SLOVENSKI STANDARD
oSIST prEN ISO 178:2017

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Polimerni materiali - Določanje upogibnih lastnosti (ISO/DIS 178:2017)

Plastics - Determination of flexural properties (ISO/DIS 178:2017)

Kunststoffe - Bestimmung der Biegeeigenschaften (ISO/DIS 178:2017)

Plastiques - Détermination des propriétés en flexion (ISO/DIS 178:2017)

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83.080.01	Polimerni materiali na splošno	Plastics in general

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Plastics — Determination of flexural properties

Plastiques — Détermination des propriétés en flexion

ICS: 83.080.01

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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).

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For an explanation on 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.

The committee responsible for this document is ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This sixth edition cancels and replaces the fifth edition (ISO 178:2010), which has been technically revised. It also incorporates the information that was given in Amendment ISO 178:2010/Amd.1:2013.

The major technical changes are the introduction of deflectometers and the reinstatement of procedures for compliance correction.

Plastics — Determination of flexural properties

1 Scope

1.1 This International Standard specifies a method for determining the flexural properties of rigid (see 3.12) and semi-rigid plastics under defined conditions. A standard test specimen is defined, but parameters are included for alternative specimen sizes for use where appropriate. A range of test speeds is included.

1.2 The method is used to investigate the flexural behaviour of the test specimens and to determine the flexural strength, flexural modulus and other aspects of the flexural stress/strain relationship under the conditions defined. It applies to a freely supported beam, loaded at midspan (three-point loading test).

1.3 The method is suitable for use with the following range of materials:

— thermoplastic moulding, extrusion and casting materials, including filled and reinforced compounds in addition to unfilled types; rigid thermoplastics sheets;

— thermosetting moulding materials, including filled and reinforced compounds; thermosetting sheets.

In agreement with ISO 10350-1 [5] and ISO 10350-2 [6], this International Standard applies to fibre-reinforced compounds with fibre lengths $\leq$ 7,5 mm prior to processing. For long-fibre-reinforced materials (laminates) with fibre lengths > 7,5 mm, see ISO 14125 [7].

The method is not normally suitable for use with rigid cellular materials or sandwich structures containing cellular material. In such cases, ISO 1209-1 [3] and/or ISO 1209-2 [4] can be used.

NOTE For certain types of textile-fibre-reinforced plastic, a four-point bending test is preferred. This is described in ISO 14125.

1.4 The method is performed using specimens which may be either moulded to the specified dimensions, machined from the central section of a standard multipurpose test specimen (see ISO 20753) or machined from finished or semi-finished products, such as mouldings, laminates, or extruded or cast sheet.

1.5 The method specifies the preferred dimensions for the test specimen. Tests which are carried out on specimens of different dimensions, or on specimens which are prepared under different conditions, can produce results which are not comparable. Other factors, such as the test speed and the conditioning of the specimens, can also influence the results.

NOTE Especially for injection moulded semi-crystalline polymers, the thickness of the oriented skin layer, which is dependent on the moulding conditions, also affects the flexural properties.

1.6 The method is not suitable for the determination of design parameters but can be used in materials testing and as a quality control test.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 291, *Plastics — Standard atmospheres for conditioning and testing*

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

ISO 294-1, *Plastics — Injection moulding of test specimens of thermoplastic materials — Part 1: General principles, and moulding of multipurpose and bar test specimens*

ISO 295, *Plastics — Compression moulding of test specimens of thermosetting materials*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

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

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometers used in uniaxial testing*

ISO 10724-1, *Plastics — Injection moulding of test specimens of thermosetting powder moulding compounds (PMCs) — Part 1: General principles and moulding of multipurpose test specimens*

ISO 16012, *Plastics — Determination of linear dimensions of test specimens*

ISO 20753, *Plastics — Test specimens*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

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
test speed
v
rate of relative movement between the specimen supports and the loading edge

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

3.2
flexural stress
σ_f
nominal stress at the outer surface of the test specimen at midspan

Note 1 to entry: It is calculated from the relationship given in 9.1, Equation (5).

Note 2 to entry: It is expressed in megapascals (MPa).

3.3
flexural stress at break
σ_{fR}
flexural stress at break of the test specimen (see Figure 1, curves a and b)

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

3.4
flexural strength
σ_{fM}
maximum flexural stress sustained by the test specimen during a bending test (see Figure 1, curves a and b)

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

3.5
flexural stress at conventional deflection
σ_{fc}
flexural stress at the conventional deflection, s_C, defined in 3.7 (see also Figure 1, curve c)

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

3.6
deflection
s
distance over which the top or bottom surface of the test specimen at midspan deviates from its original position during flexure

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

3.7
conventional deflection
s_C
deflection equal to 1,5 times the thickness, h, of the test specimen

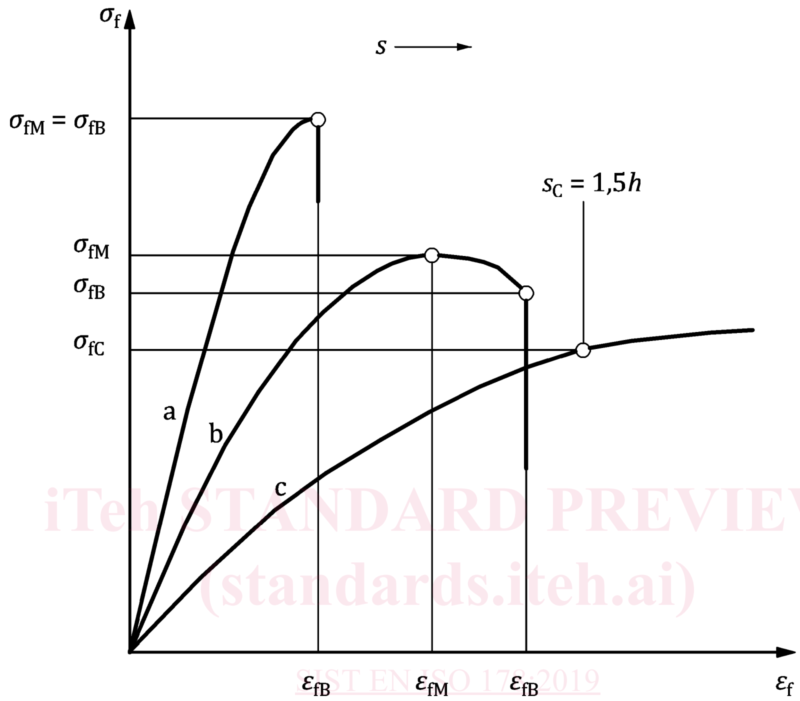
Note 1 to entry: It is expressed in millimetres (mm).

Note 2 to entry: Using a span, L, of $16h$, the conventional deflection corresponds to a flexural strain (see 3.8) of 3,5 %.

3.8
flexural strain
ε_f
nominal fractional change in length of an element of the outer surface of the test specimen at midspan

Note 1 to entry: It is expressed as a dimensionless ratio or a percentage (%).

Note 2 to entry: It is calculated in accordance with the relationships given in 9.2, Equations (6) and (7).



Key

Curve a Specimen that breaks before yielding.
Curve b Specimen that gives a maximum and then breaks before the conventional deflection, s_C.
Curve c Specimen that neither gives a maximum nor breaks before the conventional deflection, s_C.

Figure 1 — Typical curves of flexural stress, σ_f, versus flexural strain, ε_f, and deflection, s

3.9
flexural strain at break
ε_{fB}
flexural strain at which the test specimen breaks (see Figure 1, curves a and b)

Note 1 to entry: It is expressed as a dimensionless ratio or a percentage (%).

3.10
flexural strain at flexural strength
ε_{fM}
flexural strain at maximum flexural stress (see Figure 1, curves a and b)

Note 1 to entry: It is expressed as a dimensionless ratio or a percentage (%).

3.11
modulus of elasticity in flexure
flexural modulus
E_f
ratio of the stress difference, $\sigma_{f2} - \sigma_{f1}$, to the corresponding strain difference, ε_{f2} (= 0,0025) − ε_{f1} (= 0,0005) [see 9.3, Equation (9)]

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

Note 2 to entry: The flexural modulus is only an approximate value of Young's modulus of elasticity.

3.12
rigid and semi rigid plastic
rigid plastic has a modulus of elasticity in flexure or, if that is not applicable, then in tension, greater than 700 MPa. Semi rigid plastic has a modulus of elasticity in flexure or, if that is not applicable, then in tension, between 70 MPa and 700 MPa under a given set of conditions

[SOURCE: ISO 472:2013, 2.884 and 2.909, modified]

3.13
span between specimen supports
L
distance between the points of contact between the test specimen and the test specimen supports (see Figure 2)

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

3.14
flexural strain rate
r
rate at which the flexural strain (see 3.8) increases during a test

Note 1 to entry: It is expressed in percent per minute ($\% \cdot \text{min}^{-1}$).

4 Principle

A test specimen of rectangular cross-section, resting on two supports, is deflected by means of a loading edge acting on the specimen midway between the supports. The test specimen is deflected in this way at a constant rate at midspan until rupture occurs at the outer surface of the specimen or until a maximum strain of 5 % (see 3.8) is reached, whichever occurs first. During this procedure, the force applied to the specimen and the resulting deflection of the specimen at midspan are measured.

This International Standard specifies two methods, method A and method B. Method A uses a strain rate of 1 %/min throughout the test. Method B uses two different strain rates: 1 %/min for the determination of the flexural modulus and 5 %/min or 50 %/min, depending on the ductility of the material, for the determination of the remainder of the flexural stress-strain curve.

NOTE 1 The strain rates mentioned above are to be interpreted as nominal ones. Nominal test speeds are calculated using equation (4). For the machine settings the best fitting ones are selected from Table 1.

NOTE 2 For materials exhibiting non-linear stress/strain behaviour, the flexural properties are only nominal. The equations given have been derived assuming linear elastic behaviour and are valid for deflections of the specimen that are small compared to its thickness. With the preferred specimen (which measures 80 mm × 10 mm × 4 mm) at the conventional flexural strain of 3,5 % and a span-to-thickness ratio, L/h, of 16, the deflection is 1,5h. Flexural tests are more appropriate for stiff and brittle materials showing small deflections at break than for very soft and ductile ones.

5 Test machine

5.1 General

The machine shall comply with ISO 7500-1 and ISO 9513 and the requirements given in 5.2 to 5.4.

5.2 Test speed

The test machine shall be capable of maintaining the test speed (see 3.1), as specified in Table 1.

Table 1 — Recommended values of the test speed *v*

Test speed, *v* mm/min	**Tolerance** %
1[a]	±20
2	±20
5	±20
10	±20
20	±10
50	±10
100	±10
200	±10
500	±10

[a] The lowest speed is used for specimens with thicknesses between 1 mm and 3,5 mm (see also 8.5).

5.3 Supports and loading edge

Two supports and a central loading edge shall be arranged as shown in Figure 2. The supports and the loading edge shall be parallel to within ±0,2 mm over the width of the test specimen.

The radius, R_1, of the loading edge and the radius, R_2, of the supports shall be as follows:

$R_1 = 5{,}0\ \text{mm} \pm 0{,}2\ \text{mm}$;

$R_2 = 2{,}0\ \text{mm} \pm 0{,}2\ \text{mm}$ for test specimen thicknesses ≤ 3 mm;

$R_2 = 5{,}0\ \text{mm} \pm 0{,}2\ \text{mm}$ for test specimen thicknesses > 3 mm.

The span, *L*, shall be adjustable.

5.4 Force- and deflection-measuring systems

5.4.1 Introductory remarks

Flexural tests, according to the specific requirements on the data to be obtained, can be differentiated in several classes, comprising different complexity and requirements on accuracy. This starts with simple tests for obtaining flexural strength only on the one hand and on the other hand necessitates the use of