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

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Rubber Manufacturers Association (JRMA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS K 6254:2010** is replaced with this Standard.

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

Introduction

This Japanese Industrial Standard has been prepared based on the fourth edition of **ISO 7743** published in 2011 with some modifications of the technical contents, mainly the addition of the tensile deformation requirements that are not given in the said corresponding **ISO** Standard.

The vertical lines on both sides of the text and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA.

1 Scope

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

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 7743:2011 *Rubber, vulcanized or thermoplastic—Determination of compression stress-strain properties* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are **IDT** (identical), **MOD** (modified), and **NEQ** (not equivalent) according to **ISO/IEC Guide 21-1**.

WARNING Persons using this 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.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS K 6200 *Rubber—Vocabulary*

JIS K 6250 *Rubber—General procedures for preparing and conditioning test pieces for physical test methods*

NOTE : Corresponding International Standard: ISO 23529 *Rubber—General procedures for preparing and conditioning test pieces for physical test methods* (MOD)

JIS K 6272 *Rubber—Tensile, flexural and compression test equipment (constant rate of traverse)—Specification*

JIS Z 8401 *Guide to the rounding of numbers*

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

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS K 6200** and the following apply.

3.1 compression stress

stress applied so as to cause a deformation of the test piece in the direction of the applied stress

NOTE : The compression stress is expressed as the force applied divided by the original cross-section area of test piece.

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

value of the compression stress divided by the compression strain

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 %

NOTE : It is expressed in N or N/m depending on the shape of the test piece.

3.5 tensile strain

deformation of a test piece in the direction of the applied tension divided by the original dimension of the test piece in that direction

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

3.6 shear modulus

value obtained by dividing a stress generated when shear force is applied to a test piece by a specified strain

The shear modulus is a modulus measured when the stress resulting from application of a specified strain to a test piece is in a state of equilibrium. This modulus, for the purpose of this Standard, is a conversion value calculated by using a tensile stress determined by a tensile test under low strain.

NOTE : Shear modulus is a physical property value which expresses the deformation resistance of a material in a state of equilibrium.

4 Types of test

The stress-strain properties of vulcanized or thermoplastic rubber shall be determined by the following two tests.

- a) **Compression test** A test piece is compressed at a constant speed to a specified strain and the compression force is measured. From a compression force-deformation curve obtained, the compression modulus of vulcanized or thermoplastic rubber is determined.
- b) **Tensile test** A test piece is pulled at a constant speed to a specified strain and the tensile force is measured. From a tensile force-deformation curve obtained, the tensile stress and shear modulus of the vulcanized or thermoplastic rubber are obtained.

5 Compression test

5.1 Methods of compression test

Four procedures are given:

- using standard test piece 1 (see 5.4) with metal plates lubricated (Method A);
- using standard test piece 1 with metal plates bonded to the test piece (Method B);
- using standard test piece 2 (see 5.4) with metal plates (Method C);
- using a product or a part of a product with metal plates lubricated (Method D).

The four methods do not give the same results.

Method A (standard test piece 1, 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 (standard test piece 1, 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.

In Method C (standard test piece 2), the test results are dependent on neither the test piece shape nor the lubrication. Therefore, use of lubricant is fairly optional. For determining characteristics inherent to a material, standard test piece 2 is more suitable and convenient (see Annex A for details).

For Method D (products), the result is dependent on the shape, but as tests on products are mainly comparative, this is acceptable.

Test pieces different in dimensions and/or shape from the standard test piece may be used; however, in this case, test results cannot be compared with those determined using the standard test piece.

The guideline on the effect of dimensions and shape of test pieces and that of bonding or lubricant is given in Annex B.

This method is not suitable for testing materials with greater compression set.

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

5.2 Test apparatus and materials

The test apparatus and materials shall be as follows.

5.2.1 Flat metal plates, used for compressing test pieces, having a uniform thickness and sufficient rigidity not to deform more than 0.01 mm when subjected to a force exerted by the test piece. The plates, if lubricated, shall have plane dimensions greater than the test piece by at least 20 mm. If bonded through vulcanization, the plates shall have the same plane dimensions as the test piece.

The surface of the metal plates to be in contact with the test piece shall be as follows.

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

NOTE : The surface of metal plates should be finished to an arithmetic mean roughness (R_a) specified in **JIS B 0601** of 0.4 μm or under.

- For Method B, one surface of each plate shall be suitably prepared, e.g. by removing debris on it, for the bonding system to be used.
- For Method C, no specific preparation of the contact surfaces is required.

5.2.2 Dies and cutters, for preparing test pieces, complying with 8.3 of **JIS K 6250**.

5.2.3 Thickness gauge, complying with 10.1 a) of **JIS K 6250**.

5.2.4 Compression-testing machine, equipped with means of autographic recording of the compression force and the compression deformation to an accuracy corresponding to Class 1 or superior in force-measuring system specified in clause 4 of **JIS K 6272**.

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 calibration schedule for the compression testing machine for this test is provided in Annex C.

The machine shall be fitted with parallel compression platens at least as large as the metal plates specified in 5.2.1, and shall be capable of operating at a speed of 10 mm/min $\pm$ 2 mm/min. When testing lubricated test pieces, a suitable guard should be provided to avoid damage or injury should the rubber be ejected when strained.

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

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

NOTE 3 Machines with x-y recorders are preferred.

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

For Method C, lubrication is not necessary since the test results are not affected by the friction on the interface of test piece and compression platens (see Figure A.3).

NOTE : For most purposes, a silicone or fluorosilicone fluids having a kinematic viscosity of 0.01 m²/s is suitable.

5.3 Calibration of test apparatus

Calibration of a test apparatus shall be performed in accordance with Annex C.

5.4 Test pieces

The following two types of test pieces shall be used.

- Standard test piece 1: the standard test piece for both Method A and Method B is a cylinder of diameter 29.0 mm ± 0.5 mm and height 12.5 mm ± 0.5 mm.
- Standard test piece 2: the standard test piece for Method C is a cylinder of diameter 17.8 mm ± 0.15 mm and height 25.0 mm ± 0.25 mm.

The test pieces can be cut, vulcanized or moulded. Cut test pieces shall be prepared in accordance with 8.4 of **JIS K 6250**.

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. 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.

5.5 Number of test pieces

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

5.6 Time-lapse between vulcanization and testing

Unless otherwise specified for technical reasons, requirements in 7 b) of **JIS K 6250** shall be observed. If not tested immediately, the test pieces shall be kept at the standard laboratory temperature until tested.

5.7 Conditioning

Samples, after any necessary preparation, shall be conditioned at standard laboratory temperature specified in clause 6 of **JIS K 6250** 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 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.

5.8 Test temperature

The test shall normally be carried out at the standard laboratory temperature specified in 11.2.1 of **JIS K 6250**. If another temperature is used, it shall preferably be one of the following:

$(-75 \pm 2) ^\circ\text{C}$, $(-55 \pm 2) ^\circ\text{C}$, $(-40 \pm 2) ^\circ\text{C}$, $(-25 \pm 2) ^\circ\text{C}$, $(-10 \pm 2) ^\circ\text{C}$, $(0 \pm 2) ^\circ\text{C}$, $(40 \pm 1) ^\circ\text{C}$,
 $(55 \pm 1) ^\circ\text{C}$, $(70 \pm 1) ^\circ\text{C}$, $(85 \pm 1) ^\circ\text{C}$, $(100 \pm 1) ^\circ\text{C}$, $(125 \pm 2) ^\circ\text{C}$, $(150 \pm 2) ^\circ\text{C}$, $(175 \pm 2) ^\circ\text{C}$,
 $(200 \pm 2) ^\circ\text{C}$, $(225 \pm 2) ^\circ\text{C}$, $(250 \pm 2) ^\circ\text{C}$

5.9 Test methods

5.9.1 Measurement of test pieces

Determine the dimensions of the test pieces by Method A specified in 10.1 a) of **JIS K 6250**. For the test piece bonded to metal plates by vulcanizing or moulding, the thickness of the bonded assembly shall be measured, and the thickness of rubber shall be determined by subtracting the sum of thicknesses of the metal plates from the thickness of the bonded assembly.

5.9.2 Determination of stress-strain properties

5.9.2.1 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 $10 \text{ mm/min} \pm 2 \text{ mm/min}$ until a strain of 25 % is reached. Release the strain at the same speed of $10 \text{ mm/min} \pm 2 \text{ mm/min}$ and repeat the compression and release cycle three more times, the four compression cycles forming an uninterrupted sequence. Record the force-deformation curve.

The four compression cycles shall be performed by reciprocating the compression platens to gain a compression strain between 0 % to 25 % (percentage of the original test piece height).

5.9.2.2 Method B Insert the bonded test piece centrally in the compression machine and operate the machine at a speed of $10 \text{ mm/min} \pm 2 \text{ mm/min}$ until a strain of 25 % is reached. Release the strain at the same speed of $10 \text{ mm/min} \pm 2 \text{ mm/min}$ and repeat the compression and release cycle three more times, the four compression cycles forming an uninterrupted sequence. Record the force-deformation curve.

The four compression cycles shall be performed by reciprocating the compression platens to gain a compression strain between 0 % to 25 % (percentage of the original test piece height).