INDIAN STANDARDS

ON

METHODS OF TEST FOR VULCANIZED RUBBERS

IS : 3400 Methods of test for vulcanized rubbers:

3400 (Part I)-1977 Tensile stress-strain properties (*first revision*

3400 (Part II)-1965 Hardness

3400 (Part III)-1965 Abrasion resistance — Du Pont constant load method

3400 (Part IV)-1965 Accelerated ageing

3400 (Part V)-1965 Adhesion of rubbers to textile fabrics

3400 (Part VI)-1967 Resistance to liquids

3400 (Part VII)-1967 Resistance to flex-cracking

3400 (Part VIII)-1967 Resistance to crack-growth

3400 (Part IX)-1967 Relative density and density

3400 (Part X)-1969 Compression set at constant strain

3400 (Part XI)-1969 Determination of rebound resilience

3400 (Part XII)-1971 Tear strength — Crescent test piece

3400 (Part XIII)-1972 Tension set

3400 (Part XIV)-1971 Adhesion of rubber to metal

3400 (Part XV)-1971 Volume resistivity of electrically conducting and antistatic rubbers

3400 (Part XVI)-1974 Measurement of cut growth of rubber by the use of the ross flexing machine

3400 (Part XVII)-1974 Tear strength — angular test piece

3400 (Part XVIII)-1976 Stiffness at low temperature (Gehman test)

3400 (Part XIX)-1976 Permeability to gases (constant volume method)

3400 (Part XX)-1977 Resistance to ozone

Indian Standard

METHODS OF TEST FOR VULCANIZED RUBBERS

PART I TENSILE STRESS-STRAIN PROPERTIES

(First Revision)

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Indian Standard

METHODS OF TEST FOR VULCANIZED RUBBERS

PART I TENSILE STRESS-STRAIN PROPERTIES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part I) (First Revision) was adopted by the Indian Standards Institution on 12 September 1977, after the draft finalized by the Rubber Products Sectional Committee had been approved by the Petroleum, Coal and Related Prouducts Division Council.

0.2 This standard was first published in 1965. In this revision small dumb-bell test piece (Type 3) has also been included. Opportunity has also been taken to align this revision with the latest International Standard on the subject.

0.3 This standard is essentially based on ISO 37-1976 'Rubber, vulcanized—Determination of tensile stress-strain properties', issued by the International Organization for Standardization.

0.4 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard (Part I) prescribes the method for the determination of tensile stress-strain properties of vulcanized rubbers. This method is not applicable to the testing of materials ordinarily classified as ebonite or hard rubber or latex film.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 7503 (Part I)-1974† shall apply.

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*Rules for rounding off numerical values (*revised*).

†Glossary of terms used in rubber industry, Part I.

3. PRINCIPLE OF THE METHOD

3.1 In this test, 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 load and elongation are taken as required during the uninterrupted stretching of the test piece and when it breaks.

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

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

a) *Tensile strength* — Rings give lower, sometimes much lower, values than dumb-bells, the latter being much nearer to the true tensile strength of the rubber. The estimation of true tensile strength from ring data involves extrapolation of the stress-strain curve. Dumb-bells are, therefore, preferable for determination of tensile strength.

b) *Elongation at break* — Rings give, on the average, approximately the same value as dumb-bells, provided the elongation of rings is calculated as a percentage of the internal circumference and dumb-bells are cut perpendicular to the grain if this is present to a marked degree. With some rubbers, however, rings and dumb-bells may be found to differ markedly for reasons not yet clear. Generally, there is little to choose between rings and dumb-bells except that the latter should be used if it is desired to study grain effects. Otherwise, rings usually have the advantage of more accurately measurable values of elongation.

c) *Elongation at a given stress and modulus* — Rings and dumb-bells give substantially the same values, provided the elongation of the rings is calculated as a percentage of the initial mean circumference and the average value is taken for dumb-bells cut parallel and perpendicular to the grain if this is present to a marked degree. Rings usually have the advantage of giving more consistent readings and more accurately measurable values of elongation, and facilitate autographic recording of stress-strain curves.

3.1.3 Small size test pieces give somewhat higher values for the stress-strain properties than those obtained with normal size test pieces.

4. APPARATUS

4.1 Marker — The marker for marking the bench marks shall have tv parallel knife edges. They shall be ground smooth and true. The recor mended thickness of the lines shall be 0·05 to 0·08 mm.

4.2 Tensile-Test Machine — The machine shall be of such capaci that the maximum load required to break the test specimen shall not exce 85 percent nor be less than 15 percent of the rated capacity. The rate travel of the power actuated grip shall be 500 ± 50 mm/min and shall uniform at all times. If conditions allow and a higher rate of separati is desirable, an increase up to 1 000 mm rate may be used in routine wo and notation of the speed used made on the report, but in case of dispute, the 500 mm rate shall be considered standard. Possible separ tion of the grips of at least 750 mm shall be provided. The machine sh be equipped with a scale or other device graduated to 1 mm for measu ing the elongation, as shown by either the distance between the ben marks on the dumb-bell or the distance between the pulleys in test rings. Means should be provided for obtaining the following measur ments without stopping the machine:

a) The force on the test piece; and

b) The elongation of the test piece, as shown by either the distan between the bench marks on the dumb-bell, or the distan between the pulleys in tests on rings.

NOTE — Inertia (pendulum) type dynamometers are apt to give results wh differ because of frictional and inertial effects. An inertia-less (for exam electronic or optical transducer type) dynamometer gives results which are f from these effects and is, therefore, to be preferred.

4.2.1 For testing dumb-bell specimens, the machine shall be equipp with a type of grip which tightens automatically and exerts a unifor pressure across the gripping surfaces increasingly as the tension increas so as to prevent uneven slipping, and to favour failure of the specimen its constructed section. It is advisable to have at the end of each grip positioning device so that all specimens are inserted to the same depth the jaws and are perpendicular to the direction of pull.

4.2.2 For testing ring pieces, the machine shall be provided wi pulleys, both of which are free to rotate whilst one at least is aut matically rotated by the machine to equalize the strain in the ring duri the test. The pulleys shall be 25 mm in diameter.

4.2.3 The machine shall be power-driven.

4.2.4 *Calibration of Tensile-Test Machine* — The load scale and t recording mechanism shall be calibrated at least once in three months ensure that the load scale error does not exceed two percent of t applied load.

5. TEST PIECE

5.0 The test piece shall be in the shape of either a ring or dumb-bell as described in **5.1** and **5.2.**

5.1 Ring Test Piece — Rings shall be nominally of internal diamete 44·6 mm and external diameter 52·6 mm, the radial width no wher deviating by more than ± 0·2 mm, from the mean width. The thickness shall preferably be 4 ± 0·2 mm. In any ring the thickness shall no where deviate by more than ± 0·2 mm from the mean thickness.

5.2 Dumb-Bell Test Piece — Dumb-bell test pieces shall have the outline shown in Fig. 1, when punched with dies, and shall conform to the dimensions given for Types 1, 2 and 3 in Table 1 when read with Fig. 1.

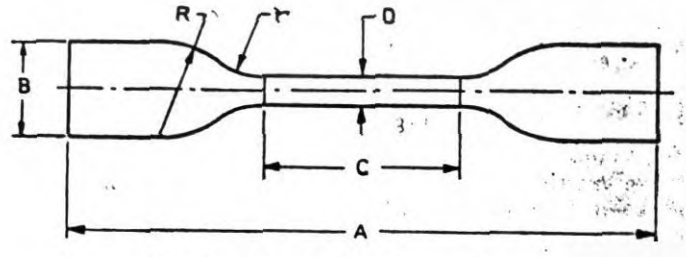

FIG. 1 DUMB-BELL TEST PIECES

5.2.1 Dumb-bell Type 2 and Type 3 (*see* Fig. 1 and Table 1) shall be used only in cases where there is insufficient material to enable dumb-bell, Type 1 to be used.

5.2.2 The bench marks shall not be more than 25 mm for Type 1, 20 mm for Type 2 and 10 mm for Type 3 and shall be equidistant from the ends of the central parallel-sided part of the test piece.

NOTE 1 — The use of automatic extensometers is recommended, particularly when bench marks, 10 mm apart are used to measure the elongation.

NOTE 2 — If fabric is attached or embodied in the rubber sample, remove the same before cutting the test pieces. Avoid preferably the use of a swelling agent while removing the fabric, but benzene, chloroform or carbon tetrachloride may be used to wet the contacting surfaces, if necessary. Take care to avoid stretching of the rubber during the separation from the fabric, and if swelling liquid is used, allow the same to evaporate completely from the rubber surfaces after separation. Make the cloth marked surfaces smooth by buffing. Buff as and when necessary the rubber sample which is of an even thickness, or of thickness above that specified for the test piece which is to be cut from it. During buffing avoid undue heating of the rubber.

TABLE 1 DIMENSIONS OF DUMB-BELL TEST PIECES

(*Clause* 5.2)

DIMENSIONS	TYPE 1	TYPE 2	TYPE 3
(1)	(2)	(3)	(4)
	mm	mm	mm
Overall length (*A*), *Min*	115	75	35
Width of ends (*B*)	25 ± 1	12·5 ± 1·0	6 ± 0·5
Length of narrow parallel portion (*C*)	33 ± 2	25 ± 1	12 ± 0·5
Width of narrow parallel portion* (*D*)	6 + 0·4 − 0·0	4·0 ± 0·1	2 ± 0·1
Small radius (*r*)	14 ± 1	8·0 ± 0·5	3 ± 0·1
Large radius (*R*)	25 ± 2	12·5 ± 1·0	3 ± 0·1†
Thickness	2 ± 0·2	2·0 ± 0·2	1 ± 0·1

*The variation within any one die shall not exceed 0·05 mm.
†Centre of circle on the central line of dumb-bell.

6. TIME LAPSE BETWEEN VULCANIZATION AND TESTING

6.1 The minimum time between vulcanization and testing shall be 16 hours.

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

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

6.4 Samples and test pieces shall be protected from light as completely as possible during the interval between vulcanization and testing.

7. CONDITIONING

7.1 Prepared test pieces shall be conditioned immediately before testing for a minimum of 3 hours at the test temperature, the same temperature being used throughout any one test or series of tests intended to be comparable.

8. TEMPERATURE OF TEST

8.1 Testing shall be carried out at 27 ± 2°C unless otherwise specified.

9. PROCEDURE

9.1 Measurement of Test Piece

9.1.1 *Ring Test Piece* — Measure the thickness by a micrometer gauge, the foot of which exerts a pressure of 20k Pa (approx 200 gf/cm^2) on the rubber. Measure the width in the same way but using a gauge with curved feet to fit the curvature of the ring. For precise work, the cross-section of the ring may be calculated from its mass, density and mean circumference, for the ring specified in **5.1**, the circumference is $\pi \times 48{\cdot}6 = 152$ mm.

9.1.2 *Dumb-Bell Test Piece* — Measure the thickness by a gauge as described in **9.1.1**. The width of the test portion is assumed to be equal to the width between the cutting edge of the narrow central part of the die; for the purpose, the width of this part of the die is measured to the nearest 0·05 mm. Take the average of three measurements, one in the centre and two on each side.

9.2 Determination of Tensile Stress-Strain Properties

9.2.1 Insert a dumb-bell test piece into the grips of the tensile testing machine, taking care to adjust it symmetrically so that the tension will be distributed uniformly over the cross-section. If tension is greater on one side of the test piece than on the other, the bench marks will not remain parallel and the maximum strength of the rubber will not be developed. Then start the machine and measure the distance between the centres of the bench as required to the nearest 1 mm taking care to avoid parallax, until the test piece breaks, if necessary. Note the load on the test piece as required.

9.2.2 Place a ring test piece around the two pulleys with a minimum of tension and carry out the test in the same way as for dumb-bell test pieces except for the noting of the internal circumference as required.

10. CALCULATIONS

10.1 Tensile Strength — The tensile strength is given, in megapascals, by the formula:

a) For rings = $\frac{F}{2A}$

b) For dumb-bells = $\frac{F}{A}$

where

F = the breaking force, in newtons; and

A = the initial cross-sectional area, in square millimetres.

10.2 Elongation at Break — The percentage elongation at break is given by the formula:

a) For rings = $\frac{I - I_o}{I_o} \times 100$

b) For dumb-bells = $\frac{L - L_o}{L_o} \times 100$

where

I = the internal circumference, in millimetres, at break;

I_o = the initial internal circumference, in millimetres;

L = the length, in millimetres, between bench marks at break; and

L_o = the initial length, in millimetres, between bench marks.

10.3 Modulus — The modulus is given, in megapascals, by the formula:

a) For rings = $\frac{f}{2A}$

b) For dumb-bells = $\frac{f}{A}$

where

f = the force, in newtons, at the required elongation; and

A = the initial cross-sectional area, in square millimetres.

10.4 Percent Elongation at Constant Stress — The percentage elongation at constant stress is given by the formula:

a) For rings = $\frac{C - C_o}{C_o} \times 100$

b) For dumb-bells = $\frac{L - L_o}{L_o} \times 100$

where

C = the mean circumference, in millimetres, at the required stress;

C_o = the initial mean circumference, in millimetres;

L = the length, in millimetres, between bench marks at the required stress; and

L_o = the initial length, in millimetres, between bench marks.

10.5 For tensile strength, elongation at break, modulus or elongation at constant stress, the result reported shall be the middle value if an odd number of test pieces is used, or the average of the middle two values if an even number of test pieces is used, the various results being arranged in order of increasing value.

11. REPORT

11.1 The report shall include the following particulars:

a) The values determined for tensile strength, elongation at break, and modulus or elongation at constant stress;

b) Type of test piece used;

c) Method of determing cross-section (of rings);

d) Number of test pieces used;

e) Temperature of test; and

f) Direction of grain (for dumb-bells).

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