

INTERNATIONAL STANDARD

**ISO
4664**

Third edition
1998-05-01

Rubber — Guide to the determination of dynamic properties

*Caoutchouc — Lignes directrices pour la détermination des propriétés
dynamiques*



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

This third edition cancels and replaces the second edition (ISO 4664:1987) as well as ISO 2856:1981, of which it constitutes a technical revision.

© ISO 1998

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet central@iso.ch
X.400 c=ch; a=400net; p=iso; o=isocs; s=central

Printed in Switzerland

Rubber — Guide to the determination of dynamic properties

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 for use with both materials and products. It does not cover rebound resilience nor cyclic tests in which the main objective is to fatigue the rubber.

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 471:1995, *Rubber – Temperatures, humidities and times for conditioning and testing*.

ISO 815:1991, *Rubber, vulcanized or thermoplastic – Determination of compression set at ambient, elevated or low temperatures*.

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 4663:1986, *Rubber – Determination of dynamic behaviour of vulcanizates at low frequencies – Torsion pendulum method*.

ISO 5893:1993, *Rubber and plastics test equipment – Tensile, flexural and compression types (constant rate of traverse) – Description*.

ISO 7743:1989, *Rubber, vulcanized or thermoplastic – Determination of compression stress-strain properties*.

3 Definitions

For the purposes of this International Standard, the following definitions apply (for the symbols used, see clause 4):

3.1 Terms applying to any periodic deformation

3.1.1 mechanical-hysteresis loop

The closed curve representing successive stress-strain states of the material during a cyclic deformation.

NOTE – Loops may be centred on the origin of the coordinate system or, more frequently, displaced to various levels of strain or stress; in the latter case, the shape of the loop becomes asymmetrical, but this fact is frequently disregarded.

3.1.2 energy loss (J/m^3)

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

3.1.3 power loss (W/m^3)

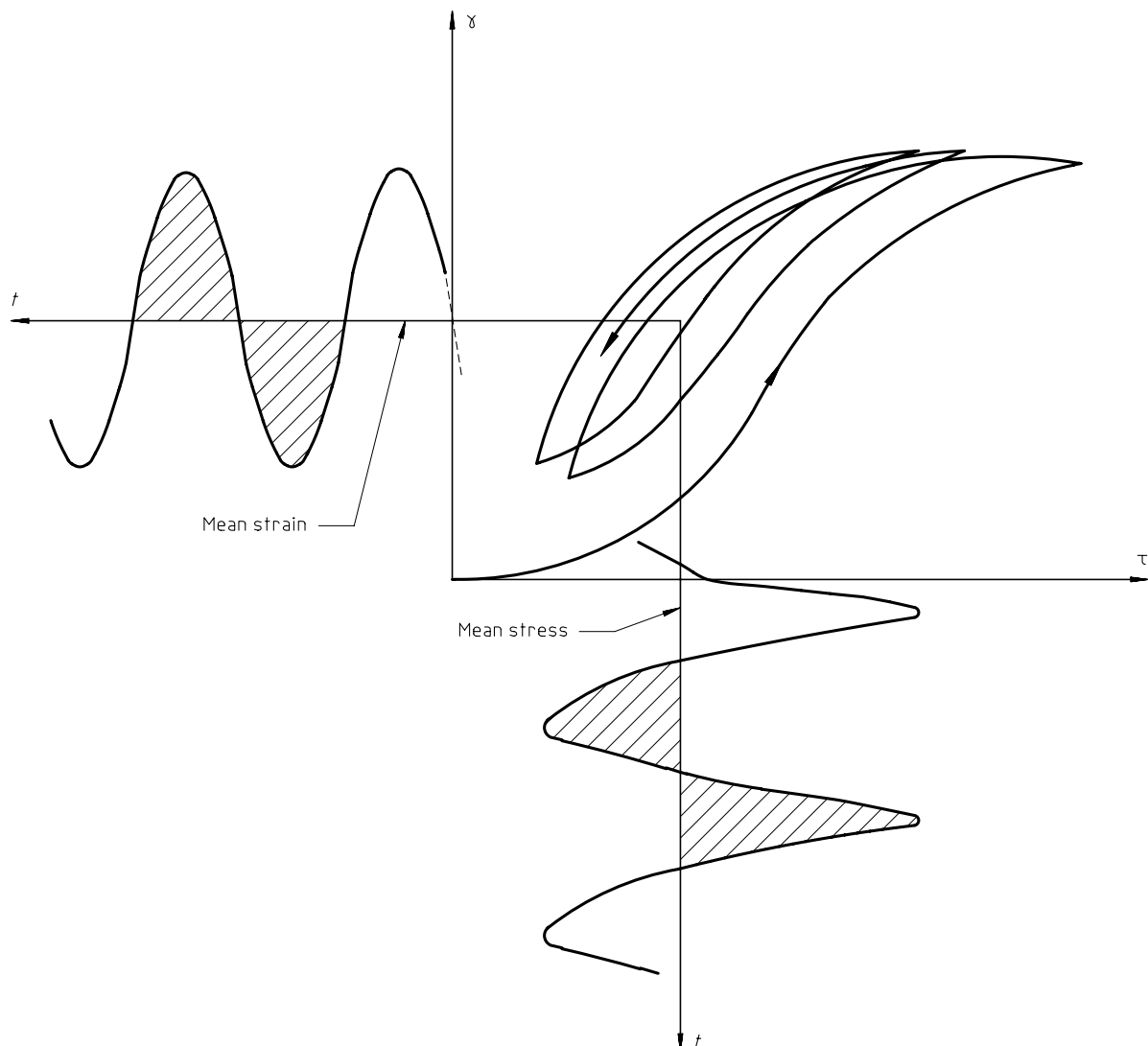
The power per unit volume which is transformed into heat through hysteresis. It is the product of energy loss and frequency.

3.1.4 mean stress (Pa)

The average value of the stress during a single complete hysteresis loop (see figure 1).

3.1.5 mean strain (dimensionless)

The average value of the strain during a single complete hysteresis loop (see figure 1).



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

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

3.1.6 mean modulus (Pa)

The ratio of the mean stress to the mean strain.

3.1.7 stress amplitude (Pa)

The 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).

3.1.8 root-mean-square stress (Pa)

The square root of the mean value of the square of the stress averaged over one deformation cycle.

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

3.1.9 strain amplitude (dimensionless)

The ratio of the maximum deformation, measured from the mean deformation, to the free length (thickness) of an unstrained test piece (zero to peak on one side only) in the direction of loading.

3.1.10 root-mean-square strain (dimensionless)

The 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

NOTE 1 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).

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.

3.2.1 spring constant, k (N/m)

The component of applied force which is in phase with the deformation, divided by the deformation.

3.2.2 elastic shear modulus (storage shear modulus), G' (Pa)

The component of applied shear stress which is in phase with the shear strain, divided by the strain.

3.2.3 elastic normal modulus (storage normal modulus; elastic Young's modulus), E' (Pa)

The component of applied normal stress which is in phase with the normal strain, divided by the strain.

3.2.4 damping constant, c (N.s/m)

The component of applied force which is in quadrature with the deformation, divided by the velocity of the deformation.

3.2.5 loss shear modulus, G'' (Pa)

The component of applied shear stress which is in quadrature with the shear strain, divided by the strain.

3.2.6 loss normal modulus (loss Young's modulus), E'' (Pa)

The component of applied normal stress which is in quadrature with the normal strain, divided by the strain.

3.2.7 complex shear modulus, G^* (Pa)

The ratio of the shear stress to the shear strain, where each is a vector which may be represented by a complex number.

$$G^* = G' + jG''$$

3.2.8 complex normal modulus (complex Young's modulus), E^* (Pa)

The ratio of the normal stress to the normal strain, where each is a vector which may be represented by a complex number.

$$E^* = E' + jE''$$

3.2.9 absolute (value of) complex shear modulus

The magnitude of the complex shear modulus.

$$G^* = |G^*| = \sqrt{G'^2 + G''^2} \quad (\text{Pa})$$

3.2.10 loss factor $\tan\delta$ (dimensionless)

The ratio of the loss modulus to the elastic modulus. For shear stresses $\tan\delta = G''/G'$ and for normal stresses $\tan\delta = E''/E'$.

3.2.11 loss angle (rad)

The phase angle between the stress and the strain, the tangent of which is the loss factor.

3.3 Other terms applying to periodic motion**3.3.1 logarithmic decrement, Λ (dimensionless)**

The natural (Naperian) logarithm of the ratio between successive amplitudes of the same sign of a damped oscillation.

3.3.2 damping ratio, u (dimensionless)

The ratio of the actual to the critical damping, where critical damping is that required for the borderline condition between oscillatory and non-oscillatory behaviour. The damping ratio is a function of the logarithmic decrement:

$$u = \frac{\frac{\Lambda}{2\pi}}{\sqrt{1 + \left(\frac{\Lambda}{2\pi}\right)^2}} = \sin \arctan\left(\frac{\Lambda}{2\pi}\right) \quad \dots(1)$$

NOTE – $u = \Lambda/2\pi$ for small values of Λ .

3.3.3 dynamic spring rate, K_0

$$K_0 = F_0/x_0$$

3.3.4 damping coefficient, C

$$C = 1/\omega K_0 \sin\delta$$

where $\omega = 2\pi f$