INTERNATIONAL STANDARD

# ISO 4664-2

First edition
2006-10-01

# Rubber, vulcanized or thermoplastic — Determination of dynamic properties —

## Part 2: Torsion pendulum methods at low frequencies

*Caoutchouc vulcanisé ou thermoplastique — Détermination des propriétés dynamiques —*

*Partie 2: Méthodes du pendule de torsion à basses fréquences*



Reference number
ISO 4664-2:2006(E)

# Contents

Page

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



It cancels and replaces ISO 4663:1986, of which it constitutes a technical revision.



ISO 4664 consists of the following parts, under the general title *Rubber, vulcanized or thermoplastic — Determination of dynamic properties*:



— *Part 1: General guidance*

— *Part 2: Torsion pendulum methods at low frequencies*

# Rubber, vulcanized or thermoplastic — Determination of dynamic properties —

# Part 2: Torsion pendulum methods at low frequencies

**WARNING — Persons using this part of ISO 4664 should be familiar with normal laboratory practice. This part of ISO 4664 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 part of ISO 4664 specifies methods, using a torsion pendulum, of determining the dynamic properties in shear, that is the shear modulus and mechanical damping, of vulcanized or thermoplastic rubbers over a wide temperature range at low frequencies in the range 0,1 Hz to 10 Hz and at comparatively low strains of less than $5 \times 10^{-4}$.



## 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 4664-1, *Rubber, vulcanized or thermoplastic — Determination of dynamic properties — Part 1: General guidance*

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 terms and definitions given in ISO 4664-1 apply.

## 4 Principle

This test is primarily intended for the determination of the temperature at which the test piece shows transitions in its visco-elastic properties, by plotting observed values of modulus and damping as a function of temperature. The methods are not particularly accurate for the determination of absolute values of the modulus.

In the torsion pendulum, a strip test piece of uniform cross-section constitutes the elastic member of the pendulum. The test piece is clamped at both ends. One clamp is fixed to a rigid frame while the other one is provided with an appropriate inertial mass, for example a flywheel.

Three methods of using the torsion pendulum are specified:

— **method A**, in which the mass of the inertial member is supported by the test piece and the pendulum is set in free damped oscillation;

— **method B**, in which the mass of the inertial member is supported by a fine suspension wire and the pendulum is set in free damped oscillation;

— **method C**, which is similar to method B except that the oscillations are maintained at constant amplitude by supplying energy to the system.

## 5 Apparatus

### 5.1 Test piece holder

The test piece shall be held between clamps, one of which is fixed and the other attached to the inertial member. The length of the test piece between the clamps shall be between 30 mm and 100 mm, 50 mm being the preferred length. Provision shall be made for the measurement of the length between the clamps to an accuracy of 0,5 mm.

In order to obtain a constant temperature over the length of test pieces, the parts of the clamp protruding from the thermostatted test chamber (5.4) shall be made of material having low thermal conductivity.

Care shall be taken to ensure that the test piece is free to expand or retract as a result of changes in temperature without changing the initial stress or tension in the test piece.



### 5.2 Inertial member

The inertial member may be a disc or a symmetrically supported rod having a moment of inertia such that the frequency of oscillation of the pendulum and test piece is between 0,1 Hz and 10 Hz at standard laboratory temperature. In the case of method A, the mass of the inertial member is limited by the longitudinal stress (see 5.3.1). The moment of inertia of a disc or rod of about 30 kg·mm$^2$ has been found to be suitable.

Means shall be attached to the inertial member to enable a torsional disturbance to be applied to the pendulum in order to start the system oscillating. Low angles of deformation shall be used, such that the shear strain in the rubber is below $5 \times 10^{-4}$.

Means shall be provided for measuring the frequency of oscillation to an accuracy of ± 1 % in the region of rubber elasticity. In the transition range, an accuracy of ± 5 % is permissible.

### 5.3 Torsion pendulum

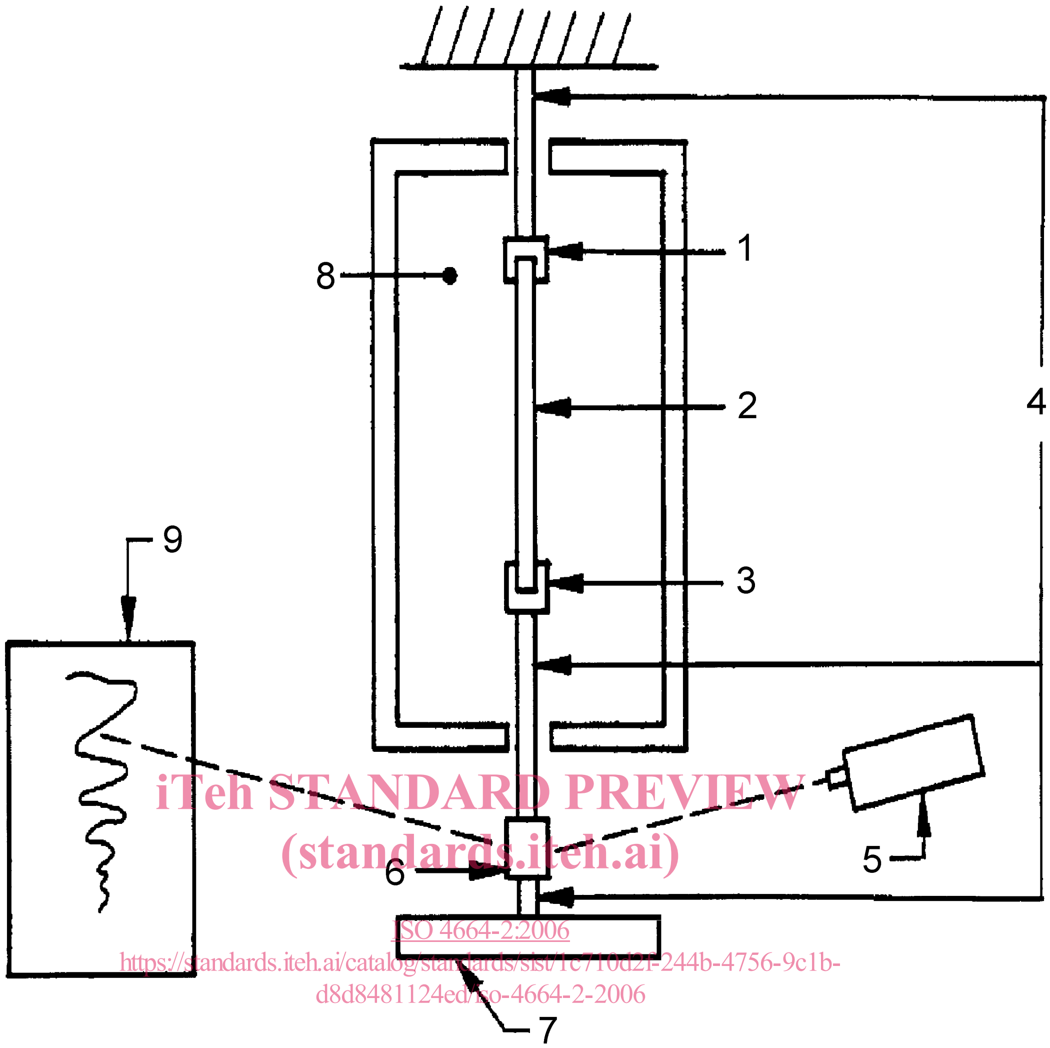
#### 5.3.1 Method A

The inertial member shall be freely suspended below the test piece as shown in Figure 1. The mass of the inertial member shall be such that the longitudinal stress in the test piece is less than 30 kPa.

The method of measurement shall permit the determination of the amplitudes of deformation to an accuracy of ± 1 %. When recorders are used, the recording strip shall move with a speed which is known to within ± 1 %, and with a linearity within ± 1 %.

NOTE If a lamp and mirror system is used to measure amplitude, a distance of at least 2 m is needed between the mirror and scale to achieve the required precision.






**Key**

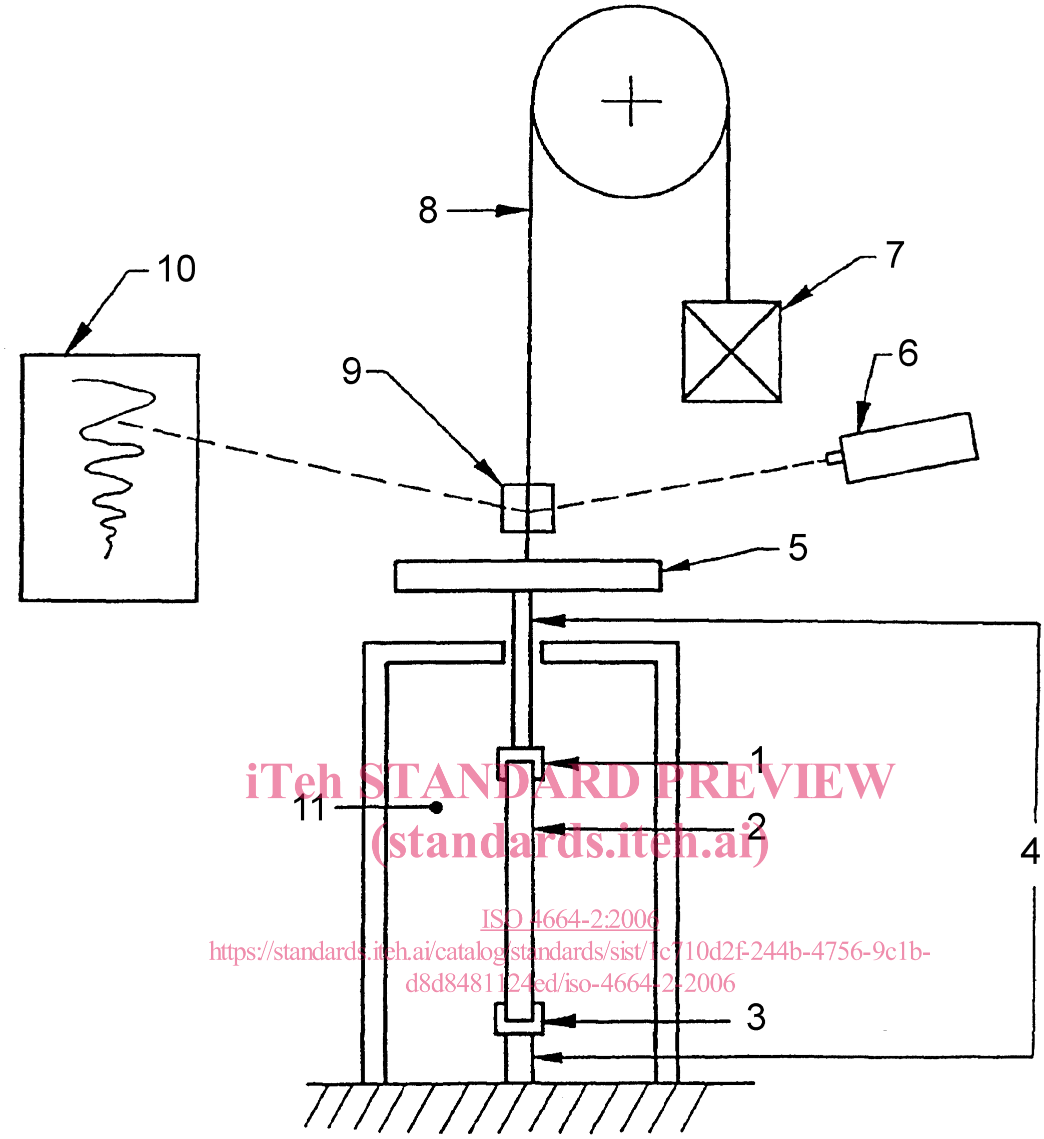
1 upper clamp
2 test piece
3 lower clamp
4 rigid connections
5 lamp
6 mirror
7 inertial member
8 thermostatted chamber
9 scale or recorder

**Figure 1 — Uncompensated free-oscillation apparatus with counterweighted inertial member suspended below the test piece**

### 5.3.2 Method B

The torsion pendulum shall be constructed according to the principles shown in Figure 2. The inertial member shall be supported from above by a fine wire suspension and the test piece shall be attached below. The length and diameter of the wire shall be chosen so that the restoring torque due to the wire suspension is not greater than 25 % of the restoring torque in the test piece plus the suspension.

The measurement system shall conform to that specified for method A.






**Key**

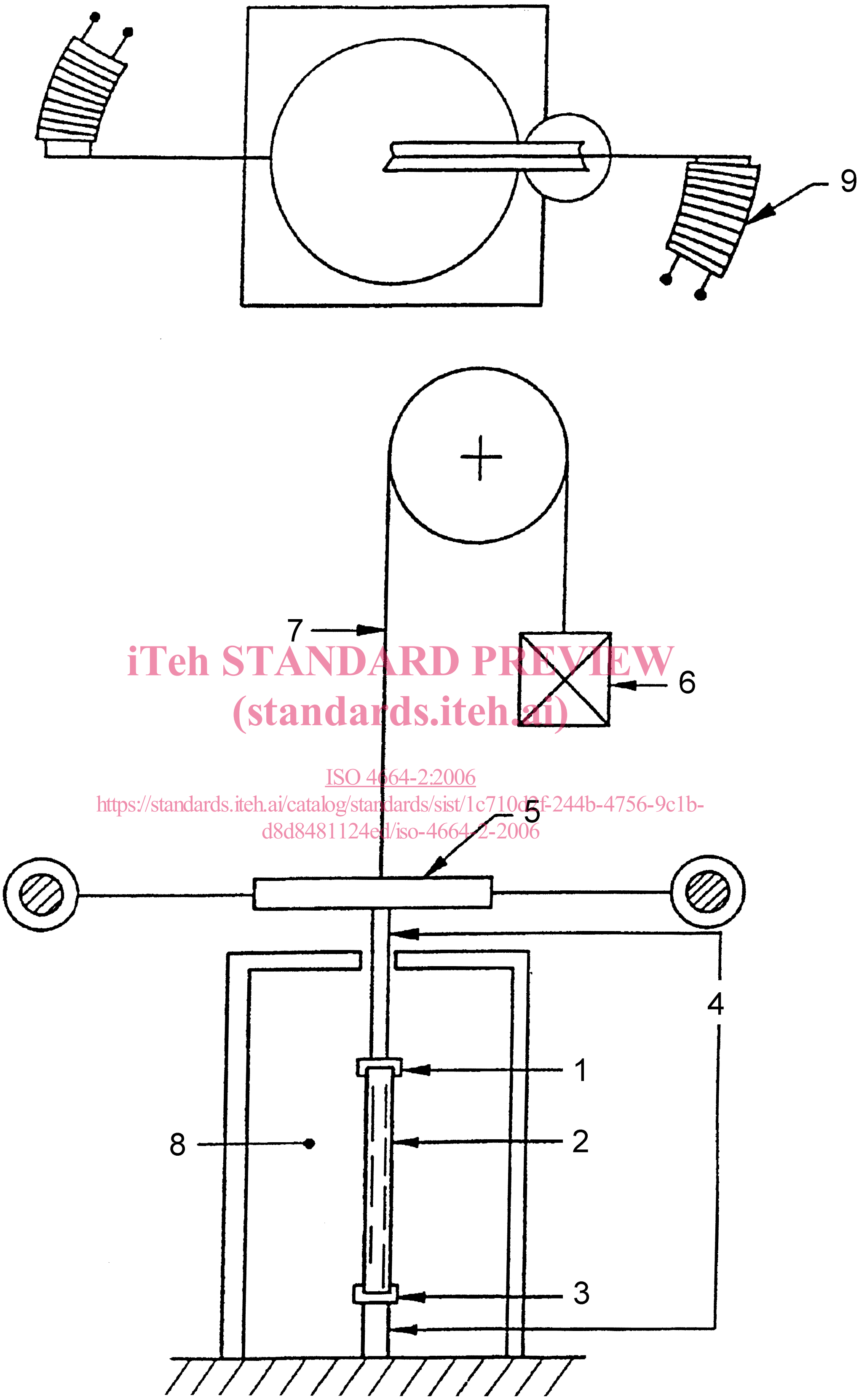
1 upper clamp
2 test piece
3 lower clamp
4 rigid connections
5 inertial member
6 lamp
7 counterweight
8 torsion wire
9 mirror
10 scale or recorder
11 thermostatted chamber

**Figure 2 — Uncompensated free-oscillation apparatus with counterweighted inertial member suspended above the test piece**

### 5.3.3 Method C

The torsion pendulum for this forced-vibration method is the same as that described for method B, with the addition of means to exert a friction-free mechanical moment on the pendulum system. A suitable system is shown in Figure 3 in which the mechanical moment is exerted electromagnetically. The applied moment shall be equal in magnitude but opposite in sign to the mechanical moment produced by damping in the test piece. In this way, a constant amplitude of oscillation can be maintained in the test piece.

A suitable amplitude-monitoring system and means of measuring the restoring moment with an accuracy of ± 2 % shall be incorporated.






**Key**

1 upper clamp
2 test piece
3 lower clamp
4 rigid connections
5 inertial member
6 counterweight
7 torsion wire
8 thermostatted chamber
9 electromagnetic compensation device

**Figure 3 — Forced-resonance oscillation device**