable multipoint data — Part 2: Thermal and processing properties*

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