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Rubber, vulcanized — Determination of tension fatigue

Caoutchouc vulcanisé — Détermination de la fatigue en traction

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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 6943 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This second edition cancels and replaces the first edition (ISO 6943:1984), which has been technically revised.

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Rubber, vulcanized — Determination of tension fatigue

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

CAUTION — Certain procedures specified in this International Standard may involve the use or generation of substances, or the generation of waste, that could constitute a local environmental hazard. Reference should be made to appropriate documentation on safe handling and disposal after use.

1 Scope

This International Standard describes a method for the determination of the resistance of vulcanized rubbers to fatigue under repeated tensile deformations, the test piece size and frequency of cycling being such that there is little or no temperature rise. Under these conditions, failure results from the growth of a crack that ultimately severs the test piece.

The method is restricted to repeated deformations in which the test piece is relaxed to zero strain for part of each cycle. Analogous fatigue processes can occur under repeated deformations which do not pass through zero strain and also, in certain rubbers, under static deformation, but this International Standard does not apply to these conditions.

The method is believed to be suitable for rubbers that have reasonably stable stress-strain properties, at least after a period of cycling, and that do not show undue stress softening or set, or highly viscous behaviour. Materials that do not meet these criteria may present considerable difficulties from the points of view of both experiment and interpretation. For example, for a rubber that develops a large amount of set during the fatigue test, the test strain will be ill-defined and the fatigue life is likely to differ markedly under constant maximum load and constant maximum extension conditions; how the results for such a rubber should be interpreted, or compared with those for other rubbers, has not been established by basic work. As a general guide, a rubber for which the set determined in accordance with 8.5 and 9.2 exceeds 10 % is likely to fall into this category. For this reason, the method is not considered suitable for most thermoplastic elastomers.

Similar considerations apply with regard to other changes in elasticity behaviour during testing.

A distinction should be made between this fatigue test and the flexometer tests described in the various parts of ISO 4666-1, where fatigue breakdown occurs under the simultaneous action of stress and temperature.

Advantages over the De Mattia flex cracking and cut growth test (see ISO 132) include the following. The test yields quantitative results which do not depend on operator interpretation and which can be recorded automatically. The initial deformation is clearly defined and can readily be varied to suit different applications.

Great caution is necessary in attempting to relate standard test results to service performance since the comparative fatigue resistance of different vulcanizates can vary according to the test conditions used and to the basis by which the results are compared. Guidance on the selection of test conditions and on the interpretation of results is given in Annex A.

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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 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
fatigue life
number of cycles required to break a test piece repeatedly deformed to a prescribed tensile strain

3.2
tension fatigue
fracture, through crack growth, of a component or test piece subjected to a repeated tensile deformation

4 Principle

Dumb-bell or ring test pieces are repeatedly deformed in simple extension until they fail by breaking. The test pieces are relaxed to zero strain for part of each cycle. The number of deformation cycles to failure, defined as the fatigue life, is determined as a function of the maximum strain and, if required, as a function of the maximum stress or strain energy density imposed during the test.

5 Apparatus

5.1 Fatigue testing machine

The fatigue testing machine shall provide a reciprocating motion at a frequency which shall normally be within the range 1 Hz to 5 Hz.

For testing dumb-bell test pieces, the machine shall be provided with clamps that grip the test piece sufficiently firmly to prevent slippage, irrespective of the magnitude of the strain applied.

For testing ring test pieces, each station on the machine shall be provided with two pairs of rollers, one pair fixed to the body of the machine and the other to the reciprocating part. To minimize friction, the rollers shall be fabricated from stainless or chromium-plated steel, well polished and fitted with free-running ball races. The roller arrangement shall be such that the test pieces are held securely in place over the rollers throughout the test.

The stroke of the machine and the position of the fixed clamps or rollers shall be adjustable to provide a range of test strains. In all cases, the test piece shall be relaxed to zero strain for part of each cycle.

The fixed clamps or rollers should preferably be fitted with contacts or other means of operating counters to register the number of cycles to failure of each test piece.

If it is required to determine the maximum stress of the cycle, manual or automatic means for measurement of the load shall be provided. Stress-strain properties and strain energy density under test conditions can be determined for rings if automatic equipment for force-extension measurement is provided.

Alternatively, and for dumb-bell test pieces, stress-strain properties can be determined separately using a conventional tensile testing machine.

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5.2 Dies and cutters

All dies and cutters used shall be made and maintained in accordance with ISO 23529.

Since fatigue life is sensitive to flaw size, it is essential that the dies or cutters used for the preparation of test pieces be carefully maintained so that the cutting edges are sharp and free from nicks. Regular control tests, using an established rubber, shall be made to check sharpness. Any oil shall be removed from the cutter after sharpening.

5.3 Marker

If a marker is used for marking the reference lines on dumb-bell test pieces, it shall have two parallel edges. These shall be ground smooth and true, 0,05 mm to 0,10 mm wide at the edge and bevelled at an angle of not more than 15°.

The marking implement shall not damage the rubber surface.

5.4 Marking substance

The marking substance shall have no deleterious effect on rubber and shall be of contrasting colour.

5.5 Measuring instruments

The instrument for measuring the thickness of dumb-bell test pieces (and the axial thickness of ring test pieces) shall be in accordance with ISO 23529, consisting essentially of a micrometer dial gauge having a circular foot which does not extend beyond the surface of the rubber where the measurement is being taken, and applying a pressure of 22 kPa $\pm$ 5 kPa for a rubber with hardness equal to or higher than 35 IRHD.

Vernier calipers, a travelling microscope or other suitable means shall be provided for the measurement of other test piece dimensions. A calibrated cone is recommended for the measurement of the internal diameter and internal circumference of ring test pieces.

6 Test piece

6.1 Dimensions

6.1.1 General

Standard test pieces shall be dumb-bells or rings having dimensions within the limits prescribed in 6.1.2 and 6.1.3. Any test piece showing irregularities or imperfections shall not be used.

6.1.2 Dumb-bell test piece

Dumb-bell test pieces and the dies with which they are cut out shall be as shown in Figure 1. The dies shall have the dimensions given in Table 1. The reference length (the distance between the marked reference lines) shall be 25 mm for the type 1 test piece and 20 mm for the type 1A and type 2 test pieces. This length shall be equidistant from the ends of the central parallel-sided part of the test piece. The tabs may have beaded ends for location purposes.

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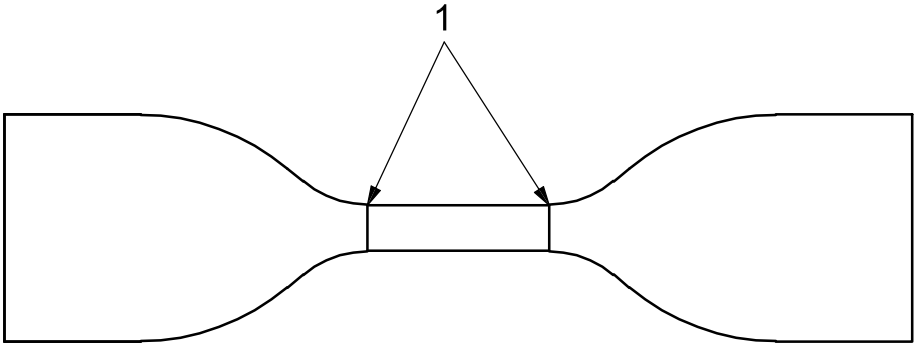
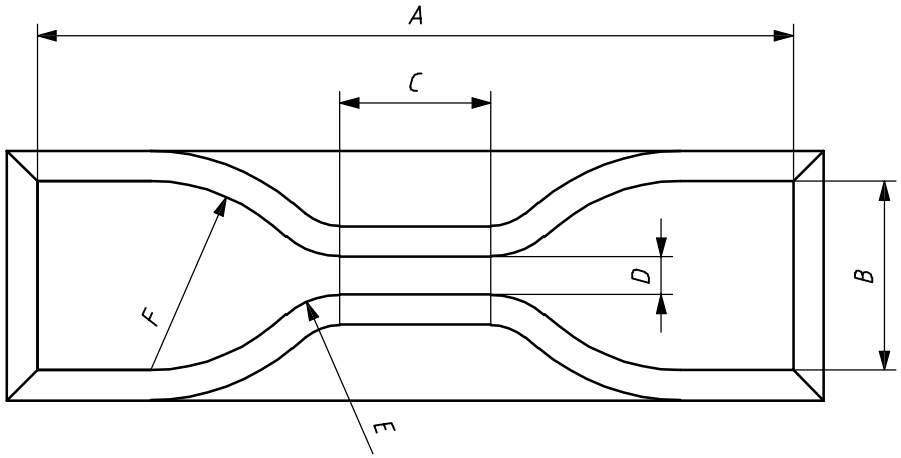


a) Test piece



b) Die

Key

1 reference lines

A to F see Table 1

Figure 1 — Shape of dumb-bell test pieces and die

Table 1 — Die dimensions for dumb-bell test pieces [see Figure 1 b)]

Dimensions in millimetres

Dimension	Type 1	Type 1A	Type 2
A Overall length, min.	115	100	75
B Width of ends	25 ± 1	25 ± 1	$12{,}5 \pm 1$
C Length of narrow parallel-sided portion	33 ± 2	20^{+2}_{0}	25 ± 1
D Width of narrow parallel-sided portion [a]	$6{,}0^{+0{,}4}_{0}$	$5 \pm 0{,}1$	$4{,}0 \pm 0{,}1$
E Small radius	14 ± 1	11 ± 1	$8 \pm 0{,}5$
F Large radius	25 ± 2	25 ± 2	$12{,}5 \pm 1$

[a] The variation within any one die shall not exceed 0,05 mm.

NOTE The dies are identical to those specified for type 1, type 1A and type 2 dumb-bell test pieces in ISO 37 for the determination of tensile stress-strain properties.

The thickness of dumb-bells shall be 1,5 mm $\pm$ 0,2 mm. In any one dumb-bell, the thickness of the narrow part shall nowhere deviate by more than 2 % from the mean. If results from two sets of dumb-bells are being compared, the mean thicknesses of the sets shall be within 10 % of one another.

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