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

Caoutchouc vulcanisé ou thermoplastique — Détermination des propriétés de contrainte/déformation en compression

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Contents

Page

Foreword ... iv
Introduction ... v
1 Scope ... 1
2 Normative references ... 2
3 Terms and definitions ... 2
4 Principle ... 2
5 Apparatus and materials ... 2
6 Calibration ... 3
7 Test pieces ... 3
8 Number of test pieces ... 4
9 Time-lapse between vulcanization and testing ... 4
10 Conditioning ... 4
11 Temperature of test ... 5
12 Procedure ... 5
12.1 Measurement of test pieces ... 5
12.2 Determination of stress-strain properties ... 5
13 Expression of results ... 6
13.1 For methods A, B and C ... 6
13.2 For method D ... 7
14 Test report ... 8
15 Precision for methods A and D ... 8
Annex A (informative) Influence of test piece geometry ... 9
Annex B (informative) Extrapolation of results to non-standard test pieces ... 13
Annex C (normative) Calibration schedule ... 16
Annex D (informative) Precision for methods A and D ... 18
Bibliography ... 21

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 7743 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 7743:2008), which has been technically revised.

Introduction

Knowledge of compression stress-strain properties is important in the design of, for instance, bridge bearings, anti-vibration mountings and O-rings. Measurement of compression stress-strain behaviour is also used for the quality control of small O-rings and other small products (i.e. those under 2 mm thick) where hardness cannot easily be measured. Compression tests are also used to detect the presence of porosity in products such as pipe sealing rings. Compression can be uniaxial or biaxial depending on test piece shape and experimental conditions. If there is no friction at the interface between the test piece and the compression device, compression is uniaxial. If friction is significant, the test piece shape affects the nature of the compression. When the thickness of the test piece is small, Saint Venant’s principle is not applicable: the boundary condition at the interface influences the stress and strain fields and compression becomes biaxial (the thinner the test piece, the higher the biaxiality). The test piece behaves as if an additional radial compression were applied (friction hampers the radial expansion due to axial compression) and this phenomenon has to be taken into account when material properties such as moduli are to be derived from compression results.

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

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This International 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.

1 Scope

This International Standard specifies methods for the determination of the compression stress-strain properties of vulcanized or thermoplastic rubber using a standard test piece, a product or a part of a product.

Four procedures are given:

— using standard test piece A with the metal plates lubricated (method A);

— using standard test piece A with the metal plates bonded to the test piece (method B);

— using standard test piece B (method C);

— using a product or a part of a product with the metal plates lubricated (method D).

The four procedures do not give the same results. Method A (test piece A, lubricated) gives results which are dependent only on the modulus of the rubber and are independent of the test piece shape, provided that complete slip conditions are achieved. Effective lubrication is sometimes difficult to achieve, however, and it is prudent to inspect the variance in the test results from replicate test pieces for indications of erratic slip conditions. Method B (test piece A, bonded) gives results which are dependent on both the modulus of the rubber and the test piece shape. The dependence on test piece shape is strong and, consequently, the results are markedly different from those obtained with lubricated test pieces. Method C (test piece B) gives results which are independent of both the test piece shape and the lubrication conditions. This test piece is more appropriate and more convenient when intrinsic material properties are to be determined (see Annex A for details). For products (method D), the result is dependent on the shape, but as tests on products are mainly comparative, this is acceptable.

NOTE For well-specified product shapes, such as O-rings, the result can be correlated to the hardness value.

Provision is made for the use of test pieces of different size and/or shape from the specified test pieces, but extrapolation of the results obtained to other sizes and shapes can prove impossible.

Information on the effect of size and shape of test piece and of bonding or lubrication is given in Annex A.

The method is not suitable for materials that exhibit high set.

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 18899:2004, *Rubber — Guide to the calibration of test equipment*

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
compression stress
stress applied so as to cause a deformation of the test piece in the direction of the applied stress, expressed as the force divided by the original area of cross-section perpendicular to the direction of application of the force

3.2
compression strain
deformation of the test piece in the direction of the applied stress divided by the original dimension in that direction

NOTE The compression strain is commonly expressed as a percentage of the original dimension of the test piece.

3.3
compression modulus
secant modulus
applied stress calculated on the original area of cross-section divided by the resultant strain in the direction of application of the stress

3.4
stiffness at 25 % compression
force which needs to be applied to a product or a part of a product to compress it by 25 %, expressed in newtons per metre or in newtons, depending on the shape of the test piece

4 Principle

A test piece (lubricated or bonded) is compressed at a constant speed between the compression plates until a pre-determined strain is reached.

5 Apparatus and materials

5.1 Flat metal plates, of uniform thickness and having lateral dimensions greater than or equal to those of test pieces for bonding or at least 20 mm greater than those of test pieces for lubrication.

For methods A and D, one surface of each plate shall be highly polished.

NOTE A surface finish not worse than Ra 0,4 µm (see ISO 4287[2]) has been found to be suitable. Such an Ra can be obtained by a grinding or polishing operation.

For method B, one surface of each plate shall be suitably prepared for the bonding system to be used.

For method C, no specific preparation of the contact surfaces is required.

5.2 Dies and cutters (if required), for preparing test pieces, complying with the relevant requirements of ISO 23529.

5.3 Thickness gauge, complying with the relevant requirements of ISO 23529.

5.4 Compression-testing machine, complying with the requirements of ISO 5893[4], equipped with means of autographic recording of the force-deformation relationship to an accuracy corresponding to grade 1 in respect of force.

When testing standard test pieces in methods A, B and C and larger test pieces in method D, it shall be possible to determine the displacement with an accuracy of ±0,02 mm, including corrections for load cell and device stiffness.

When testing products with a height less than that of the standard test piece, it shall be possible to determine the displacement with an accuracy of ±0,2 % of the height of the test piece, including corrections for load cell and device stiffness.

The machine shall be fitted with parallel compression platens at least as large as the metal plates (5.1), and shall be capable of operating at a speed of (10 ± 2) mm/min.

NOTE 1 For methods A and D, the compression platens can be used directly without the metal plates, provided they have the required surface finish.

NOTE 2 For method C, the compression platens can be used directly, whatever the surface finish.

Machines with y-time recorders can give erroneous results because of:

— inertia effects;

— deformation caused by compliance in the load cell or machine frame.

Machines with x-y recorders are therefore preferred.

When testing lubricated test pieces, a suitable guard should be provided to avoid damage or injury should the rubber be ejected when strained.

5.5 Lubricant, having no significant effect on the rubber under test, for methods A, C and D.

NOTE For most purposes, a silicone or fluorosilicone fluid having a kinematic viscosity of 0,01 m^2/s is suitable.

For method C, lubrication is recommended though it is not necessary (see Annex A).

6 Calibration

The test apparatus shall be calibrated in accordance with Annex C.

7 Test pieces

Standard test piece A: the standard test piece for both method A and method B is a cylinder of diameter (29 ± 0,5) mm and height (12,5 ± 0,5) mm.

Standard test piece B: the standard test piece for method C is a cylinder of diameter (17,8 ± 0,15) mm and height (25 ± 0,25) mm.

Test pieces can be cut or moulded. Cut test pieces shall be prepared in accordance with ISO 23529.

Other test pieces can be used, but extrapolation of the results might not be possible (see Annex B).

For method B, test pieces can be directly moulded to the metal plates using a suitable mould and bonding system or adhered to the plates using suitable non-solvent adhesive systems.

It is essential to have test pieces with flat and parallel surfaces.

For method D, the test piece is a product, or a part of a product, or multiples thereof. For profiles, a length of 50 mm to 100 mm shall be used as the test piece (or two such lengths together if it is necessary to increase the force reading). For ring-shaped products with an inner diameter of 50 mm to 100 mm, the whole product shall be used. For small products, two or more products can be tested side by side, parallel to each other, to increase the force reading.

8 Number of test pieces

At least three test pieces, or sets of test pieces, shall be tested.

9 Time-lapse between vulcanization and testing

Unless otherwise specified for technical reasons, the following requirements shall be observed (see ISO 23529).

— 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 four 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 three months. In other cases, tests shall be made within two months of the date of receipt of the product by the customer.

10 Conditioning

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

Samples, after any necessary preparation, shall be conditioned at standard laboratory temperature (see ISO 23529) for at least 3 h before the test pieces are cut. The test pieces can be marked, if necessary, and measured and tested immediately. If not tested immediately, they shall be kept at the standard laboratory temperature until tested. If the preparation involves buffing, the interval between buffing and testing shall not exceed 72 h.

Moulded test pieces shall be conditioned at standard laboratory temperature for at least 3 h immediately before being measured and tested.

If the test is to be carried out at a temperature other than standard laboratory temperature, the test pieces shall be conditioned at the test temperature, immediately prior to testing, for a period sufficient to ensure that they have reached the test temperature (see ISO 23529).

11 Temperature of test

The test shall normally be carried out at standard laboratory temperature (see ISO 23529). If another temperature is used, it shall preferably be one of the following:

(−75 ± 2) °C,	(−55 ± 2) °C,	(−40 ± 2) °C,	(−25 ± 2) °C,	(−10 ± 2) °C,	(0 ± 2) °C,
(40 ± 1) °C,	(55 ± 1) °C,	(70 ± 1) °C,	(85 ± 1) °C,	(100 ± 1) °C,	
(125 ± 2) °C,	(150 ± 2) °C,	(175 ± 2) °C,	(200 ± 2) °C,	(225 ± 2) °C,	(250 ± 2) °C.

12 Procedure

12.1 Measurement of test pieces

Determine the dimensions of the test pieces by the appropriate methods specified in ISO 23529. For test pieces bonded by vulcanization, measure the thickness of the bonded assembly and determine the thickness of the rubber by subtracting the sum of the thicknesses of the metal plates from the thickness of the bonded assembly.

12.2 Determination of stress-strain properties

12.2.1 Method A

For lubricated test pieces, lightly coat the polished surfaces of the metal plates with a film of lubricant.

Insert the test piece centrally in the compression machine between the metal plates and operate the machine at a speed of 10 mm/min until a strain of 25 % is reached. Release the strain at the same speed of 10 mm/min and repeat the compression and release cycle three more times, the four compression cycles forming an uninterrupted sequence. Record the force-deformation curve.

12.2.2 Method B

Insert the bonded assembly centrally in the compression machine and operate the machine at a speed of 10 mm/min until a strain of 25 % is reached. Release the strain at the same speed of 10 mm/min and repeat the compression and release cycle three more times, the four compression cycles forming an uninterrupted sequence. Record the force-deformation curve.

12.2.3 Method C

Insert the assembly (lubricated or not) centrally in the compression machine and operate the machine at a speed of 10 mm/min until a strain of 25 % is reached. Release the strain at the same speed of 10 mm/min and repeat the compression and release cycle three more times, the four compression cycles forming an uninterrupted sequence. Record the force-deformation curve.

12.2.4 Method D

Place the test piece centrally on the lower lubricated compression platen. Compress the test piece at a speed of 10 mm/min until a strain of 30 % is reached and record the force-deformation curve.

This test is normally done without any mechanical conditioning. Mechanical conditioning as in methods A, B or C can also be used, but its use shall be mentioned in the test report.

Holes are needed in the compression platens when testing ring-shaped products, to let the air out during compression.

If a product includes bonded-on rigid components (e.g. an engine mount), it is tested without lubricated platens.