
**Plastics — Determination of tensile
properties —**

**Part 1:
General principles**

Plastiques — Détermination des propriétés en traction —

Partie 1: Principes généraux

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| Contents | Page |
|--|-------------|
| Foreword | iv |
| 1 Scope | 1 |
| 2 Normative references | 1 |
| 3 Terms and definitions | 2 |
| 4 Principle and methods | 5 |
| 4.1 Principle | 5 |
| 4.2 Method | 6 |
| 5 Apparatus | 6 |
| 5.1 Testing machine | 6 |
| 5.2 Devices for measuring width and thickness of the test specimens | 9 |
| 6 Test specimens | 9 |
| 6.1 Shape and dimensions | 9 |
| 6.2 Preparation of specimens | 9 |
| 6.3 Gauge marks | 10 |
| 6.4 Checking the test specimens | 10 |
| 6.5 Anisotropy | 10 |
| 7 Number of test specimens | 10 |
| 8 Conditioning | 11 |
| 9 Procedure | 11 |
| 9.1 Test atmosphere | 11 |
| 9.2 Dimensions of test specimen | 11 |
| 9.3 Gripping | 11 |
| 9.4 Prestresses | 12 |
| 9.5 Setting of extensometers | 12 |
| 9.6 Test speed | 12 |
| 9.7 Recording of data | 13 |
| 10 Calculation and expression of results | 13 |
| 10.1 Stress | 13 |
| 10.2 Strain | 13 |
| 10.3 Tensile modulus | 14 |
| 10.4 Poisson's ratio | 15 |
| 10.5 Statistical parameters | 16 |
| 10.6 Significant figures | 16 |
| 11 Precision | 16 |
| 12 Test report | 16 |
| Annex A (informative) Determination of strain at yield | 18 |
| Annex B (informative) Extensometer accuracy for the determination of Poisson's ratio | 20 |
| Annex C (normative) Calibration requirements for the determination of the tensile modulus | 21 |
| Bibliography | 23 |

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 527-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 527-1:1993), which has been technically revised. It incorporates ISO 527-1:1993/Cor 1:1994 and ISO 527-1:1993/Amd 1:2005. The main changes are as follows.

- A method for the determination of Poisson's ratio has been introduced. It is similar to the one used in ASTM D638, but in order to overcome difficulties with precision of the determination of the lateral contraction at small values of the longitudinal strain, the strain interval is extended far beyond the strain region for the modulus determination.
- Definitions and methods have been optimized for computer controlled tensile test machines.
- The preferred gauge length for use on the multipurpose test specimen has been increased from 50 mm to 75 mm. This is used especially in ISO 527-2.
- Nominal strain and especially nominal strain at break will be determined relative to the gripping distance. Nominal strain in general will be calculated as crosshead displacement from the beginning of the test, relative to the gripping distance, or as the preferred method if multipurpose test specimens are used, where strains up to the yield point are determined using an extensometer, as the sum of yield strain and nominal strain increment after the yield point, the latter also relative to the gripping distance.

ISO 527 consists of the following parts, under the general title *Plastics — Determination of tensile properties*:

- *Part 1: General principles*
- *Part 2: Test conditions for moulding and extrusion plastics*
- *Part 3: Test conditions for films and sheets*
- *Part 4: Test conditions for isotropic and orthotropic fibre-reinforced plastic composites*
- *Part 5: Test conditions for unidirectional fibre-reinforced plastic composites*

Plastics — Determination of tensile properties —

Part 1: General principles

1 Scope

1.1 This part of ISO 527 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 (see 3.12 and 3.13, respectively) 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 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 referenced documents are indispensable for the application 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 7500-1:2004, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513:1999, *Metallic materials — Calibration of extensometers used in uniaxial testing*

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.

3.1 gauge length

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

NOTE 1 It is expressed in millimetres (mm).

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

3.2 thickness

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

NOTE 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 It is expressed in millimetres (mm).

3.4 cross-section

A
product of initial width and thickness, $A = bh$, of a test specimen.

NOTE It is expressed in square millimetres, (mm²).

3.5 test speed

v
rate of separation of the gripping jaws

NOTE It is expressed in millimetres per minute (mm/min).

3.6 stress

σ
normal force per unit area of the original cross-section within the gauge length

NOTE 1 It is expressed in megapascals (MPa)

NOTE 2 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

NOTE 1 It is expressed in megapascals (MPa).

NOTE 2 It may be less than the maximum attainable stress (see Figure 1, curves b and c)

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3.6.2 strength

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

NOTE 1 It is expressed in megapascals (MPa).

NOTE 2 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 reaches the specified value x expressed as a percentage

NOTE 1 It is expressed in megapascals (MPa).

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

3.6.4 stress at break

σ_b
stress at which the specimen breaks

NOTE 1 It is expressed in megapascals (MPa).

NOTE 2 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 It is expressed as a dimensionless ratio, or as a percentage (%).

3.7.1 strain at yield yield strain

ε_y
the first occurrence in a tensile test of strain increase without a stress increase

NOTE 1 It is expressed as a dimensionless ratio, or as a percentage (%).

NOTE 2 See Figure 1, curves b and c.

NOTE 3 See Annex A (informative) 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 is reduced to less than or equal to 10 % of the strength if the break occurs prior to yielding

NOTE 1 It is expressed as a dimensionless ratio, or as a percentage (%).

NOTE 2 See Figure 1, curves a and d.

3.7.3 strain at strength

ε_m
strain at which the strength is reached

NOTE It is expressed as a dimensionless ratio, or as a percentage (%).

**3.8
nominal strain**

ϵ_t
crosshead displacement divided by the gripping distance

NOTE 1 It is expressed as a dimensionless ratio, or as a percentage (%).

NOTE 2 It is used for strains beyond the yield strain (see 3.7.1) or where no extensometers are used.

NOTE 3 It may be calculated based on the crosshead displacement from the beginning of the test, or based on the increment of crosshead 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 is reduced to less than or equal to 10 % of the strength if the break occurs after yielding

NOTE 1 It is expressed as a dimensionless ratio, or as a percentage (%).

NOTE 2 See Figure 1, curves b and c.

**3.9
modulus**

E_t
slope of the stress/strain curve $\sigma(\epsilon)$ in the strain interval between $\epsilon_1 = 0,05\%$ and $\epsilon_2 = 0,25\%$

NOTE 1 It is expressed in megapascals (MPa).

NOTE 2 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 d).

NOTE 3 This definition does not apply to films.

**3.10
Poisson's ratio**

μ
negative ratio of the strain increment $\Delta\epsilon_n$, in one of the two axes normal to the direction of extension, to the corresponding strain increment $\Delta\epsilon_l$ in the direction of extension, within the linear portion of the longitudinal versus normal strain curve

NOTE It is expressed as a dimensionless ratio.

**3.11
gripping distance**

L
initial length of the part of the specimen between the grips

NOTE 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

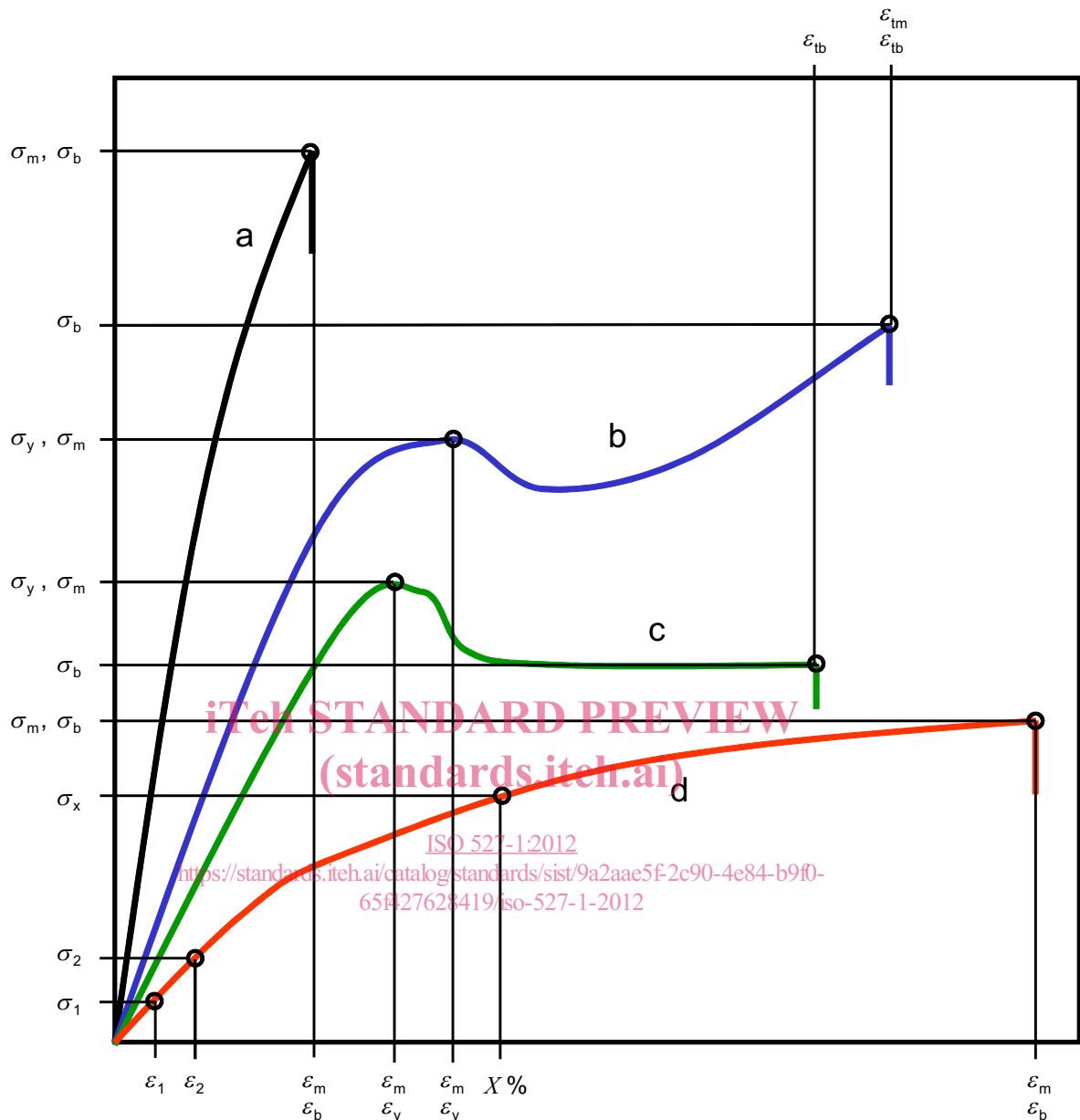


Figure 1 — Typical stress/strain curves

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

4 Principle and methods

4.1 Principle

The test specimen is extended along its major longitudinal axis at a constant 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 relevant part of ISO 527 typical for the material. In some cases, a multipurpose test specimen may be used. Multipurpose and miniaturized test specimens are described in ISO 20753.

4.2.2 The methods specify preferred dimensions for the test specimens. Tests which are carried out on specimens of different dimensions, or on specimens which are prepared under different conditions, may produce results which are not comparable. Other factors, such as the speed of testing and the conditioning of the specimens, can also influence the results. Consequently, when comparative data are required, these factors shall be carefully controlled and recorded.

5 Apparatus

5.1 Testing machine

5.1.1 General

The machine shall comply with ISO 7500-1 and ISO 9513, and meet the specifications given in 5.1.2 to 5.1.6, as follows.

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5.1.2 Test speeds

The tensile-testing machine shall be capable of maintaining the test speeds as specified in Table 1.

ISO 527-1:2012
Table 1 — Recommended test speeds
<https://standards.iteh.ai/catalog/standards/sist/9a22ac5f-2c90-4e84-b9f0-65f427628419/iso-527-1-2012>

| Test speed <i>v</i> mm/min | Tolerance % |
|----------------------------------|----------------|
| 0,125 | ±20 |
| 0,25 | |
| 0,5 | |
| 1 | |
| 2 | |
| 5 | |
| 10 | |
| 20 | ±10 |
| 50 | |
| 100 | |
| 200 | |
| 300 | |
| 500 | |

5.1.3 Grips

Grips for holding the test specimen shall be attached to the machine so that the major axis of the test specimen coincides with the direction of extension through the centre line of the grip assembly. The test specimen shall be held such that slip relative to the gripping jaws is prevented. The gripping system shall not cause premature fracture at the jaws or squashing of the specimen in the grips.

For the determination of the tensile modulus, it is essential that the strain rate is constant and does not change, for example, due to motion in the grips. This is important especially if wedge action grips are used.

NOTE For the prestress, which might be necessary to obtain correct alignment (see 9.3) and specimen seating and to avoid a toe region at the start of the stress/strain diagram, see 9.4.

5.1.4 Force indicator

The force measurement system shall comply with class 1 as defined in ISO 7500-1:2004.

5.1.5 Strain indicator

5.1.5.1 Extensometers

Contact extensometers shall comply with ISO 9513:1999, class 1. The accuracy of this class shall be attained in the strain range over which measurements are being made. Non-contact extensometers may also be used, provided they meet the same accuracy requirements.

The extensometer shall be capable of determining the change in the gauge length of the test specimen at any time during the test. It is desirable, but not essential, that the instrument should record this change automatically. The instrument shall be essentially free of inertia lag at the specified speed of testing.

For accurate determination of the tensile modulus E_t , an instrument capable of measuring the change of the gauge length with an accuracy of 1 % of the relevant value or better shall be used. When using test specimens of type 1A, this corresponds to a requirement of absolute accuracy of $\pm 1,5 \mu\text{m}$, for a gauge length of 75 mm. Smaller gauge lengths lead to different accuracy requirements, see Figure 2.

NOTE Depending on the gauge length used, the accuracy requirement of 1 % translates to different absolute accuracies for the determination of the elongation within the gauge length. For miniaturized specimens, these higher accuracies might not be attainable, due to lack of appropriate extensometers (see Figure 2)

Commonly used optical extensometers record the deformation taken at one broad test-specimen surface: In the case of such a single-sided strain-testing method, ensure that low strains are not falsified by bending, which may result from even faint misalignment and initial warpage of the test specimen, and which generates strain differences between opposite surfaces of the test specimen. It is recommended to use strain-measurement methods that average the strains of opposite sides of the test specimen. This is relevant for modulus determination, but less so for measurement of larger strains.

5.1.5.2 Strain gauges

Specimens may also be instrumented with longitudinal strain gauges; the accuracy of which shall be 1 % of the relevant value or better. This corresponds to a strain accuracy of 20×10^{-6} (20 microstrains) for the measurement of the modulus. The gauges, surface preparation and bonding agents should be chosen to exhibit adequate performance on the subject material

5.1.6 Recording of data

5.1.6.1 General

The data acquisition frequency needed for the recording of data (force, strain, elongation) must be sufficiently high in order to meet accuracy requirements.

5.1.6.2 Recording of strain data

The data acquisition frequency for recording of strain data depends on

- v the test speed, in mm/min;
- L_0/L the ratio between the gauge length and initial grip-to-grip separation;