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Rubber, vulcanized or thermoplastic — Determination of modulus in shear or adhesion to rigid plates — Quadruple shear method

Caoutchouc vulcanisé ou thermoplastique — Détermination du module ou de l'adhérence à des plaques rigides — Méthode du quadruple cisaillement

INTERNATIONAL ISO

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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.

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 1827 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Sub-Committee SC 2, *Physical and degradation tests*.

This second edition cancels and replaces the first (ISO 1827:1976), plus the first edition of ISO 1747 (ISO 1747:1976), of which it constitutes a technical revision.

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Rubber, vulcanized or thermoplastic — Determination of modulus in shear or adhesion to rigid plates — Quadruple shear method

1 Scope

This International Standard specifies methods for the determination of the modulus in shear or the strength of bonds of rubber to metal or other rigid plates, using rubber bonded between four parallel plates.

Method A describes the determination of the modulus in shear.

Method B describes the determination of the strength of the bonds.

The methods are applicable primarily to test pieces prepared in the laboratory under standard conditions, such as may be used to provide data for the development and control of rubber compounds and methods of manufacture of bonded shear units.

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 471:1983, *Rubber — Standard temperatures, humidities and times for the conditioning and testing of test pieces.*

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 5893:1985, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Description.*

3 Definition

For the purposes of this International Standard, the following definition applies.

3.1 shear modulus: The applied shear stress, calculated on the bonded areas of the rubber in a test unit as specified in this International Standard, divided by the resultant shear strain in the direction of application of the stress.

NOTES

1 **shear strain** (γ) is half the measured deformation divided by the thickness of one rubber block or element.

shear stress (τ) is the applied force divided by twice the area of a bonded face of one rubber block or element.

2 The form of the test piece specified ensures that there is zero applied stress in the direction normal to the bonded surfaces, so that the deformation can be regarded as simple shear.

3 This definition of shear modulus is sometimes referred to as the secant modulus.

4 Principle

4.1 Method A — Determination of the modulus in shear

The force required to obtain a range of predetermined shear strains of a unit of standard dimensions comprising four parallelepipeds of rubber symmet-

rically disposed and bonded to four parallel rigid plates is measured, the forces being parallel to the bonding surfaces and, as a rule, non-destructive, i.e. of maximum values appreciably lower than the bond strength.

4.2 Method B — Determination of the adhesion

The force required to cause a rupture of a unit as described for method A is measured.

5 Apparatus

5.1 Test machine, complying with the requirements of ISO 5893, capable of measuring force with an accuracy corresponding to grade A, as defined in ISO 5893, and with a rate of traverse of the moving grip of 5 mm/min (method A) or 50 mm/min (method B).

The test machine shall include apparatus to measure the deformation of the rubber of the test piece to an accuracy of 0,02 mm.

5.2 Fixtures, for holding the test pieces in the grips, provided with a universal joint to permit accurate centering of the line of action of the applied force.

5.3 Environmental chamber, for carrying out tests at non-ambient temperatures, conforming to the requirements of ISO 3383.

6 Test piece

6.1 Shape and dimensions

The test piece consists of four identical parallelepipedic rubber elements 4 mm ± 1 mm thick, 20 mm ± 5 mm wide and 25 mm ± 5 mm long, bonded on each of their two largest opposite faces to the mating faces of four rigid plates of the same width, and of appropriate lengths to obtain a symmetrical double sandwich arrangement, means being provided at the free external end of each central plate to secure its further assembly to the corresponding holding fixture. The rigid plates shall be of sufficient thickness to withstand bending. A typical arrangement is shown in figure 1.

6.2 Preparation

6.2.1 Preparation of metal plates

Rectangular rigid plates of suitable dimensions shall be prepared and treated in accordance with the requirements of a suitable adhesive system.

6.2.2 Preparation using unmoulded rubber

Prepared rigid plates and suitably sized rubber blanks shall be moulded either by compression or by transfer methods. The moulding shall be carried out using a time and temperature sequence appropriate to the rubber under test. At the conclusion of moulding, care shall be taken in removing the test pieces from the mould to avoid subjecting the adhered surfaces to undue stress.

6.2.3 Preparation using pre-moulded rubber

The four rubber elements for each test piece may be cut from a pre-moulded sheet of uniform thickness or from a rubber product. In either case, care shall be taken to ensure that all four elements are equal in all their dimensions to within ± 0,1 mm.

The elements shall be bonded to the prepared rigid plates using an adhesive system giving a high-modulus bond.

6.3 Number of test pieces

The test shall be carried out on three (method A) or five (method B) test pieces.

7 Time interval between vulcanization and testing

Unless otherwise specified for technical reasons, the time interval between vulcanization and testing shall be in accordance with ISO 1826.

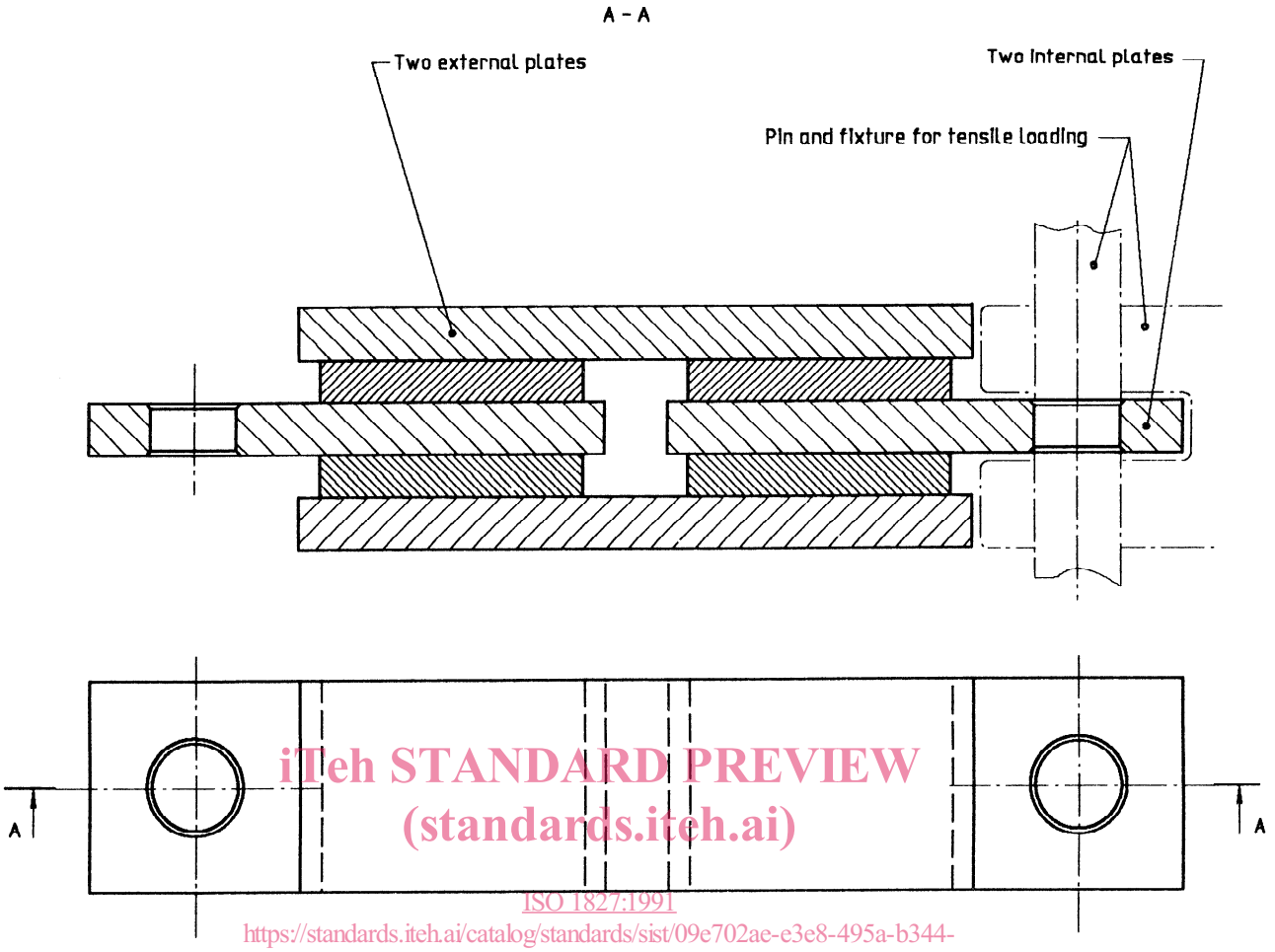

Figure 1 — Test piece arrangement

8 Conditioning

8.1 When a test is made at one of the standard temperatures specified in ISO 471, the test piece shall be maintained at that condition for at least 3 h before the test.

8.2 When tests are made at subnormal or elevated temperatures, the test pieces shall be maintained at the conditions of test for a period of time sufficient to reach temperature equilibrium with the test environment, or for the period of time required by the specification covering the material or product being tested.

9 Temperature of test

Carry out the test at one of the temperatures specified in ISO 471. Unless otherwise specified, the standard temperature shall be used.

The same temperature shall be used for any series of tests intended to be comparable.

10 Procedure

10.1 Method A

10.1.1 Determine the dimensions of the rubber elements in the test piece. Where applicable, the requirements of ISO 4648 shall be met.

For test pieces prepared by vulcanization in a mould, the mould dimensions may be used to determine the area element. The thickness shall be determined from measurements of the rigid plates and of the moulded test piece, by difference. For test pieces prepared from pre-moulded rubber elements, the dimensions of the elements shall be determined before bonding.

10.1.2 After conditioning as specified in clause 8, immediately mount a test piece in the test machine, taking care to ensure freedom of longitudinal self-alignment with the direction of force application.

For some applications, a mechanical conditioning procedure may be required.

In these cases, apply five successive shear loading cycles from zero to 30 %. During mechanical conditioning, and during subsequent testing, maintain the test piece at the test temperature.

10.1.3 When the test piece is mounted in the test machine, immediately zero the force and deformation measuring apparatus while maintaining a slight traction force, for example 1 % of the expected maximum force. Immediately apply an increasing traction force at a rate of separation of the jaws of 5 mm/min ± 1 mm/min until a maximum shear strain of 30 % is reached and record the force/deformation curve.

10.2 Method B

10.2.1 Determine the dimensions of the rubber elements in the test piece. Where applicable, the requirements of ISO 4648 shall be met.

For test pieces prepared by vulcanization in a mould, the mould dimensions may be used to determine the area of each element. The thickness shall be determined from measurements of the rigid plates and of the moulded test piece, by difference. For test pieces prepared from pre-moulded rubber elements, the dimensions of the elements shall be determined before bonding.

10.2.2 After conditioning as specified in clause 8, immediately mount the test piece in the test machine, taking care to ensure freedom of longitudinal self-alignment with the direction of force application.

Operate the test machine at a rate of separation of the jaws of 50 mm/min ± 5 mm/min until the test piece breaks. Record the maximum force.

11 Expression of results

11.1 Method A

The shear modulus shall be determined at a shear strain of 25 %.

Calculate the shear strain (γ) from the equation

$$\gamma = \frac{d}{2c}$$

where

d is the deformation, in millimetres, of the test piece;

c is the thickness, in millimetres, of one rubber element.

Calculate the deformation corresponding to 25 % shear strain (d_{25}), in millimetres, from the equation

$$d_{25} = 0{,}25 \times 2c$$

From the force/deformation curve, determine the force to give 25 % shear strain (F_{25}).

Calculate the shear stress at 25 % strain (τ_{25}), in newtons per square millimetre, from the equation

$$\tau_{25} = \frac{F_{25}}{2A}$$

where

F is the force, in newtons;

A is the bonded area, in square millimetres, of one face of one rubber element.

Calculate the shear modulus (G), in newtons per square millimetre, from the equation

$$G = \frac{\tau_{25}}{\gamma_{25}} = \frac{\tau_{25}}{0{,}25}$$

Calculate the median value of the shear modulus for the three test pieces.

11.2 Method B

11.2.1 Calculate the adhesion value, in pascals, by dividing the maximum force by the total bonded area of one of the double sandwiches on the corresponding rigid plate,

$$\text{i.e. adhesion} = \frac{F_{max}}{2A}$$

where

F_{max} is the maximum force, in newtons;

A is the bonded area, in square millimetres, of one face of one bonded rubber block or element.

11.2.2 Use the following symbols to indicate the type of adhesion failure:

R Failure in the rubber

RC Failure at the interface between the rubber and the cover

CP Failure at the interface between the cover and the primer

M Failure at the surface of the rigid plates

12 Test report

The test report shall contain the following information:

12.1 For method A

a) the reference number of this International Standard, and the method used;

b) the mean value of the shear modulus and the individual test results;

c) whether or not mechanical conditioning was used;

d) all details necessary for identification of the rubber compound;

e) the bonding and/or moulding process used (direct vulcanization, adhesive, compression, transfer, casting, etc.);

f) the duration and temperature of vulcanization and/or curing of the adhesive;

g) the temperature of the test;

h) the date of vulcanization and/or curing of the adhesive;

i) the date of the test.

12.2 For method B

a) the reference number of this International Standard, and the method used;

b) the results for all five test pieces, calculated in accordance with 11.2.1, for the adhesion value;

c) all details necessary for identification of the rubber compound;

d) the nature of the rigid plates (material, surface roughness, etc.);

e) a description of the method used to secure adhesion (preparation of surface, adhesive system, etc.);

f) the bonding and/or moulding process used (direct vulcanization, adhesive, compression, transfer, casting, etc.);

g) the duration and temperature of vulcanization and/or curing of the adhesive;

h) the temperature of the test;

i) the date of vulcanization and/or curing of the adhesive;

j) the date of the test.

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Descriptors: rubber, vulcanized rubber, tests, shear tests, adhesion tests, shear modulus.

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