INTERNATIONAL STANDARD

# ISO 2557-1

Second edition
1989-10-01

# Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified maximum reversion —

## Part 1: Bars

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*Plastiques — Thermoplastiques amorphes — Préparation des éprouvettes à niveau de retrait maximal spécifié —*

*Partie 1: Barres*

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Reference number
ISO 2557-1 : 1989 (E)

# Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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International Standard ISO 2557-1 was prepared by Technical Committee ISO/TC 61, *Plastics.*

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This second edition cancels and replaces the first edition (ISO 2557-1 : 1976), of which it constitutes a technical revision.

ISO 2557 consists of the following parts, under the general title *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified maximum reversion*:

— *Part 1: Bars*

— *Part 2: Plates*

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## Introduction

The properties of test specimens of amorphous thermoplastic materials are influenced by their molecular orientation. In particular, molecular orientation has a pronounced effect on mechanical properties. Reproducible test results can only be obtained by using test specimens that are in the same state of orientation.

The amount of orientation can be assessed by measuring the maximum reversion of the specimens at an elevated temperature under specified conditions. For industrial purposes the condition of similar state of orientation is reasonably fulfilled when the measured maximum reversions of test specimens after a specified heat treatment are equal.

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# Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified maximum reversion —

# Part 1: Bars

## 1 Scope

This part of ISO 2557 specifies procedures for the preparation of test specimens of amorphous thermoplastic materials in the form of bars with a specified level of uniaxial molecular orientation which is characterized by determination of the maximum reversion $R_m$ in accordance with ISO 8328.

It is not applicable to fibre reinforced thermoplastics or cellular plastics.

ISO 2557-2 specifies procedures for the preparation of test specimens of amorphous thermoplastic materials in the form of plates with a specified level of uniaxial molecular orientation.

The conditions required to produce a specified state of the material need to be determined for each type of moulding material. The recommended procedure will depend on the required or specified maximum reversion. To produce test specimens in the basic state, having almost no molecular orientation and a maximum reversion of nearly zero, compression moulding and thermal relaxation are the recommended procedures. Test specimens with uniaxial molecular orientation and a maximum reversion greater than that of the basic state can be obtained by injection moulding.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 2557. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 2557 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

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

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

ISO 472 : 1988, *Plastics — Vocabulary.*

ISO 2557-2 : 1986, *Plastics — Amorphous thermoplastics — Preparation of test specimens with a specified reversion — Part 2: Plates.*

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

ISO 8328 : 1989, *Plastics — Amorphous thermoplastic moulding materials — Determination of reversion.*

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## 3 Definitions

For the purposes of this International Standard, the following definitions apply.

**3.1 state of a specimen:** The condition of a specimen as characterized by its maximum longitudinal reversion.

**3.2 basic state of a specimen:** The state in which a specimen is nearly free of internal stresses and molecular orientation. A specimen is considered to be in its basic state if, after the heat treatment specified in ISO 8328,

- the surface does not change;
- its maximum reversion is nearly zero.

The maximum reversion in the basic state will depend on the type of thermoplastic and shall be as specified in the relevant material standard.

## 4 Apparatus

### 4.1 Injection moulding

**4.1.1 Injection-moulding machine,** of the hydraulic reciprocating-screw type, with associated processing control system, as specified in ISO 294.

**4.1.2 Injection moulds,** as specified in ISO 294, having balanced cooling.

NOTE — Bending of specimens during reversion is due to asymmetric distribution of stresses and molecular orientation. This behaviour can be avoided by careful mould construction, in particular balanced cooling.

### 4.2 Compression moulding

**4.2.1 Moulding press,** meeting the requirements specified in ISO 293.

**4.2.2 Moulds.**

A suitable assembly for direct compression moulding of test specimens to the required shape or for thermal relaxation of injection-moulded specimens is shown in figure 1. An example of a typical cavity for a bar measuring 80 mm × 10 mm × 4 mm in shown in figure 2. The tops and bottoms of the open cavities are covered by 0,1 mm thick aluminium foil backed by polished metal plates.

If specimens in the basic state are to be machined from compression-moulded sheets, these shall be moulded to the required thickness in a "flash mould" in accordance with ISO 293.

NOTE — Foil is helpful in preventing sticking to the mould plates, equalizing cooling and dissipating volatile material which could cause bubbles.

## 5 Procedure

### 5.1 Preparation of test specimens with a specified level of maximum reversion above the basic state

**5.1.1** Test specimens with a specified level of maximum reversion above the basic state shall be produced by injection moulding in accordance with ISO 294. The variation of the reversion within a batch of test specimens shall be within the limits specified in the relevant material standard. If information regarding suitable moulding conditions is not available, these may be determined as described in 5.1.2.

**5.1.2** Because the molecular orientation, and consequent reversion on heating, of injection-moulded specimens is a complicated function of many variables, only general guidance for the selection of moulding conditions can be given, namely: low reversion requires high melt temperatures and/or low rates of flow, combined with slow cooling.

The need to determine the required moulding conditions experimentally may be minimized by keeping all moulding parameters constant except the plastic melt temperature and then establishing a correlation between the melt temperature and the maximum reversion. Thus, for a given injection-moulding machine and mould, a particular material is moulded at several plastic melt temperatures within the range recommended for it, while maintaining all the other moulding parameters constant. At each temperature, sufficient mouldings should be made to attain steady operating conditions (checked for example by the mass or dimensions of the mouldings). At least five specimens should be sampled and the maximum reversion of each determined in accordance with ISO 8328. The average maximum reversion of the specimens is then plotted against the plastic melt temperature to give a curve as in figure 3. The plastic melt temperature required to obtain a specified maximum reversion can then be read from the graph.

Alternatively, another processing variable such as injection time (injection pressure) may be correlated with maximum reversion, while maintaining other machine control settings constant. The injection speed required to produce a desired maximum reversion can then be estimated.

NOTE — Subsequently, when the same kind of material is to be moulded with that particular machine and mould, the plastic melt temperature expected to produce the desired level of maximum reversion can be read from the graph without the need for additional experimentation.

### 5.2 Preparation of test specimens in the basic state

**5.2.1 General**

Specimens in the basic state can be prepared either by compression moulding directly to the required shape, by machining from compression-moulded sheet, or by thermal relaxation of injection-moulded specimens. The variation of the maximum reversion within a batch of test specimens shall be within the limits specified in the relevant material standard.

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**5.2.2 Direct compression moulding**

Unless otherwise stated, the moulding procedure described in ISO 293 and moulds in accordance with 4.2.2 shall be used. The moulding temperature and cooling rate shall be as specified in the relevant material standard.

Whether a sufficiently homogeneous state can be obtained by direct moulding of granules, pellets or powder depends on the properties of the particular material and the properties to be evaluated by testing. If there are any doubts about the homogeneity of the state, the use of homogenized preforms (see ISO 293) is recommended.

Due to a certain amount of flow during compression moulding, the state of the material may vary with the position in the mould. For instance, in a multicavity mould (see figure 1), specimens in the basic state will be located in the centre of the mould.

NOTE — While properties such as strength, hardness, etc., normally are not very sensitive, other properties such as toughness, elongation at break and weatherability may depend strongly on the homogeneity of the compression-moulded state.

**5.2.3 Preparation of test specimens by machining from compression-moulded sheets**

The sheets shall be prepared in accordance with ISO 293 and the detailed instructions in the relevant material standard. The

specimens shall be machined from the sheets in accordance with ISO 2818 or stamped out using sharp cutting dies.

#### 5.2.4 Thermal relaxation of injection-moulded specimens

Injection-moulded test specimens, even those with a high maximum reversion, can be transformed to their basic state by thermal relaxation. This requires rapid heating to a temperature above the glass transition temperature $T_g$ (see ISO 472) of the particular material. To maintain the shape of the specimens, they shall be placed in a mould cavity (see 4.2.2) the dimensions of which are identical to those of the injection mould (see figure 2).

These moulds shall be placed between sheets of aluminium foil and then metal plates (see 4.2.2), and heated and cooled under the conditions specified in the relevant material standard.

Unless otherwise specified, it is recommended that the mould assembly be heated for 30 min in a preheated press and then cooled at 15 K/min ± 5 K/min (method B of ISO 293:1986).

NOTE — In the absence of guidance in the relevant material standard, it is recommended that for materials with a $T_g$ below 120 °C the press be preheated to 170 °C. For materials with a $T_g$ above 120 °C, it is recommended that the temperature of the press is the Vicat softening temperature (determined in accordance with ISO 306) + 50 °C.

## 6 Report

The report shall include the following particulars:

a) a reference to this International Standard;

b) a complete identification of the moulding material (type, designation, etc.);

c) details of the preparation of the test specimens:

1) for test specimens with a specified level of maximum reversion, the injection-moulding conditions,

2) for test specimens in the basic state, the compression-moulding conditions or the conditions of thermal relaxation;

d) the type of test specimen and the test specimen dimensions;

e) details of the reversion testing:

1) the test temperature,

2) the heating time,

3) the initial and final lengths of the test specimens;

f) the individual values of the maximum reversion, expressed as a percentage, and their arithmetic mean rounded to the nearest whole number.

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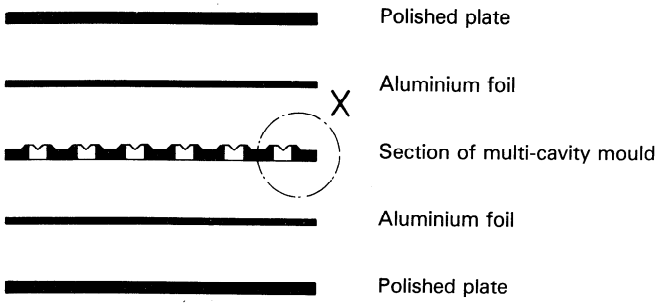
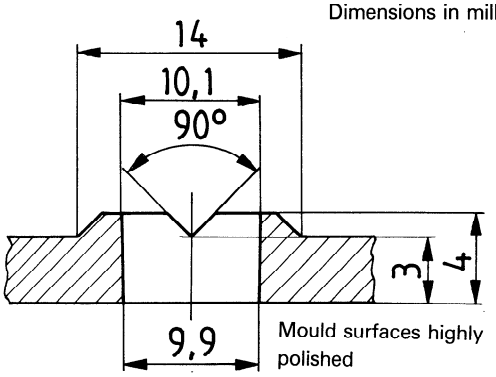



**Figure 1 — Schematic diagram of a mould for compression moulding and thermal relaxation (see 4.2.2)**

Dimensions in millimetres




**Enlarged view of area X in figure 1 and section A-A in figure 2**

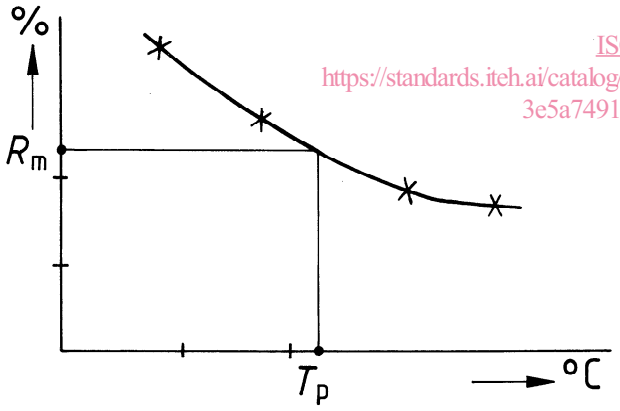



**Figure 3 — Determination of the temperature $T_p$ of a plastic melt required to produce a specified maximum reversion $R_m$**

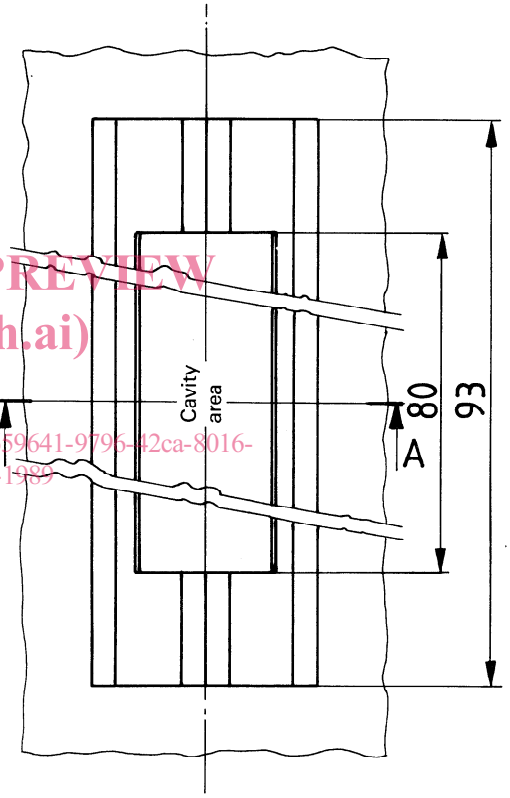



**Figure 2 — Top view of part of a multi-cavity compression mould, for example for standard bars measuring**
80 mm × 10 mm × 4 mm

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