INTERNATIONAL STANDARD

ISO 37

Third edition
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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
ISO 37:1994(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 voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 37 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Physical and degradation tests*.

This third edition cancels and replaces the second edition (ISO 37:1977).

The major changes incorporated in this revision are as follows:

a) Four dumb-bell test pieces are described. Types 1 and 2 are the same as in the previous edition. The miniature dumb-bell, type 3 in the previous edition, becomes type 4, with an additional intermediate-size dumb-bell being added as the new type 3.

b) A reference to ISO 5893 is given in place of detailed requirements for the tensile-testing machine.

c) The calculation of results is described more clearly.

d) Means of determining the yield point have been included.

e) Definitions of tensile properties, as they relate to rubber, are provided.

Annex A forms an integral part of this International Standard.

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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 may be determined are the tensile strength, the elongation at break, the stress at a given strain and the elongation at a given stress. Means of specifying or determining the yield point are also given.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard 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 471:—1), *Rubber — Times, temperatures and humidities for conditioning and testing.*

ISO 1826:1981, *Rubber, vulcanized — Time-interval between vulcanization and testing — Specification.*

ISO 3383:1985, *Rubber — General directions for achieving elevated or subnormal temperatures for test purposes.*

ISO 4648:1991, *Rubber, vulcanized or thermoplastic — Determination of dimensions of test pieces and products for test purposes.*

ISO 4661-1:1993, *Rubber, vulcanized or thermoplastic — Preparation of samples and test pieces — Part 1: Physical tests.*

ISO 5893:1993, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Description.*

3 Definitions

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

3.1 tensile stress, S: A stress applied so as to extend the test piece. It is calculated as the applied force per unit area of the original cross-section of the test length.

3.2 elongation, E: The extension, expressed as a percentage of the test length, produced in the test piece by a tensile stress.

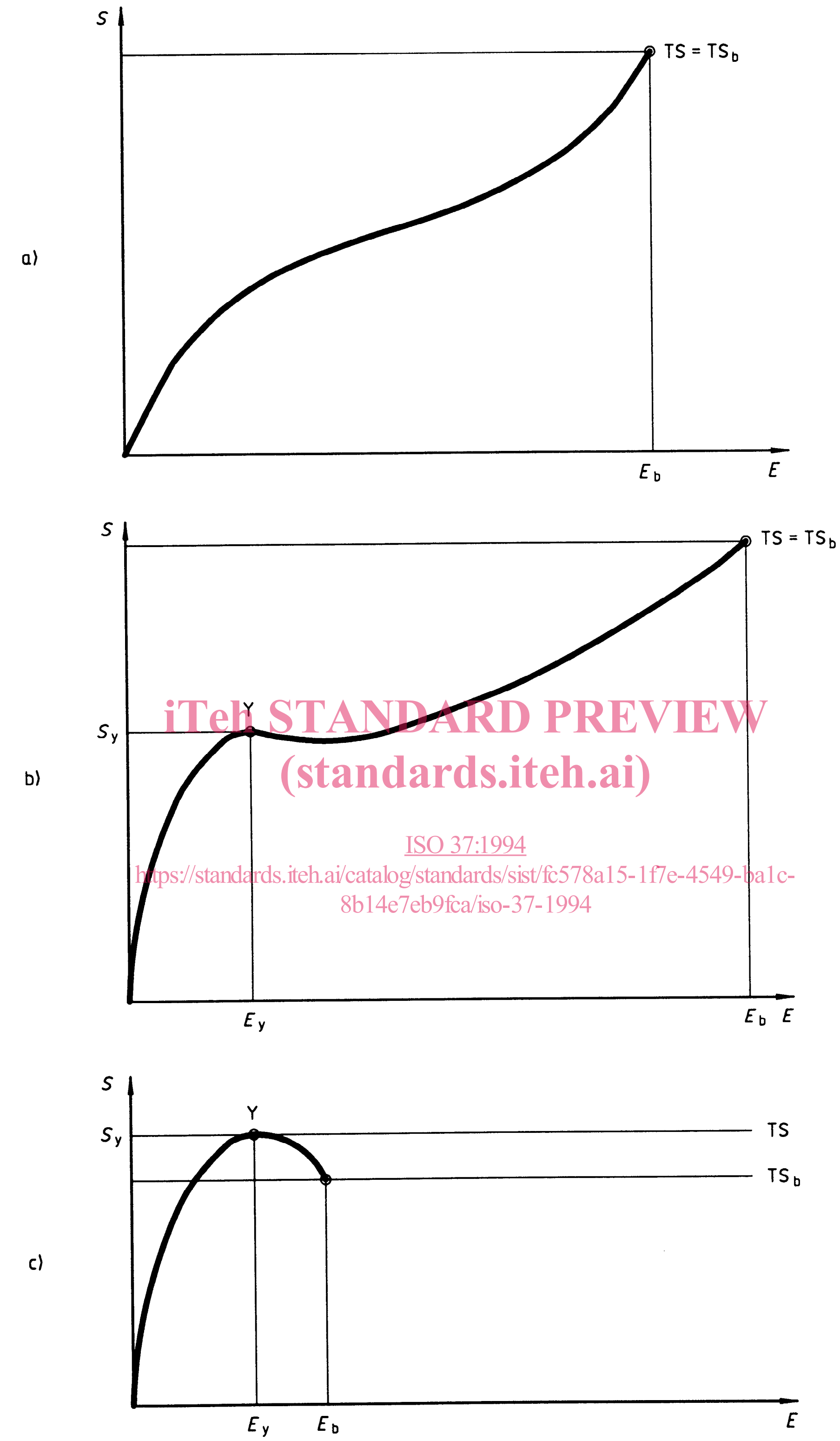
3.3 tensile strength, TS: The maximum tensile stress recorded in extending the test piece to breaking point. [See figures 1 a) to 1 c).]

3.4 tensile strength at break, TS_b: The tensile stress recorded at the moment of rupture. [See figures 1 a) to 1 c).]

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

3.5 elongation at break, E_b: The tensile strain in the test length at breaking point. [See figures 1a) to 1c).]

1) To be published. (Revision of ISO 471:1983)



E = Elongation

E_b = Elongation at break

E_y = Elongation at yield

S = Stress

S_y = Stress at yield

TS = Tensile strength

TS_b = Tensile strength at break

Y = Yield point

Figure 1 — Illustration of tensile terms

3.6 elongation at a given stress, E_s: The 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: The tensile stress in the test length required to produce a given elongation.

NOTE 2 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: The tensile stress at the first point on the stress-strain curve where some further increase in strain occurs without any increase in stress. This may correspond to either a point of inflection [see figure 1 b)] or to a maximum [see figure 1 c)].

3.9 elongation at yield, E_y: The 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. [See figures 1 b) and 1 c).]

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

Type 1 and 2 dumb-bell test pieces are preferred, and shall be used for specification purposes wherever possible.

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.

Six types of test piece are provided, i.e. dumb-bell-shaped types 1, 2, 3 and 4 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.

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

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.

6 Test pieces

6.1 Dumb-bells

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

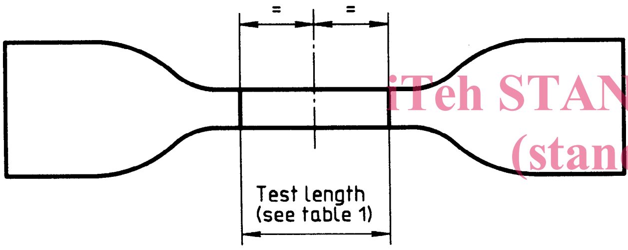


Figure 2 — Shape of dumb-bell test pieces

The standard thickness of the narrow portion shall be 2,0 mm ± 0,2 mm for types 1, 2 and 3 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 completed products, the maximum thickness of the narrow portion shall be 3,0 mm for type 1, 2,5 mm for types 2 and 3, and 2,0 mm for type 4.

Table 1 — Test length of dumb-bells

Dimensions in millimetres

Type of test piece	Type 1	Type 2	Type 3	Type 4
Test length	25,0 ± 0,5	20,0 ± 0,5	10,0 ± 0,5	10,0 ± 0,5

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 4,0 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 8,0 mm ± 0,1 mm. The median axial thickness and median radial width shall be 1,0 mm ± 0,1 mm. The radial width within any ring shall nowhere deviate from the median by more than 0,1 mm.

If two groups of rings of either size are being compared, the median thickness of each group shall be within 7,5 % of the grand median thickness of the two groups.

7 Apparatus

7.1 Dies and cutters

All dies and cutters used shall be in accordance with ISO 4661-1. 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.

7.2 Thickness gauge

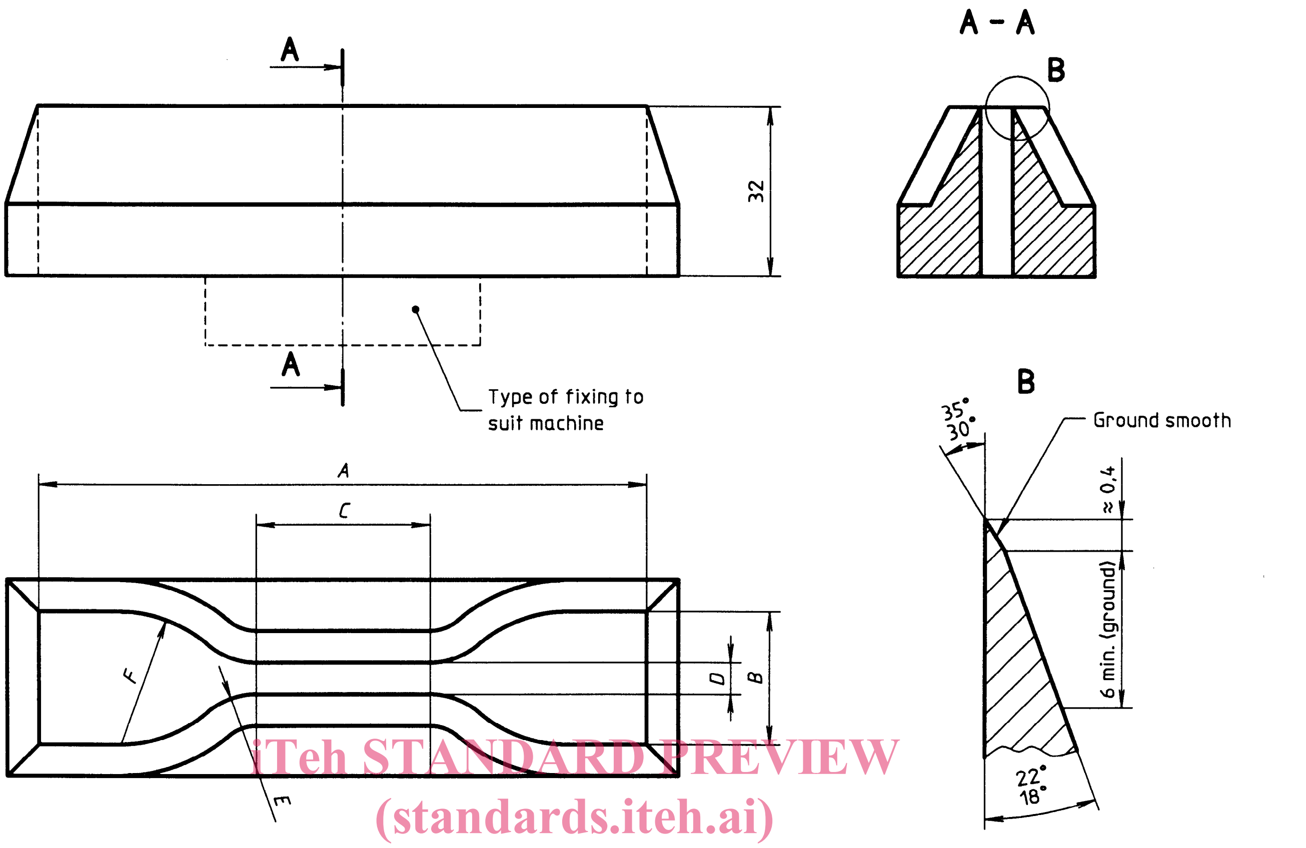
The instrument for measuring the thickness of dumb-bell test pieces and the axial thickness of ring test pieces shall be in accordance with that used in method A of ISO 4648:1991.

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.

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 to be measured shall be such as to avoid any significant change in the dimension being measured.

Dimensions in millimetres



NOTES

1 For dimensions *A* to *F*, see table 2.

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

Figure 3 — Die for dumb-bell test pieces

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

Dimensions in millimetres

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

1) A greater overall length may be necessary to ensure that only the wide parallel-sided end portions come into contact with the machine grips, thus helping to avoid "shoulder breaks".

7.4 Tensile-testing machine

7.4.1 The tensile-testing machine shall comply with the requirements of ISO 5893:1993, having an accuracy of force measurement complying with grade B and, where used, an extensometer accuracy complying with grade D[1] for type 1 and 2 dumb-bell and type A ring test pieces, and grade E[1] for type 3 and 4 dumb-bell and type B ring test pieces. The machine shall as a minimum be capable of operating at a rate of traverse of 100 mm/min, 200 mm/min and 500 mm/min and should preferably be equipped with facilities for the autographic recording of stress and strain.

7.4.2 For tests at temperatures other than standard temperature, a suitable thermostated chamber shall be fitted to the tensile-testing machine. Guidance for achieving elevated or subnormal temperatures is given in ISO 3383.

8 Number of test pieces

A minimum of three test pieces shall be tested.

9 Preparation of test pieces

9.1 Dumb-bells

The test pieces shall be prepared by the appropriate methods described in ISO 4661-1. 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 4661-1, or by moulding.

10 Conditioning of samples and test pieces

10.1 Time between vulcanization and testing

The time interval between vulcanization and testing shall be in accordance with ISO 1826. 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 471 at standard 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 471 at standard 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 471. 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 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 temperature shall be allowed.

For tests at temperatures other than standard temperature, condition the test pieces at the temperature at which the test is to be conducted for a period sufficient to enable test pieces to attain substantial equilibrium in accordance with ISO 3383 (see 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.

12 Measurement of test pieces

12.1 Dumb-bells

Measure the thickness at the centre and at each end of the test length with the thickness gauge. The median value of the three measurements shall be used in calculating the area of the cross-section. In any one dumb-bell, none of the three thickness measurements of the narrow portion shall differ by more than 2 % from the median thickness. If two groups of test pieces are being compared, the median thickness of each group shall be within 7,5 % of the median thickness of the two groups. The width of the test piece shall be taken as the distance between the cutting edges of the die in the narrow part, and this distance shall be measured in accordance with ISO 4661-1 to the nearest 0,05 mm.

12.2 Rings

Measure the radial width and axial thickness at six approximately equally spaced positions around the ring. The median value of each set of measurements shall be used in calculating the area of the cross-section. The internal diameter shall be measured to the nearest 0,1 mm. It may be measured on a suitable cone and the internal circumference and the mean circumference calculated as follows:

Internal circumference = $\pi \times$ internal diameter

Mean circumference = $\pi \times$ (internal diameter + radial width)

13 Procedure

13.1 Dumb-bell test pieces

Insert the test piece into the tensile-testing machine, ensuring that the parallel-sided portions of the tab ends are gripped symmetrically so that the tension is distributed uniformly over the cross-section. If necessary, set up the extensometry device. Start the machine and monitor continuously the change in test length and force throughout the test to an accuracy within ± 2 %, as required for the purposes of clause 15.

The nominal rate of traverse of the moving grip shall be 500 mm/min for type 1 and type 2 test pieces and 200 mm/min for type 3 and type 4 test pieces.

Any test piece that breaks outside the test length (see figure 2) shall be discarded and a repeat test conducted on an additional test piece.

NOTE 3 In making visual measurements, care should be taken to avoid inaccuracies due to parallax.

13.2 Ring test pieces

Place the test piece with a minimum of tension around the two pulleys. Start the machine and monitor continuously the distance between the pulleys and the increase in stress throughout the test to an accuracy of ± 2 % or as required for the purposes of clause 15.

The nominal rate of traverse of the moving pulley shall be 500 mm/min for type A ring test pieces and 100 mm/min for type B ring test pieces.

14 Temperature of test

The test shall normally be carried out at one of the standard temperatures specified in ISO 471. When other temperatures are required, these shall be selected from the list of preferred temperatures given in ISO 471.

The same temperature shall be used throughout any one test or series of tests intended to be comparable.

15 Calculation of results

15.1 Dumb-bells

15.1.1 Calculate the tensile strength TS, expressed in megapascals, using the equation

$$\mathrm{TS} = \frac{F_m}{Wt}$$

15.1.2 Calculate the tensile strength at break $\mathrm{TS_b}$, expressed in megapascals, using the equation

$$\mathrm{TS_b} = \frac{F_b}{Wt}$$

15.1.3 Calculate the elongation at break E_b, expressed as a percentage, using the equation

$$E_b = \frac{100(L_b - L_0)}{L_0}$$