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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

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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).

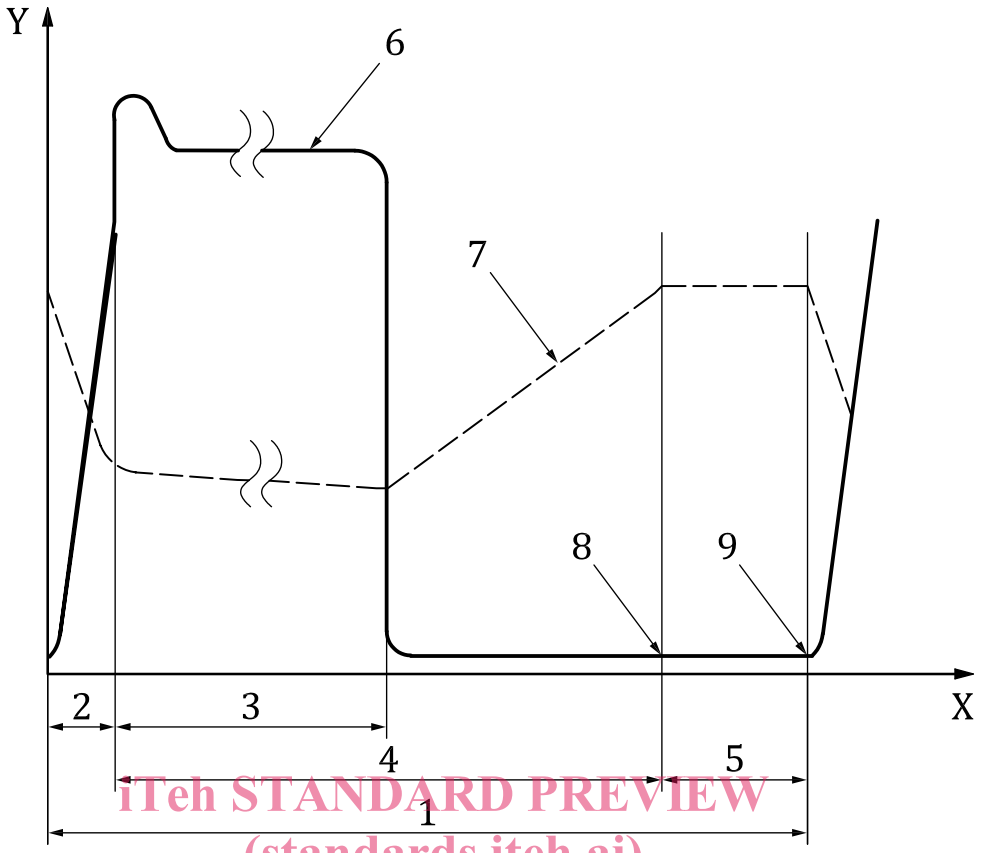
3.5
moulding cycle
complete sequence of operations in the moulding process required for the production of one set of test specimens

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.

