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Rubber, vulcanized or thermoplastic — Determination of dynamic properties — General guidance

Caoutchouc vulcanisé ou thermoplastique — Détermination des propriétés dynamiques — Lignes directrices

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In accordance with the provisions of Council Resolution 15/1993, this document is **circulated in the English language only**.

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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.

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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.

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ISO 4664 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analyses*.

This fourth edition cancels and replaces the third edition (ISO 4664:1998), which has been technically revised.

Rubber, vulcanized or thermoplastic — Determination of dynamic properties — General guidance

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.

1 Scope

This International Standard provides guidance on the determination of dynamic properties of vulcanized and thermoplastic rubbers. It includes both free- and forced-vibration methods carried out on both materials and products. It does not cover rebound resilience or cyclic tests in which the main objective is to fatigue the rubber.

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 815, *Rubber, vulcanized or thermoplastic — Determination of compression set at ambient, elevated or low temperatures*

ISO 4663, *Rubber — Determination of dynamic behaviour of vulcanizates at low frequencies — Torsion pendulum method*

ISO 5893, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 7743:2004, *Rubber, vulcanized or thermoplastic — Determination of compression stress-strain properties*

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 Terms applying to any periodic deformation

3.1.1
mechanical hysteresis loop
closed curve representing successive stress-strain states of a material during a cyclic deformation

NOTE Loops may be centred around the origin of co-ordinates or more frequently displaced to various levels of strain or stress; in this case the shape of the loop becomes variously asymmetrical in more than one way, but this fact is frequently ignored.

3.1.2
energy loss
energy per unit volume which is lost in each deformation cycle, the hysteresis loop area, calculated with reference to coordinate scales

NOTE It is expressed in J/m^3.

3.1.3
power loss
power per unit volume in each deformation cycle which is transformed into heat through hysteresis, expressed as the product of energy loss and frequency

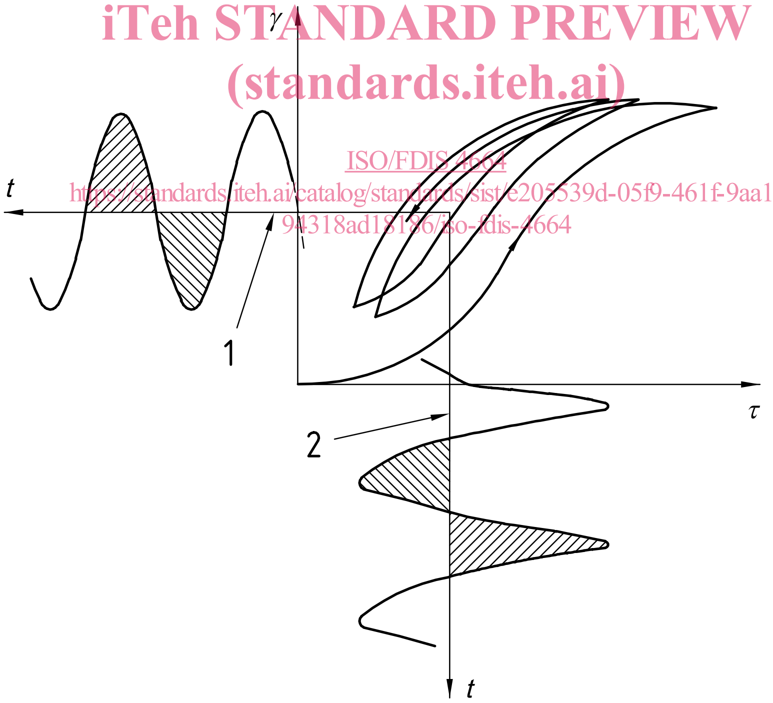
NOTE It is expressed in W/m^3.

3.1.4
mean load
average value of the load during a single complete hysteresis loop

NOTE It is expressed in N.

3.1.5
mean deflection
average value of the deflection during a single complete hysteresis loop (see Figure 1)

NOTE It is expressed in m.



Key

1 mean strain

2 mean stress

NOTE 1 Open initial loops are shown, as well as equilibrium mean strain and mean stress as time-averages of instantaneous strain and stress.

NOTE 2 A sinusoidal response to a sinusoidal motion implies hysteresis loops which are or can be considered to be elliptical. The term “incremental” may be used to designate dynamic response to sinusoidal deformation about various levels of mean stress or mean strain (for example, incremental spring constant, incremental elastic shear modulus).

Figure 1 — Heavily distorted hysteresis loop obtained under forced pulsating sinusoidal strain

3.1.6
mean stress
average value of the stress during a single complete hysteresis loop (see Figure 1)

NOTE It is expressed in Pa.

3.1.7
mean strain
average value of the strain during a single complete hysteresis loop (see Figure 1)

3.1.8
mean modulus
ratio of the mean stress to the mean strain

NOTE It is expressed in Pa.

3.1.9
maximum load amplitude
F_0
ratio of the maximum applied load, measured from the mean load (zero to peak on one side only)

NOTE It is expressed in N.

3.1.10
maximum stress amplitude
τ_0
ratio of the maximum applied force, measured from the mean force, to the cross-sectional area of the unstressed test piece (zero to peak on one side only)

NOTE It is expressed in Pa.

3.1.11
root-mean-square stress
square root of the mean value of the square of the stress averaged over one cycle of deformation

NOTE 1 For a symmetrical sinusoidal stress the root-mean-square stress equals the stress amplitude divided by $\sqrt{2}$.

NOTE 2 It is expressed in Pa.

3.1.12
maximum deflection amplitude
X_0
ratio of the maximum deflection, measured from the mean deflection (zero to peak on one side only)

NOTE It is expressed in m.

3.1.13
maximum strain amplitude
γ_0
ratio of the maximum strain, measured from the mean strain (zero to peak on one side only)

3.1.14
root-mean-square strain
square root of the mean value of the square of the strain averaged over one cycle of deformation

NOTE For a symmetrical sinusoidal strain, the root-mean-square strain equals the strain amplitude divided by $\sqrt{2}$.

3.2 Terms applying to sinusoidal motion

3.2.1
spring constant
K
component of the applied load which is in phase with the deflection, divided by the deflection

NOTE It is expressed in N/m.

3.2.2
elastic shear modulus
storage shear modulus
G'
component of the applied shear stress which is in phase with the shear strain, divided by the strain

$$G' = |G^*| \cos \delta$$

NOTE It is expressed in Pa.

3.2.3
loss shear modulus
G''
component of the applied shear stress which is in quadrature with the shear strain, divided by the strain

$$G'' = |G^*| \sin \delta$$

NOTE It is expressed in Pa.

3.2.4
complex shear modulus
G^*
ratio of the shear stress to the shear strain, where each is a vector which can be represented by a complex number

$$G^* = G' + iG''$$

NOTE It is expressed in Pa.

3.2.5
absolute (value of) complex shear modulus
$|G^*|$
absolute value of the complex shear modulus

$$|G^*| = \sqrt{G'^2 + G''^2}$$

NOTE It is expressed in Pa.

3.2.6
elastic normal modulus
storage normal modulus
elastic Young's modulus
E'
component of the applied normal stress which is in phase with the normal strain, divided by the strain

$$E' = |E^*| \cos \delta$$

NOTE It is expressed in Pa.

3.2.7
loss normal modulus
loss Young's modulus
E''
component of the applied normal stress which is in quadrature with the normal strain, divided by the strain

$$E'' = |E^*| \sin\delta$$

NOTE It is expressed in Pa.

3.2.8
complex normal modulus
complex Young's modulus
E^*
ratio of the normal stress to the normal strain, where each is a vector which can be represented by a complex number

$$E^* = E' + iE''$$

NOTE It is expressed in Pa.

3.2.9
absolute (value of) normal modulus
absolute value of the complex normal modulus

$$|E^*| = \sqrt{E'^2 + E''^2}$$

3.2.10
storage (dynamic) spring constant
K'
component of the applied load which is in phase with the deflection, divided by the deflection

$$K' = |K^*| \cos\delta$$

NOTE It is expressed in N/m.

3.2.11
loss spring constant
K''
component of the applied load which is in quadrature with the deflection, divided by the deflection

$$K'' = |K^*| \sin\delta$$

NOTE It is expressed in N/m.

3.2.12
complex spring constant
K^*
ratio of the load to the deflection, where each is a vector which can be represented by a complex number

$$K^* = K' + iK''$$

NOTE It is expressed in N/m.

3.2.13
absolute (value of) complex spring constant
$|K^*|$
absolute value of the complex spring constant

$$|K^*| = \sqrt{K'^2 + K''^2}$$

NOTE It is expressed in N/m.

3.2.14
tangent of the loss angle
$\tan\delta$
ratio of the loss modulus to the elastic modulus

NOTE For shear stresses, $\tan\delta = \frac{G''}{G'}$ and for normal stresses $\tan\delta = \frac{E''}{E'}$.

3.2.15
loss factor
L_f
ratio of the loss spring constant to the storage spring constant

$$L_f = \frac{K''}{K'}$$

3.2.16
loss angle
δ
phase angle between the stress and the strain, the tangent of which is the tangent of the loss angle

NOTE It is expressed in rad.

3.3 Other terms applying to periodic motion

3.3.1
logarithmic decrement
natural (Napierian) logarithm of the ratio between successive amplitudes of the same sign of a damped oscillation

3.3.2
damping ratio
u
ratio of actual to critical damping, where critical damping is that required for the borderline condition between oscillatory and non-oscillatory behaviour

NOTE 1 The damping ratio is a function of the logarithmic decrement:

$$u = \frac{\frac{\Lambda}{2\pi}}{\sqrt{1+\left(\frac{\Lambda}{2\pi}\right)^2}} = \sin\tan^{-1}\left(\frac{\Lambda}{2\pi}\right)$$

NOTE 2 For large sinusoidal deformations, the hysteresis loop will deviate from an ellipse since the stress-strain relationship of rubber is non-linear and the response is no longer sinusoidal (see Figure 1).

