INTERNATIONAL STANDARD

ISO 294-1

Second edition
2017-05

Plastics — Injection moulding of test specimens of thermoplastic materials —

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

Plastiques — Moulage par injection des éprouvettes de matériaux thermoplastiques —

Partie 1: Principes généraux, et moulage des éprouvettes à usages multiples et des barreaux

Reference number
ISO 294-1:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 9, *Thermoplastic materials.*

This second edition cancels and replaces the first edition (ISO 294-1:1996), which has been technically revised with the following changes:

— the types of test specimen have been replaced according to ISO 20753;

— Annex D has been added to clarify the methods for setting the operation parameters on injection machine;

— the original Annex D has been renamed as Annex E.

It also incorporates the Amendments ISO 294-1:1996/Amd.1:2001 and ISO 294-1:1996/Amd.2:2005.

A list of all the parts in the ISO 294 series can be found on the ISO website.

Introduction

Many factors in the injection-moulding process influence the properties of moulded test specimens and hence the measured values obtained when the specimens are used in a test method. The mechanical properties of such specimens are 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. Thermoplastics exhibit differences in molecular orientation in crystallization morphology (for crystalline and semicrystalline polymers), in phase morphology (for heterogeneous thermoplastics) as well as in the orientation of anisotropic fillers such as short fibres. Residual ("frozen-in") stresses in the moulded test specimens and thermal degradation of the polymer during moulding also influence properties. Each of these phenomena must be controlled to minimize variability of the numerical values of the properties measured.

Care has been taken to ensure that the ISO moulds described can all be fitted in existing injection-moulding equipment and have interchangeable cavity plates.

Plastics — Injection moulding of test specimens of thermoplastic materials —

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

1 Scope

This document specifies the general principles to be followed when injection moulding test specimens of thermoplastic materials and gives details of mould designs for preparing two types of specimen for use in acquiring reference data, i.e. type A1 and type B1 test specimens as specified in ISO 20753, and provides a basis for establishing reproducible moulding conditions. Its purpose is to provide consistent descriptions of the main parameters of the moulding process and to establish a uniform practice in reporting moulding conditions. The particular conditions required for the reproducible preparation of test specimens will vary for each material used and are given in the International Standard for the relevant material or are to be agreed upon between the interested parties.

NOTE Interlaboratory tests with acrylonitrile/butadiene/styrene (ABS), styrene/butadiene (SB) and poly(methyl methacrylate) (PMMA) have shown that mould design is an important factor in the reproducible preparation of test specimens.

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 294-2, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 2: Small tensile bars*

ISO 294-3:2002, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 3: Small plates*

ISO 294-4, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 4: Determination of moulding shrinkage*

ISO 20753, *Plastics — Test specimens*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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

3.1
mould temperature
T_C
average temperature of the mould cavity surfaces measured after the system has attained thermal equilibrium and immediately after opening the mould

Note 1 to entry: It is expressed in degrees Celsius (°C).

3.2
melt temperature
T_M
temperature of the molten plastic in a free shot

Note 1 to entry: It is expressed in degrees Celsius (°C).

3.3
melt pressure
p
pressure of the plastic material in front of the screw at any time during the moulding process

Note 1 to entry: It is expressed in megapascals (MPa).

3.4
hold pressure
p_H
melt pressure (3.3) during the *hold time* (3.9)

Note 1 to entry: It is expressed in megapascals (MPa).

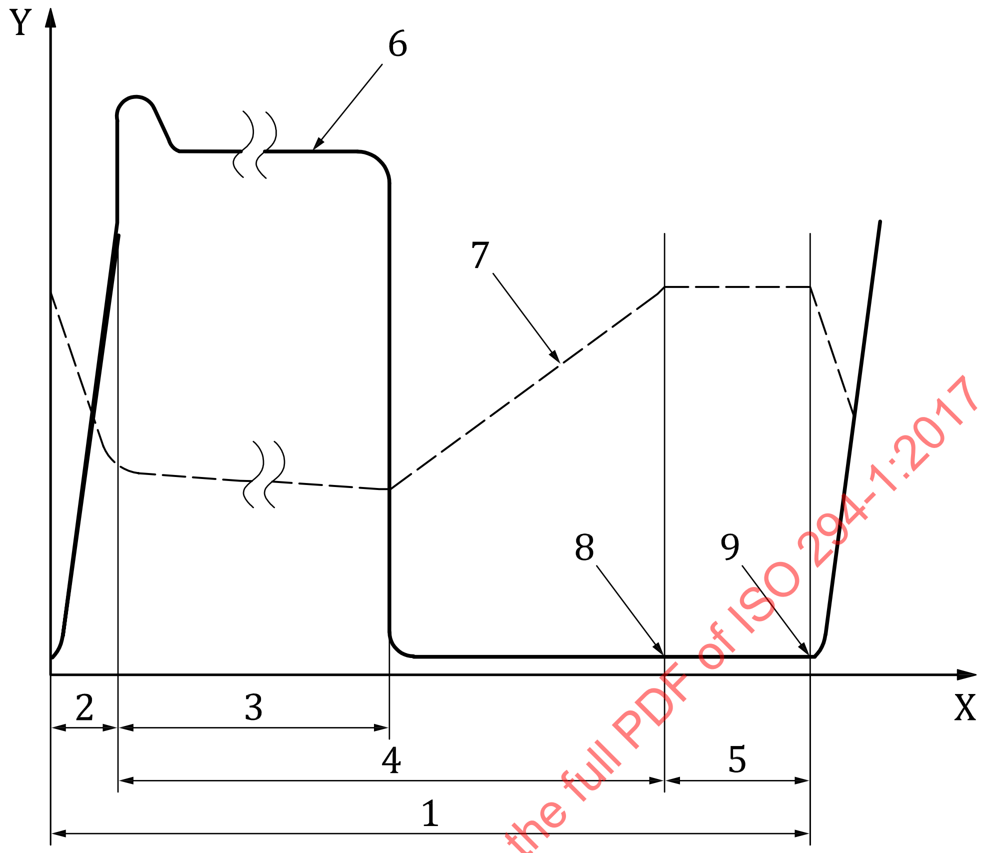
3.5
moulding cycle
complete sequence of operations in the moulding process required for the production of one set of test specimens

Note 1 to entry: See Figure 1.

3.6
cycle time
t_T
time required to carry out a complete *moulding cycle* (3.5)

Note 1 to entry: The cycle time is the sum of the injection time, t_I, the cooling time, t_C, and the mould-open time, t_O.

Note 2 to entry: It is expressed in seconds (s).



Key

X time, t

Y melt pressure, p, and longitudinal screw position, l

1 cycle time, t_T

2 injection time, t_I

3 hold time, t_H

4 cooling time, t_C

5 mould-open time, t_O

6 melt pressure, p

7 longitudinal position of screw, l

8 mould opening

9 mould closing

NOTE The melt pressure during the cooling phase is not zero due to back pressure effects.

Figure 1 — Schematic diagram of an injection-moulding cycle showing the melt pressure (full line) and the longitudinal position of the screw (dashed line) as a function of time

3.7
injection time

t_I

time from the instant the screw starts to move forward until the switchover point between the injection period and the hold period

Note 1 to entry: It is expressed in seconds (s).

3.8
cooling time
t_C
time from the end of the injection period until the mould starts to open

Note 1 to entry: It is expressed in seconds (s).

3.9
hold time
t_H
time during which the pressure is maintained at the *hold pressure* (3.4)

Note 1 to entry: It is expressed in seconds (s).

3.10
mould-open time
t_O
time from the instant the mould starts to open until the mould is closed and exerts the full *clamping force* (3.19)

Note 1 to entry: It is expressed in seconds (s).

Note 2 to entry: It includes the time required to remove the mouldings from the mould.

3.11
cavity
part of the hollow space in a mould that produces one specimen

3.12
single-cavity mould
mould with one *cavity* (3.11) only

3.13
multi-cavity mould
mould that has two or more identical cavities (3.11) in a parallel-flow arrangement

Note 1 to entry: Identical flow-path geometries and symmetrical positioning of the cavities in the mould ensure that all test specimens from one shot are equivalent in their properties.

3.14
family mould
multi-cavity mould (3.13) containing cavities (3.11) which have different geometries

3.15
ISO mould
one of several standard moulds (designated ISO 20753 type A1, B1, C1, D11 and D12) intended for the reproducible preparation of test specimens with comparable properties

Note 1 to entry: The moulds have a fixed plate with a central sprue, plus a multi-cavity cavity plate as described in 3.13.

Note 2 to entry: Additional details are given in 4.1.1.4. An example of a complete mould is shown in Annex C.

3.16
critical cross-sectional area
A_C
cross-sectional area of the *cavity* (3.11) in a *single-cavity mould* (3.12) or *multi-cavity mould* (3.13) at the position where the critical portion of the test specimen, i.e. that part on which the measurement will be made, is moulded

Note 1 to entry: It is expressed in square millimetres (mm^2).

Note 2 to entry: For tensile test specimens, for instance, the critical portion of the test specimen is the narrow section which is subjected to the greatest stress during testing.

3.17
moulding volume
V_M
ratio of the mass of the moulding to the density of the solid plastic

Note 1 to entry: It is expressed in cubic millimetres (mm^3).

3.18
projected area
A_p
overall profile of the moulding projected on to the parting plane

Note 1 to entry: It is expressed in square millimetres (mm^2).

3.19
clamping force
F_M
force holding the plates of the mould closed

Note 1 to entry: It is expressed in kilonewtons (kN).

3.20
injection velocity
v_I
average velocity of the melt as it passes through the *critical cross-sectional area* (3.16)

Note 1 to entry: It is expressed in millimetres per second (mm/s).

3.21
shot volume Max.
V_S
product of the maximum metering stroke of the injection-moulding machine and the cross-sectional area of the screw

Note 1 to entry: It is expressed in cubic millimetres (mm^3).

3.22
mass of moulding
total mass of the test specimens, the runner(s) and the sprue in a single moulding

Note 1 to entry: It is expressed in grams (g).

3.23
mass of test specimen
mass of a single specimen, excluding the runner(s) and the sprue

Note 1 to entry: It is expressed in grams (g).

3.24
sink mark ratio
SR
indication of the relative depth of a sink mark on the surface of the specimen, as given by:

$$SR = \frac{\left(h_{max} - h_{min}\right)}{h_{max}}$$

where

h_{min} is the minimum thickness of the specimen, calculated as the average of the thicknesses at three points P_{min1}, P_{min2} and P_{min3} along the length of the specimen, as defined in Figures E.2 and E.3;

h_{max} is the maximum thickness of the specimen, calculated as the average of the thicknesses at three points P_{max1}, P_{max2} and P_{max3} along the length of the specimen, as defined in Figures E.2 and E.3.

Note 1 to entry: It is expressed to two significant figures (e.g. 0,032).

3.25
cavity pressure
pressure of the melt in the mould cavity, measured with a pressure sensor on the inner surface of the cavity

Note 1 to entry: It is expressed in megapascals (MPa).

4 Apparatus

4.1 Moulds

4.1.1 ISO (multi-cavity) moulds

4.1.1.1 ISO moulds are strongly recommended for producing test specimens for the acquisition of data which are intended to be comparable (see ISO 10350-1, ISO 10350-2, ISO 11403-1, ISO 11403-2 and ISO 11403-3), as well as for use in the case of disputes involving International Standards.

4.1.1.2 Multipurpose test specimen as specified in ISO 20753 type A1 shall be moulded in a two-cavity mould using a Z- or T-runner (see Annex A). The mould as shown in Figure 2 shall meet the requirements specified in 4.1.1.4. Of the two types of runner, the Z-runner is preferred owing to the more symmetrical closure force obtained. The specimen mouldings produced shall have the dimensions of the ISO 20753 type A1 specimen specified in ISO 20753.

4.1.1.3 Rectangular 80 mm × 10 mm × 4 mm bars (ISO 20753 type B1) shall be moulded in a four-cavity mould with a double-T runner. The mould shall be as shown in Figure 3 and shall meet the requirements specified in 4.1.1.4. The bars produced shall have the same cross-sectional dimensions along their central section as multipurpose test specimens (see ISO 20753) and a length of 80 mm ± 2 mm.

4.1.1.4 The main constructional details of ISO 20753 type A1 and B1 moulds are shown in Figures 2 and 3. They shall meet the following requirements:

a) The sprue diameter on the nozzle side shall be at least 4 mm.

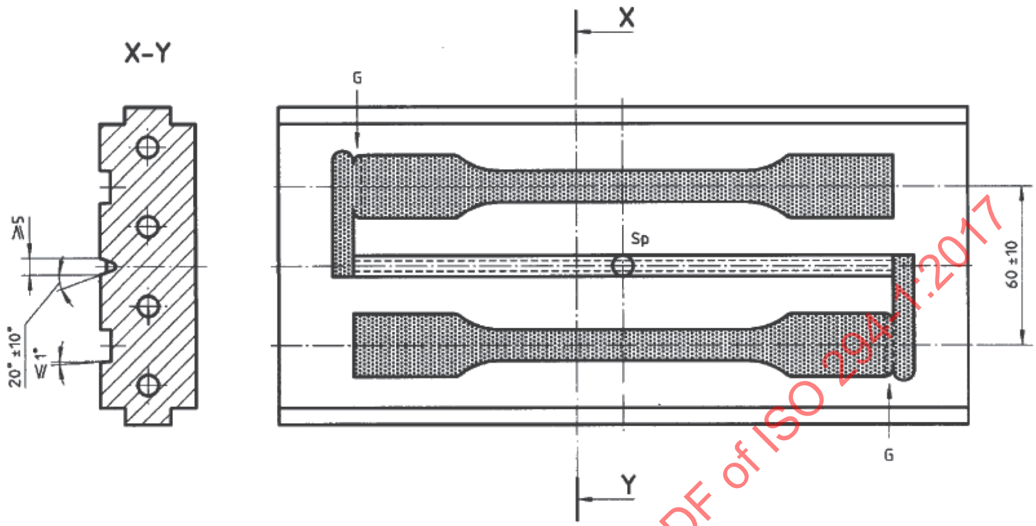
b) The width and height (or the diameter) of the runner system shall be at least 5 mm.

c) The cavities shall be one-end gated as shown in Figures 2 and 3.

d) The height of the gate shall be at least two-thirds the height of the cavity and the width of the gate shall be equal to that of the cavity at the point where the gate enters the cavity.

e) The gate shall be as short as possible, in any case not exceeding 3 mm.

Dimensions in millimetres



Key

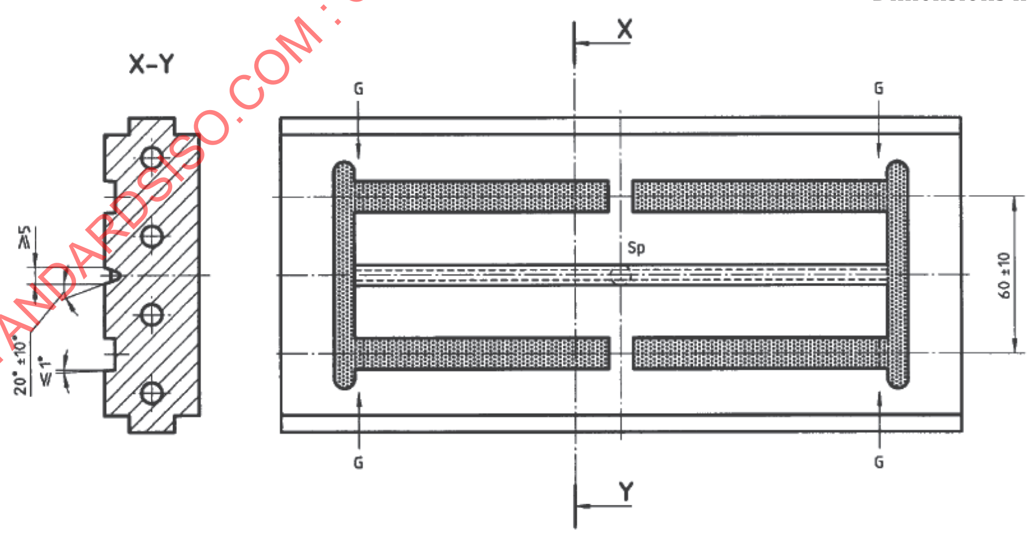
Sp sprue

G gates

NOTE Moulding volume $V_M \approx 30\ 000\ mm^3$, projected area $A_p \approx 6\ 300\ mm^2$.

Figure 2 — Two-cavity mould for an ISO 20753 type A1 mould

Dimensions in millimetres



Key

Sp sprue

G gates

NOTE Moulding volume $V_M \approx 30\ 000\ mm^3$, projected area $A_p \approx 6\ 500\ mm^2$.

Figure 3 — Four cavity mould for an ISO 20753 type B1 mould

f) The draft angle of the runners shall be at least 10°, but not more than 30°. The cavity shall have a draft angle not greater than 1°, except in the area of tensile-specimen shoulders where the draft angle shall not be greater than 2°.

g) 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 moulding 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. In the case of ISO 20753 type A1 and B1 moulds, the main cavity dimensions, in millimetres, shall be as follows (see ISO 20753):

   1) depth: 4,0 mm to 4,2 mm;

   2) width of central section: 10,0 mm to 10,2 mm;

   3) length (ISO 20753 type B1 mould): 80 mm to 82 mm.

h) Ejector pins, if used, shall be located outside the test area of the specimen, i.e. at the shoulders of dumbbell specimens produced from ISO 20753 type A1 and type C moulds (for type C, see ISO 294-2), outside the central 20 mm section of bar specimens from ISO 20753 type B1 moulds and outside the 50-mm-diameter central area of plate specimens from ISO 20753 type D moulds (see ISO 294-3).

i) The heating/cooling 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 5 °C.

j) 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. An example is shown in Annex A.

k) It is recommended that a pressure sensor be fitted in the central runner to give proper control of the injection period (the sensor is mandatory for ISO 294-4). A sensor position suitable for the various types of ISO mould is given in ISO 294-3:2002, Figure 2 and 4.1 k).

l) To ensure that cavity plates are interchangeable between different ISO moulds, it is important to note the following constructional details in addition to those shown in Figures 2 and 3 and those given in ISO 294-2 and ISO 294-3:

   1) It is recommended that a cavity length of 170 mm be used for multipurpose test specimens moulded in the ISO 20753 type A1 mould. This gives a maximum length of 180 mm for the space between the cavity plates.

   2) The width of the mould plates may be affected by the minimum distance required between the connection points for the heating/cooling channels. In addition, space may need to be provided in ISO 20753 type B1 moulds for the fitting of a special insert enabling notched bars for use in ISO 179-1 to be moulded.

   3) Lines along which the test specimens can be cut from the runners may be defined, e.g. 170 mm apart for ISO 20753 type A1, B1 and C moulds (for type C, see ISO 294-2). A second pair of lines 80 mm apart may be defined for cutting bars from multipurpose test specimens from a type A mould and may be used as well for cutting off small-plate mouldings (see ISO 294-3).

m) To make it easier 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 [see item h) above]. 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.

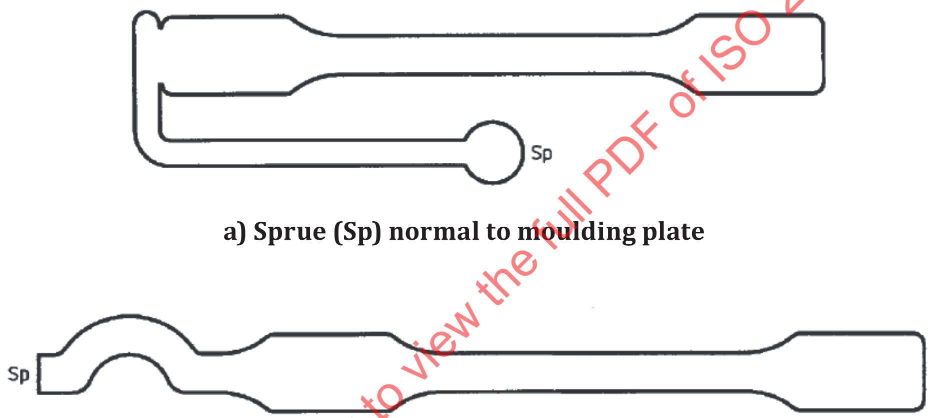
n) Surface imperfections can influence the results, especially those of mechanical tests. Where appropriate, the surfaces of the mould cavities shall be highly polished therefore, the direction of polishing corresponding to the direction in which the test specimen will be placed under load when it is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

4.1.1.5 For more information on those mould components described in other International Standards, see Annex B.

4.1.2 Single-cavity moulds

The cavity of a single-cavity mould (see Figure 4) may be that of a dumbbell, a disc or any other shape. Test specimens from a single-cavity mould generally give values for certain properties which are different from those obtained with specimens from ISO moulds.

NOTE This difference can occur because the ratio of the volume of the cavity to the volume of the moulding, V_M, can be different from that for ISO moulds. Also, the smaller volume of the moulding produced by a single-cavity mould makes conformance with the volume-ratio requirements of 4.2.2 different and failure to conform to these requirements can contribute to erratic values of properties.



a) Sprue (Sp) normal to moulding plate

b) Sprue parallel to the parting plane (the bend in the runner prevents jetting)

Figure 4 — Examples of single-cavity moulds

4.1.3 Family moulds

A family mould (see Figure 5) may be used to produce, for example, flat bars plus dumbbells and discs. A family mould may be used when the properties of the test specimens obtained correspond to those obtained from ISO moulds.

NOTE In most cases, steady, simultaneous filling of the different cavities is not possible with a family mould under more than one set of moulding conditions. Thus this type of mould is not suitable for the preparation of referee test specimens. In addition, the injection velocity, v_I, cannot be defined precisely for a family mould.

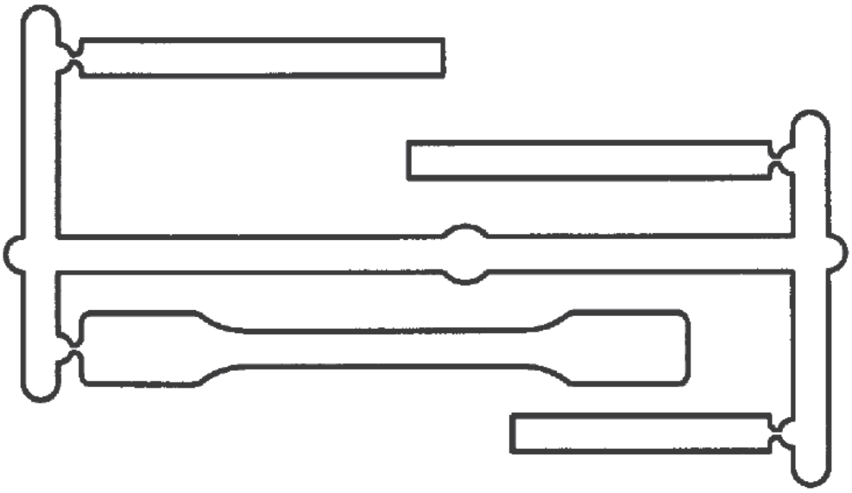


Figure 5 — Example of a family mould

4.2 Injection-moulding machine

4.2.1 General

For further information, see Reference [7].

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.

4.2.2 Moulding volume

The ratio of the moulding volume, V_M, to the shot volume Max., V_S, shall be between 20 % and 80 % unless a higher ratio is required by the relevant material standard or is recommended by the manufacturer.

4.2.3 Control system

The control system of the machine shall be capable of maintaining the operating conditions within the following tolerance limits:

Injection time, t_I	±0,1 s
Hold pressure, p_H	±5 %
Hold time, t_H	±5 %
Melt temperature, T_M	±3 °C
Mould temperature, T_C	±3 °C up to 80 °C
	±5 °C above 80 °C
Mass of moulding	±2 %

4.2.4 Screw

The screw shall be of a type suitable for the moulding material (e.g. length, diameter, thread height, compression ratio).

It is recommended that a screw with a diameter in the range between 18 mm and 40 mm is used.

4.2.5 Clamping force

The clamping force, F_M, shall be high enough to prevent flash forming under any operating conditions.

The minimum clamping force necessary may be calculated from Formula (1):

$$F_M \geq A_p \times p_{max} \times 10^{-3} \quad (1)$$

where

F_M is the clamping force, in kilonewtons;

A_p is the projected area, in square millimetres;

p_{max} is the maximum value of the melt pressure, p, in megapascals.

The melt pressure, p, which is generated hydraulically for instance, can be calculated from the force, F_s, acting longitudinally on the screw using Formula (2):

$$p = \frac{4 \times 10^3 F_s}{\pi D^2} \quad (2)$$

where

p is the melt pressure, in megapascals;

F_s is the longitudinal force, in kilonewtons, acting upon the screw;

D is the screw diameter, in millimetres.

The recommended minimum clamping force, F_M, for type ISO 20753 type A1 and B1 moulds is given by $F_M \geq 6\,500 \times p_{max} \times 10^{-3}$, i.e. 520 kN for a maximum melt pressure of 80 MPa.

An injection-moulding system with interchangeable cavity plates will need to take into account the ISO 20753 type D11 and D12 moulds for which $A_p \approx 11\,000$ mm^2, thus requiring a significantly higher clamping force.

4.2.6 Thermometers

A needle-probe thermometer accurate to ±1 °C shall be used to measure the melt temperature, T_M. A surface thermometer accurate to ±1 °C shall be used to measure the temperature of the surface of the mould cavity, which gives the mould temperature, T_C.

5 Procedure

5.1 Conditioning of material

Prior to moulding, condition the pellets or granules of the thermoplastic material as required in the relevant material standard or as recommended by the manufacturer if no standard covers this subject.

Avoid exposing the material 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 agreed between the interested parties if no standard covers this subject.

5.2.2 For many thermoplastics, the most suitable range for the injection velocity, v_I, is 200 mm/s ± 100 mm/s when using ISO 20753 type A1 or B1 moulds. Note that 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 Formula (3)]. Keep any changes in the injection velocity during the injection period as small as possible.

NOTE Methods for setting the injection moulding operation parameters are given in Annex D.

It is applicable to single- and multi-cavity moulds only, and may be calculated from Formula (3):

$$v_I = \frac{V_M}{t_I \times A_c \times n} \quad (3)$$

where

v_I is the injection velocity, in millimetres per second;

n is the number of cavities;

A_c is the critical cross-sectional area, in square millimetres;

V_M is the moulding volume, in cubic millimetres;

t_I is the injection time, in seconds.

5.2.3 The hold pressure, p_H, is determined by the material's structure and property; it should be confirmed by relevant properties of specimen with different hold pressure. When similar properties of the specimen which are free from sink marks, voids, flash and other visible faults at different hold pressure are acquired, the low pressure is recommended.

The hold pressure may be determined using one of the following methods:

a) using the mass of specimens cut from the moulding;

b) using the sink mark ratio;

c) using the maximum melt pressure that does not yield flash marks.

NOTE Each of these methods is described in Annex E to determine the range of hold pressure, for example, method c) is for the maximum. Other comparable methods of determining the correct hold pressure are also allowed.

5.2.4 Ensure that the hold pressure is maintained constant until the material in the gate region has solidified, i.e. during the hold time, t_H. The hold time can be determined using one of the following methods:

a) using the mass of the specimens;

b) using the cavity pressure.

NOTE Each of these methods is described in E.2. Other comparable methods of determining the correct hold time are also allowed.

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.

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 four points on each pair of the mould cavity using a surface thermometer. Between each reading, cycle the mould for a minimum of three cycles before continuing with the next point of measurements. Record each measurement and calculate the mould temperature as the average of all the measurements.

5.4 Measurement of the melt temperature

Measure the melt temperature, T_M, by one of the following methods.

a) After thermal equilibrium has been attained, inject a free shot of at least 30 cm^3 into an insulated, non-metallic container of a suitable size and immediately insert the probe of a preheated rapid-response needle thermometer into the centre of the molten mass, moving it about gently until the reading of the thermometer has reached a maximum. Ensure that the preheating temperature is close to the melt temperature. Use the same injection conditions for the free shot as those to be used to mould the specimens, allowing the appropriate cycle time to elapse between each free shot.

b) The melt temperature may alternatively 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 melt-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 a).

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. Protect test specimens made from thermoplastics sensitive to atmospheric exposure by keeping them in airtight containers, together with a desiccant if necessary. Perform any additional conditioning as specified in the relevant material or product standard.

6 Report on test-specimen preparation

The report shall include the following information:

a) a reference to this document, i.e. ISO 294-1;

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 mould used (type A1, type B1 or, in the case of another type of mould, the type of specimen produced, the relevant standard, the number of cavities and the gate size and location);

f) details of the injection-moulding machine used (manufacturer, shot volume Max., clamping force, control systems);

g) the moulding conditions;

   1) melt temperature, T_M, in degrees Celsius;

   2) mould temperature, T_C, in degrees Celsius;

   3) injection velocity, v_I, in millimetres per second;

   4) injection time, t_I, in seconds;

   5) hold pressure, p_H, in megapascals;

   6) hold time, t_H, in seconds;

   7) cooling time, t_C, in seconds;

   8) cycle time, t_T, in seconds;

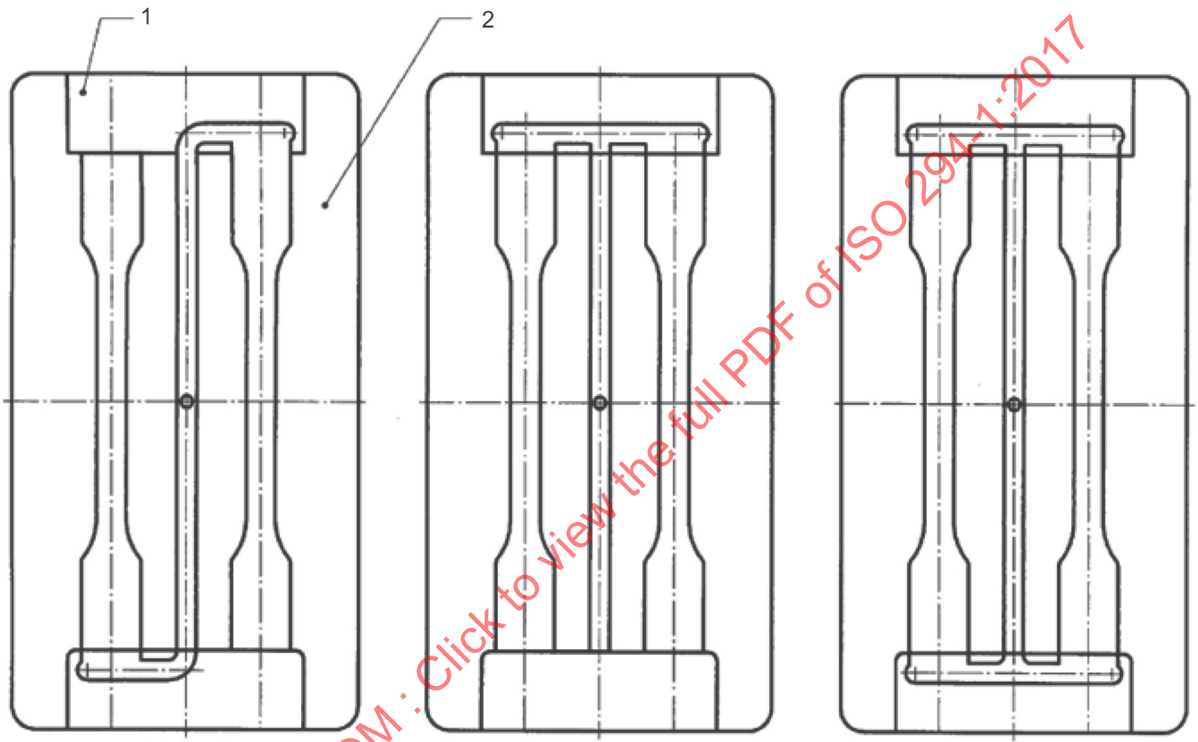
   9) mass of the moulding, in grams;

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

Annex A
(informative)

Examples of runner configurations

The layout of a mould may be changed by means of gate inserts as shown in Figure A.1.



a) Injection mould with Z-runner

b) Variant with T-runner

c) Variant with double-T runner (e.g. for studying weld strength)

Key

1 interchangeable gate insert

2 interchangeable cavity plate

Figure A.1 — Different types of runner configuration

Annex B
(informative)

Standardized injection-moulding mould components

ISO 6751, *Tools for moulding — Ejector pins with cylindrical head*

ISO 6753-2, *Tools for pressing and moulding — Machined plates — Part 2: Machined plates for moulds*

ISO 8017, *Tools for moulding — Guide pillars, straight and shouldered, and locating guide pillars, shouldered*

ISO 8018, *Tools for moulding — Guide bushes, headed, and locating guide bushes, headed*

ISO 8404, *Tools for moulding — Angle pins*

ISO 8405, *Tools for moulding — Ejector sleeves with cylindrical head — Basic series for general purposes*

ISO 8406, *Tools for moulding — Mould bases — Round locating elements and spacers*

ISO 8693, *Tools for moulding — Flat ejector pins*

ISO 8694, *Tools for moulding — Shouldered ejector pins*

ISO 9449, *Tools for moulding — Centring sleeves*

ISO 10072, *Tools for moulding — Sprue bushes — Dimensions*

ISO 10073, *Tools for moulding —Support pillars*

ISO 10907-1, *Tools for moulding — Locating rings — Part 1: Locating rings for mounting without thermal insulating sheets in small or medium moulds (types A and B)*

ISO 12165, *Tools for moulding — Components of compression and injection moulds and diecasting dies — Terms and symbols*

Annex C
(informative)

Example of an injection mould

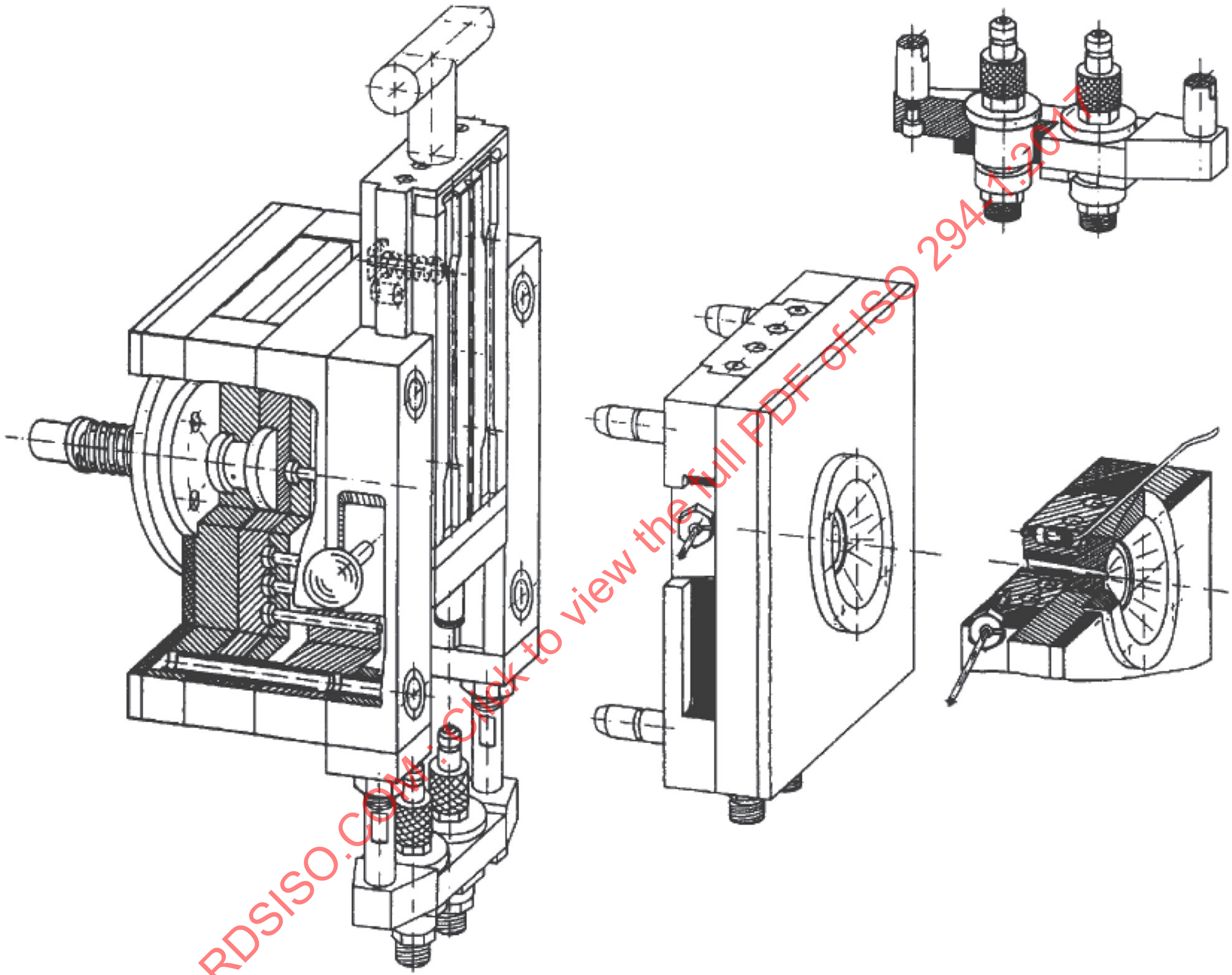


Figure C.1 — Exploded view of an injection mould with an interchangeable two-cavity plate for an ISO 20753 type A1 mould

Annex D
(informative)

Methods for setting the injection moulding parameters

D.1 General

This annex recommends methods of setting injection moulding parameters for preparing specimens according to 5.2 and following its technical requirements.

The user of this test method should refer to the material specifications for specific moulding conditions; if these are not available, the injection moulding parameters shall be determined by agreement between the concerned parties in accordance with this annex.

D.2 Setting of temperature

Set the melt and mould temperatures according to the relevant material specifications or by mutual agreement.

D.3 Plastification of materials

D.3.1 General

The injection moulding machine plasticizes and homogenizes the plastic particles (i.e. materials) to provide a homogeneous melt to the front end of the screw. A certain volume of melt is injected in each moulding cycle to produce the moulding. Some of melt remains at the front end of screw as padding (cushion) at the end of the injection stage to "pack" the mould and minimize shrinkage. In order to ensure the consistency and homogeneity of the melt in each injection moulding cycle, it is necessary to control parameters including back pressure, screw speed, plasticizing time (screw recovery time) and plasticizing volume during the cooling stage.

D.3.2 Determination of back pressure

Set the back pressure value appropriate to the material and make sure the material is fully plasticized. Excessive back pressure can result in excessive melt temperature and material degradation. Inadequate back pressure can result in poorly molten, non-homogeneous material. Both conditions will affect the quality of the melt and the quality of the specimens.

D.3.3 Setting of plasticizing time

The screw speed and back pressure shall be balanced to provide a plasticizing (screw recovery) time that is shorter than the cooling time.

D.3.4 Determination of plasticizing volume (dosing)

Plasticizing volume (dosing) includes the moulding injection volume at the time of preparing the moulding, feeding melt in holding process and padding (cushion) volume. The volume depends on the padding volume required after holding process and the padding volume is subject to the effective transfer of the screw thrust. See D.6.

D.3.5 Setting of barrel pressure decompression

Upon the completion of plasticization by the screw, if the melt in the barrel leaks from the nozzle under the action of back pressure, it is necessary that the screw retract by a certain distance to lower the melt pressure. This step ensures the accurate control on injection volume throughout the injection moulding process, so the set retraction distance shall be minimized to exactly prevent the melt from flowing out of the nozzle before injection moulding starts.

D.4 Injection moulding

D.4.1 General

It is a process that the melt fills the mould cavity at a certain injection speed before the mould cavity is full; see Figure D.1. The termination of this process is controlled by the switchover point set. In general, the injection machine can employ a volume (stroke), pressure or time switchover mode. It is recommended to use the method of setting the switchover point with D.4.3.1 volume (or displacement) conversion and injecting the melt at a constant screw speed. Because pressure or time conversion are more liable to result in excessive or incomplete filling of the cavity, it is recommended that volume conversion be used (see D.4.3.1) using a constant injection rate.

NOTE 1 Other switchover point control methods are acceptable, provided that such methods will not result in incomplete filling the cavity.

NOTE 2 Specimen preparation by this method guarantees good repeatability and reproducibility.

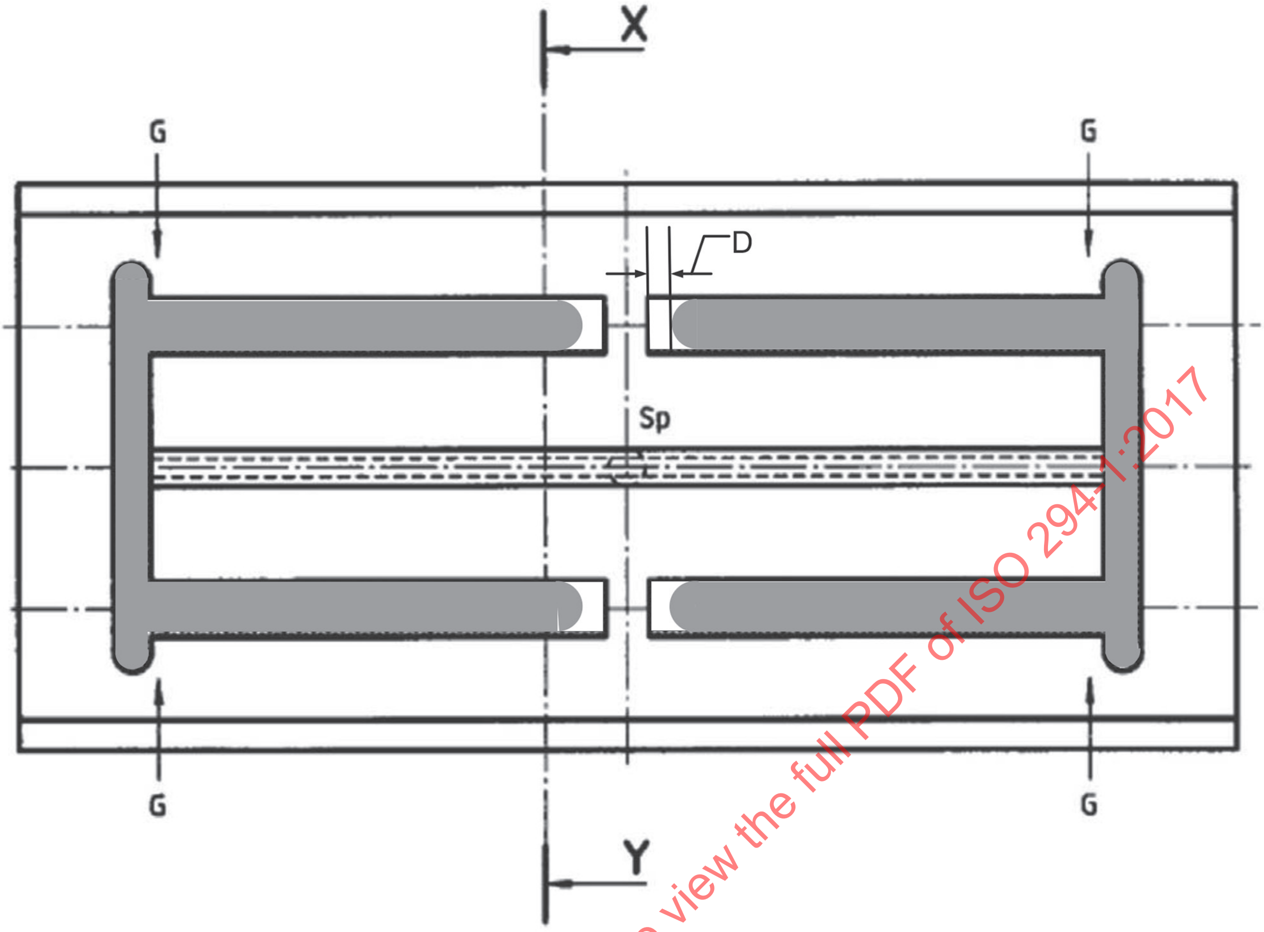
D.4.2 Determination of injection moulding volume

When the melt nearly unfills the mould cavity, the volume of melt injected into the mould is the injection moulding volume. To determine the volume, set the holding pressure to zero and inject the melt at a preset screw injection speed, and then observe the distance between the front end of melt and the "end" of the cavity after the melt injected into the mould has cooled down for an appropriate period. Change the switchover point volume (displacement) to reach the state that the melt nearly unfilled the cavity.

Record the plasticizing (dosing) volume (or displacement) and the switchover point volume (or displacement) once the distance between the front end of melt flow and the "end "of the cavity is within 1 mm to 2 mm (see Figure D.1). The difference between them is the injection moulding volume (displacement) at the current injection speed.

NOTE 1 Preset screw injection speed used at this step can differ from the final one determined in D.4.3.1.

NOTE 2 The moulding will not be properly ejected as there are depressions on the sample resulting from the absence of a holding process.



Key

Sp sprue

G gates

D distance between the melt edge and cavity is 1 mm~2 mm

Figure D.1 — Melt position before the cavity is filled

D.4.3 Selection of switchover mode

D.4.3.1 Volume switchover

Set the switchover mode to volume (screw stroke) and set the volume (screw stroke) as the injection moulding volume identified in D.4.1. Adjust the screw injection speed, maintaining a constant speed to inject the melt, and let the injection time displayed on the injection moulding machine in accord to the injection time calculated by Formula D.1. Formula (D.1) is a conversion from Formula (3).

$$t_I = \frac{V_M}{v_I \cdot A_c \cdot n} \quad \text{(D.1)}$$

where

t_I is the injection time in s;

V_M is the moulding volume in mm^3;

v_I is the injection velocity in mm/s;

A_c is the critical cross-sectional area in mm^2;

n is the number of cavities.

In this process, the injection pressure is the displayed value, which is supposed to rise gradually throughout the injection. Record the maximum pressure as the injection pressure. The injection pressure (pressure at the switchover point) is different for every cycle due to the homogeneity difference of melt and the precision of injection machine.

If the injection pressure stops at a certain value, adjust the set injection pressure of the injection moulding machine until it is higher than the displayed injection pressure. In case of a sudden rise, the melt over-fills the mould cavity and the injection moulding volume shall be adjusted.

Repeat D.4.1 to D.4.2 and verify that the melt injection volume at the screw injection speed nearly unfills the cavity. The screw injection speed in D.4.1 may differ from the screw speed at the moment and the change in injection pressure therefore will result in a change in the volume of injection moulding.

D.4.3.2 Pressure switchover

Set the switchover mode to pressure and select the desired injection pressure. The pressure can be the melt pressure or pressure measured in the mould cavity. Set the volume (displacement) to the injection moulding volume identified in D.4.1. Then change the pressure to make sure the injection time meets Formula (D.1) when melt nearly fills up the cavity and record the injection pressure, maximum or average screw injection speed and injection moulding volume.

If the injection of excessive melt into the cavity is required for the material to get packed (or excessive filling) at the injection stage, the volume of injected melt shall be added to the moulding injection volume determined in D.4.2 and the injection pressure shall be increased. Record the injection pressure, screw injection speed and injection moulding volume. Indicate the pack operations (if used) in the report.

Due to the increased injection volume, the speed of melt through the critical cross section shall be accelerated to ensure the injection time is the same as that in D.4.3.1, which may increase the pressure of melt filling the cavity in the flow state.

D.4.3.3 Time switchover

As a critical parameter monitoring the injection speed, injection time is subject to the impact of many parameters. Accordingly, this method can be employed only when the injection conditions are determined by volume or pressure switchover or other methods. Record the injection pressure, screw speed and injection moulding volume.

D.5 Determination of hold conditions

Determine the hold pressure and hold time according to the product standard or Annex E and initiate the hold process at a speed identical to the injection speed.

After hold process, a certain melt cushion (padding) is required in front of the screw in the barrel. At the moment, the screw displacement is generally maintained at 3 mm~6 mm. When adjusting the padding, make sure the injection moulding volume employed in D.4.2 is unchanged. The method is used to simultaneously increase or decrease the plasticizing volume (displacement) and the switchover point volume (displacement) by the same amount to keep dosing constantly.

D.6 Setting of cooling time

After holding process, continue to lower the sample temperature, until moulded parts demould smoothly and the sample is free of distortion. The melt plasticization (see D.3) is implemented at this stage, so the cooling time set on machine shall be longer than the plasticizing time.

NOTE The cooling time set on an injection machine is different from the cooling time defined in 3.8.

D.7 Setting of mould-open time

The time is supposed to be short to reduce the residence time of plasticized material in the barrel.

D.8 Determination of cycle time

Set corresponding injection moulding parameters for the injection machine according to different switchover modes and inject the melt in cycle to verify whether the total cycle time meets the requirements of corresponding product standards. In case of any difference, adjust parameters such as the cooling time and mould open time or determine the final cycle time by mutual agreement.

D.9 Sample preparation

Specimen collection can begin once the moulding machine cycle has reached an equilibrium as defined by the appropriate material and moulding standards.