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Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties

Caoutchouc vulcanisé ou thermoplastique — Détermination des caractéristiques de contrainte-déformation en traction

Reference number
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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.

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 37 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This fourth edition cancels and replaces the third edition (ISO 37:1994).

The major changes incorporated in this revision are as follows:

— The addition of a new dumb-bell test piece designated type 1A.

— The addition of a new annex, Annex B, with precision data on type 1, type 2 and type 1A test pieces.

— The addition of a new annex, Annex C, with an analysis of the dependence of the precision data on dumb-bell test piece shape.

Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties

1 Scope

This International Standard describes a method for the determination of the tensile stress-strain properties of vulcanized and thermoplastic rubbers.

The properties which can be determined are tensile strength, elongation at break, stress at a given elongation, elongation at a given stress, stress at yield and elongation at yield. The measurement of stress and strain at yield applies only to some thermoplastic rubbers and certain other compounds.

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 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 23529:2004, *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.

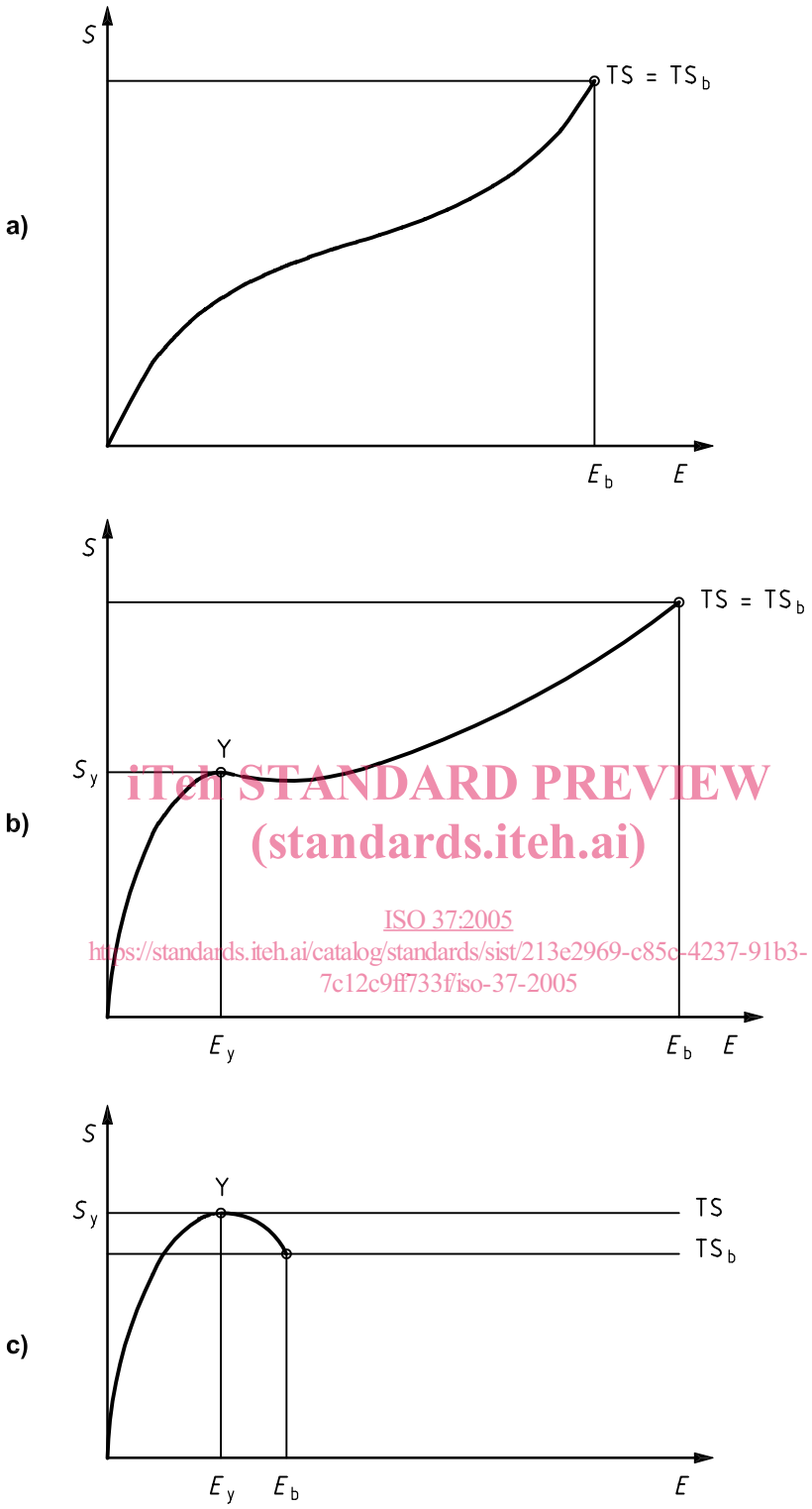
3.1
tensile stress
S
stress applied so as to extend the test piece

NOTE It is calculated as the applied force per unit area of the original cross-section of the test length.

3.2
elongation
E
tensile strain, expressed as a percentage of the test length, produced in the test piece by a tensile stress

3.3
tensile strength
TS
maximum tensile stress recorded in extending the test piece to breaking point

NOTE See Figures 1a) to 1c).



Key

E	elongation	S_y	stress at yield
E_b	elongation at break	TS	tensile strength
E_y	elongation at yield	TS_b	tensile strength at break
S	stress	Y	yield point

Figure 1 — Illustration of tensile terms

3.4
tensile strength at break
TS_b
tensile stress recorded at the moment of rupture

NOTE 1 See Figures 1a) to 1c).

NOTE 2 The values of TS and TS_b may be different if, after yield at S_y, the elongation continues and is accompanied by a drop in stress, resulting in TS_b being lower than TS [see Figure 1c)].

3.5
elongation at break
E_b
tensile strain in the test length at breaking point

NOTE See Figures 1a) to 1c).

3.6
elongation at a given stress
E_s
tensile strain in the test length when the test piece is subjected to a given tensile stress

3.7
stress at a given elongation
S_e
tensile stress in the test length required to produce a given elongation

NOTE In the rubber industry, this definition is widely identified with the term “modulus”, and care should be taken to avoid confusion with the other use of “modulus” to denote the slope of the stress-strain curve at a given elongation.

3.8
tensile stress at yield
S_y
tensile stress at the first point on the stress-strain curve where some further increase in strain occurs without any increase in stress

NOTE This may correspond to either a point of inflection [see Figure 1b)] or to a maximum [see Figure 1c)].

3.9
elongation at yield
E_y
tensile strain at the first point on the stress-strain curve where some further increase in strain is not accompanied by an increase in stress

NOTE See Figures 1b) and 1c).

3.10
test length of a dumb-bell
initial distance between reference points within the length of the narrow portion of a dumb-bell test piece used to measure elongation

NOTE See Figure 2.

4 Principle

Standard test pieces, either dumb-bells or rings, are stretched in a tensile-testing machine at a constant rate of traverse of the driven grip or pulley. Readings of force and elongation are taken as required during the uninterrupted stretching of the test piece and when it breaks.

5 General

Dumb-bell and ring test pieces do not necessarily give the same values for their respective stress-strain properties. This is mainly because in stretched rings the stress is not uniform over the cross-section. A second factor is in the existence of “grain” which may cause dumb-bells to give different values depending whether their length is parallel or at right angles to the grain.

The main points to be noted in choosing between rings and dumb-bells are as follows:

a) Tensile strength

Dumb-bells are preferable for determination of tensile strength. Rings give lower, sometimes much lower, values than dumb-bells.

b) Elongation at break

Rings give approximately the same values as dumb-bells, provided that

1) the elongation of rings is calculated as a percentage of the initial internal circumference and

2) dumb-bells are cut at right angles to the grain if this is present to a significant degree.

Dumb-bells shall be used if it is required to study grain effects for which rings are not suitable.

c) Elongation at a given stress and stress at a given elongation

The larger dumb-bells (types 1, 2 and 1A) are generally preferred.

Rings and dumb-bells give approximately the same values provided that

1) the elongation of rings is calculated as a percentage of the initial mean circumference and

2) the average value is taken for dumb-bells cut parallel and at right angles to the grain if this is present to a significant degree.

Rings may be preferred in automated testing, due to the ease of handling of the test pieces, and in the determination of stress at a given strain.

d) Miniature test pieces may give somewhat different, usually higher, values for tensile strength and elongation at break than the larger test pieces.

Seven types of test piece are provided, i.e. dumb-bell-shaped types 1, 2, 3, 4 and 1A and ring-shaped types A (normal) and B (miniature). The results obtained for a given material are likely to vary according to the type of test piece used, and the results obtained for different materials should therefore not be regarded as comparable unless the same type of test piece has been used.

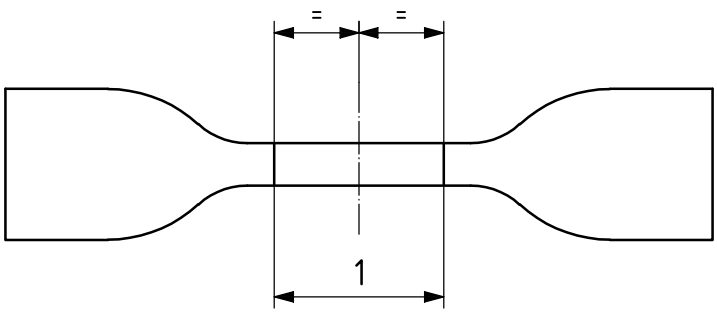
Type 3 and 4 dumb-bell test pieces and type B ring test pieces shall only be used where insufficient material is available for the larger test pieces. These test pieces are particularly suitable for testing products and are used in certain product standards, e.g. type 3 dumb-bells have been used for testing pipe sealing rings and cables.

When preparation of test pieces requires buffing or thickness adjustment, results may be affected.

6 Test pieces

6.1 Dumb-bells

Dumb-bell test pieces shall have the outline shown in Figure 2.



Key

1 test length (see Table 1)

Figure 2 — Shape of dumb-bell test pieces

The standard thickness of the narrow portion shall be 2,0 mm ± 0,2 mm for types 1, 2, 3 and 1A and 1,0 mm ± 0,1 mm for type 4.

The test length shall be in accordance with Table 1.

The other dimensions of the dumb-bells shall be as produced by the appropriate die (see Table 2).

For non-standard test pieces, e.g. those taken from finished products, the maximum thickness of the narrow portion shall be 3,0 mm for types 1 and 1A, 2,5 mm for types 2 and 3, and 2,0 mm for type 4.

Table 1 — Test length of dumb-bells

Type of test piece	Type 1	Type 1A	Type 2	Type 3	Type 4
Test length (mm)	25 ± 0,5	20 ± 0,5[a]	20 ± 0,5	10 ± 0,5	10 ± 0,5
[a] The test length shall not exceed the length of narrow portion of the test piece (dimension C in Table 2).					

6.2 Rings

The standard type A ring test piece shall have an internal diameter of 44,6 mm ± 0,2 mm. The median axial thickness and median radial width shall be 4 mm ± 0,2 mm. The radial width within any ring shall nowhere deviate from the median by more than 0,2 mm and the axial thickness within the ring shall nowhere deviate from the median by more than 2 %.

The standard type B ring test piece shall have an internal diameter of 8 mm ± 0,1 mm. The median axial thickness and median radial width shall be 1 mm ± 0,1 mm. The radial width within any ring shall nowhere deviate from the median by more than 0,1 mm.

7 Apparatus

7.1 Dies and cutters

All dies and cutters used shall be in accordance with ISO 23529. Dies for preparation of dumb-bells shall have the dimensions given in Table 2 and Figure 3. The departure from parallelism at any point along the width of the narrow portion of the die shall nowhere exceed 0,05 mm.

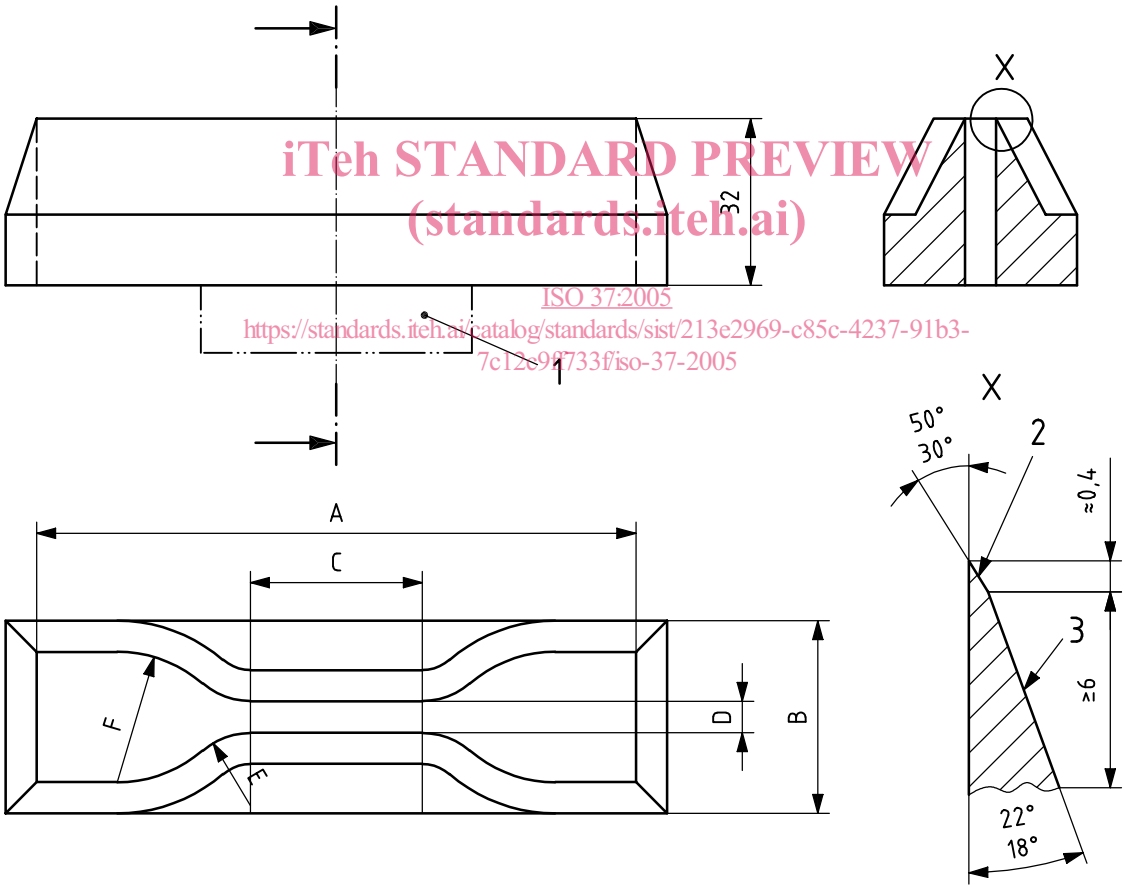
For a method of cutting type B ring test pieces, see Annex A.

7.2 Thickness gauge

The instrument for measuring the thickness of dumb-bell test pieces and the axial thickness of ring test pieces shall be in accordance with that used in method A of ISO 23529:2004.

The instrument for measuring the radial width of ring test pieces shall be similar to the above, except that the contact and base plate shall be shaped to fit the curvature of the ring.

Dimensions in millimetres



Key

1 method of fixing to suit machine
2 ground smooth
3 ground

NOTE For dimensions A to F, see Table 2.

Figure 3 — Die for dumb-bell test pieces

Table 2 — Dimensions of dies for dumb-bell test pieces

Dimension		Type 1	Type 1A	Type 2	Type 3	Type 4
A	Overall length (minimum)[a] (mm)	115	100	75	50	35
B	Width of ends (mm)	25,0 ± 1	25,0 ± 1	12,5 ± 1	8,5 ± 0,5	6 ± 0,5
C	Length of narrow portion (mm)	33 ± 2	20^{+2}_{0}	25 ± 1	16 ± 1	12 ± 0,5
D	Width of narrow portion (mm)	$6^{+0,4}_{0}$	5 ± 0,1	4 ± 0,1	4 ± 0,1	2 ± 0,1
E	Transition radius outside (mm)	14 ± 1	11 ± 1	8 ± 0,5	7,5 ± 0,5	3 ± 0,1
F	Transition radius inside (mm)	25 ± 2	25 ± 2	12,5 ± 1	10 ± 0,5	3 ± 0,1

[a] A greater overall length may be necessary to ensure that only the wide end tabs come into contact with the machine grips, thus avoiding "shoulder breaks".

7.3 Cone gauge

A calibrated cone gauge or other suitable equipment shall be used to measure the internal diameter of ring test pieces. The equipment shall be capable of measuring the diameter with an error of not more than 0,01 mm. The means of supporting the ring test piece to be measured shall be such as to avoid any significant change in the dimension being measured.

7.4 Tensile-testing machine

7.4.1 The tensile-testing machine shall comply with the requirements of ISO 5893, having an accuracy of force measurement complying with class 2. An extensometer, where used, shall have an accuracy complying with class D for type 1, 2 and 1A dumb-bell and type A ring test pieces, and class E for type 3 and 4 dumb-bell and type B ring test pieces. The machine shall, as a minimum, be capable of operating at rates of traverse of 100 mm/min, 200 mm/min and 500 mm/min.

7.4.2 For tests at temperatures other than standard laboratory temperature, a suitable thermostatically controlled chamber shall be fitted to the tensile-testing machine. Guidance for achieving elevated or subnormal temperatures is given in ISO 23529.

8 Number of test pieces

A minimum of three test pieces shall be tested.

NOTE The number of test pieces should be decided in advance and the use of five test pieces will give a lower uncertainty than a test with three test pieces.

9 Preparation of test pieces

9.1 Dumb-bells

Dumb-bell test pieces shall be prepared by the appropriate methods described in ISO 23529. Dumb-bells shall, wherever possible, be cut parallel to the grain of the material unless grain effects are to be studied, in which case a set of dumb-bells shall also be cut perpendicular to the grain.

9.2 Rings

Ring test pieces shall be prepared by cutting or punching, using the appropriate methods described in ISO 23529, or by moulding.

10 Conditioning of sample and test pieces

10.1 Time between vulcanization and testing

For all test purposes, the minimum time between vulcanization and testing shall be 16 h.

For non-product tests the maximum time between vulcanization and testing shall be 4 weeks and, for evaluations intended to be comparable, the tests, as far as possible, shall be carried out after the same time interval.

For product tests, whenever possible, the time between vulcanization and testing shall not exceed 3 months. In other cases, tests shall be made within 2 months of the date of receipt of the product by the customer.

10.2 Protection of samples and test pieces

Samples and test pieces shall be protected as completely as possible from all external influences likely to cause damage during the interval between vulcanization and testing, e.g. they shall be protected from light and heat.

10.3 Conditioning of samples

Condition all samples, other than those from latex, in accordance with ISO 23529 at standard laboratory temperature, without humidity control, for not less than 3 h prior to cutting out the test pieces.

Condition all prepared latex samples in accordance with ISO 23529 at standard laboratory temperature, with humidity control, for not less than 96 h prior to cutting out the test pieces.

10.4 Conditioning of test pieces

Condition all test pieces in accordance with ISO 23529. If the preparation of test pieces involves buffing, the interval between buffing and testing shall be not less than 16 h and not greater than 72 h.

For tests at standard laboratory temperature, test pieces that do not require further preparation may be tested immediately, if cut from conditioned test samples. Where additional preparation is involved, a minimum conditioning period of 3 h at standard laboratory temperature shall be allowed.

For tests at temperatures other than standard laboratory temperature, condition the test pieces at the temperature at which the test is to be conducted for a period sufficient to enable the test pieces to attain substantial equilibrium in accordance with ISO 23529 (see also 7.4.2).

11 Marking of dumb-bell test pieces

If using a non-contact extensometer, mark the dumb-bell test pieces with two reference marks to define the test length as specified in Table 1, using a suitable marker. The test piece shall be unstrained when it is marked.

The lines shall be marked on the narrow part of the test piece, as shown in Figure 2, i.e. equidistant from the centre of the test piece and at right angles to its longitudinal axis.