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Plastics — Determination of tensile properties —

Part 1: General principles

Plastiques — Détermination des propriétés en traction —

Partie 1: Principes généraux

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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 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 2, *Mechanical properties*.

This third edition cancels and replaces the second edition (ISO 527-1:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— an error in Figure 1 concerning ε_{tM} has been removed;

— the inconsistency concerning the accuracy of the elongation used in the calculation of the tensile modulus between 5.1.5.1, Figure 1 and Annex C has been removed. For gauge lengths $L_0 \leq 50$ mm, the accuracy is set to ±1 µm;

— the normative references (see Clause 2) have been updated;

— minor editorial changes have been applied;

— language has been clarified.

A list of all parts in the ISO 527 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Plastics — Determination of tensile properties —

Part 1:
General principles

1 Scope

1.1 This document specifies the general principles for determining the tensile properties of plastics and plastic composites under defined conditions. Several different types of test specimen are defined to suit different types of material which are detailed in subsequent parts of ISO 527.

1.2 The methods are used to investigate the tensile behaviour of the test specimens and for determining the tensile strength, tensile modulus and other aspects of the tensile stress/strain relationship under the conditions defined.

1.3 The methods are selectively suitable for use with the following materials:

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

— rigid and semi-rigid thermosetting moulding materials, including filled and reinforced compounds; rigid and semi-rigid thermosetting sheets, including laminates;

— fibre-reinforced thermosets and thermoplastic composites incorporating unidirectional or non-unidirectional reinforcements, such as mat, woven fabrics, woven rovings, chopped strands, combination and hybrid reinforcement, rovings and milled fibres; sheet made from pre-impregnated materials (prepregs);

— thermotropic liquid crystal polymers.

The methods are not normally suitable for use with rigid cellular materials, for which ISO 1926 is used, or for sandwich structures containing cellular materials.

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

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

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 9513:2012, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

ISO 16012, *Plastics — Determination of linear dimensions of 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:

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

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

3.1
gauge length
L_0
initial distance between the gauge marks on the central part of the test specimen

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

Note 2 to entry: The values of the gauge length that are indicated for the specimen types in the different parts of ISO 527 represent the maximum relevant gauge length.

3.2
thickness
h
smaller initial dimension of the rectangular cross-section in the central part of a test specimen

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

3.3
width
b
larger initial dimension of the rectangular cross-section in the central part of a test specimen

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

3.4
cross-section
A
product of initial *width* (3.3) and *thickness* (3.2), $A = bh$, of a test specimen

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

3.5
test speed
v
rate of separation of the gripping jaws

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

3.6
stress
σ
normal force per unit area of the original *cross-section* (3.4) within the *gauge length* (3.1)

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

Note 2 to entry: In order to differentiate from the true stress related to the actual cross-section of the specimen, this stress is frequently called “engineering stress”.

3.6.1
stress at yield
σ_y
stress at the *yield strain* (3.7.1)

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

Note 2 to entry: It may be less than the maximum attainable stress (see Figure 1, curve 2).

3.6.2
strength
σ_m
stress at the first local maximum observed during a tensile test

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

Note 2 to entry: This may also be the stress at which the specimen yields or breaks (see Figure 1).

3.6.3
stress at x **% strain**
σ_x
stress at which the strain, ε, reaches the specified value x expressed as a percentage

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

Note 2 to entry: Stress at x % strain may, for example, be useful if the stress/strain curve does not exhibit a yield point (see Figure 1, curve 4).

3.6.4
stress at break
σ_b
stress at which the specimen breaks

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

Note 2 to entry: It is the highest value of stress on the stress-strain curve directly prior to the separation of the specimen, i.e directly prior to the load drop caused by crack initiation.

3.7
strain
ε
increase in length per unit original length of the gauge

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

3.7.1
strain at yield
yield strain
ε_y
first occurrence in a tensile test of strain increase without a stress increase

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

Note 2 to entry: See Figure 1, curves (2) and (3).

Note 3 to entry: See Annex A for computer-controlled determination of the yield strain.

3.7.2
strain at break
ε_b
strain at the last recorded data point before the *stress* (3.6) is reduced to less than or equal to 10 % of the *strength* (3.6.2) if the break occurs prior to yielding

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

Note 2 to entry: See Figure 1, curves (1) and (4).

3.7.3
strain at strength
ε_m
strain at which the *strength* (3.6.2) is reached

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

3.8
nominal strain
ε_t
representation of *strain* (3.7) calculated from grip displacement and the *gripping distance* (3.11) by one of the methods in 10.2.2

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

Note 2 to entry: It may be calculated either based on the grip displacement from the beginning of the test or based on the increase of grip displacement beyond the strain at yield, if the latter is determined with an extensometer (preferred for multipurpose test specimens).

3.8.1
nominal strain at break
ε_{tb}
nominal strain at the last recorded data point before the *stress* (3.6) is reduced to less than or equal to 10 % of the *strength* (3.6.2) if the break occurs after yielding

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

Note 2 to entry: See Figure 1, curves (2) and (3).

3.8.2
nominal strain at strength
ε_{tm}
nominal strain at which the *strength* (3.6.2) is reached

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

Note 2 to entry: See Figure 1, curves (2), (3) and (4).

3.9
tensile modulus
modulus of elasticity under tension
E_t
slope of the stress/strain curve σ(ε) in the interval between the two strains ε_1 = 0,05 % and ε_2 = 0,25 %

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

Note 2 to entry: It may be calculated either as the chord modulus or as the slope of a linear least-squares regression line in this interval (see Figure 1, curve 4).

Note 3 to entry: This definition does not apply to films.

3.10
Poisson's ratio
μ
negative ratio of the strain change $\Delta\varepsilon_n$, in one of the two axes normal to the direction of extension, to the corresponding strain change $\Delta\varepsilon_l$ in the direction of extension, within the linear portion of the longitudinal versus normal strain curve

Note 1 to entry: It is expressed as a dimensionless ratio.

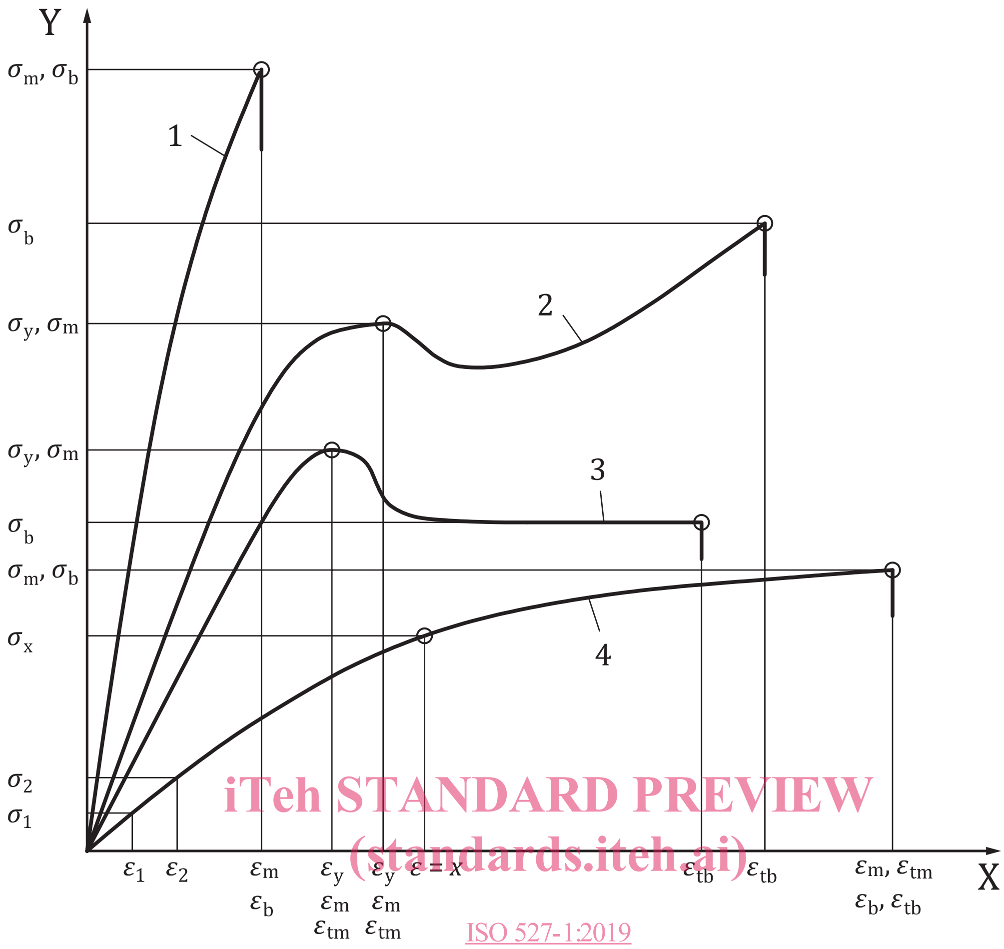
Note 2 to entry: Since the lateral strain change $\Delta\varepsilon_n$ is a negative number and the longitudinal strain change $\Delta\varepsilon_l$ is positive, the Poissons ratio as defined in 3.10 is a positive number.

3.11
gripping distance
L
initial length of the part of the specimen between the grips

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

3.12
rigid plastic
plastic that has a modulus of elasticity in flexure (or, if that is not applicable, in tension) greater than 700 MPa under a given set of conditions

3.13
semi-rigid plastic
plastic that has a modulus of elasticity in flexure (or, if that is not applicable, in tension) between 70 MPa and 700 MPa under a given set of conditions



Key

X strain and/or nominal strain

Y stress

1 Curve (1) represents a brittle material, breaking without yielding at low strains. Curve (4) represents a soft rubberlike material breaking at larger strains (>50 %).

2, 3 Curves (2) and (3) represent materials that have a yield point with (2) or without (3) stress increase after yielding. Curves (2) and (3) are curves “stress vs. strain” up to the yield point and “stress vs. nominal strain” beyond the yield point.

4 Curve (4) may be either stress vs. strain or stress vs. nominal strain depending on equipment used.

Figure 1 — Typical stress/strain curves

4 Principle and methods

4.1 Principle

The test specimen is extended along its major longitudinal axis at a constant test speed until the specimen fractures or until the stress (load) or the strain (elongation) reaches some predetermined value. During this procedure, the load sustained by the specimen and the elongation are measured.

4.2 Method

4.2.1 The methods are applied using specimens which may be either moulded to the chosen dimensions or machined, cut or punched from finished and semi-finished products, such as mouldings, laminates, films and extruded or cast sheet. The types of test specimen and their preparation are described in the