
**Rubber, vulcanized or
thermoplastic — Determination of
rebound resilience**

*Caoutchouc vulcanisé ou thermoplastique — Détermination de la
résilience de rebondissement*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document 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 4662:2009), which has been technically revised to add the calculation of the impact velocity for tripsometer method ([Annex E](#)). It also incorporates the Technical Corrigendum ISO 4662:2009/Cor.1:2010.

Introduction

When rubber is deformed, an energy input is involved; part of which is returned when the rubber returns to its original shape. That part of the energy which is not returned as mechanical energy is dissipated as heat in the rubber.

The ratio of the energy returned to the energy applied is termed the resilience. When the deformation is an indentation due to a single impact, this ratio is termed the rebound resilience.

The value of the rebound resilience for a given material is not a fixed quantity, but varies with temperature, strain distribution (determined by the type of indenter and test piece and by their dimensions), strain rate (determined by the velocity of the indenter), strain energy (determined by the mass and velocity of the indenter) and strain history. Strain history is particularly important in the case of filler-loaded polymers, where the stress-softening effect necessitates a mechanical conditioning.

This variation of resilience with conditions is an inherent property of polymers, which can therefore only be fully evaluated if tests are carried out over a wide range of conditions. The factors described can have a different quantitative influence on resilience. While temperature can critically affect resilience near transition regions of the material tested, factors connected with time and amplitude of indentation have only moderate effects, and fairly wide tolerances may be admissible for them.

Ideally, rebound resilience should be measured on a test piece the back surface of which is bonded to a rigid support in order to avoid friction losses due to slippage during the impact. Since the use of bonded test pieces is impractical in many applications, unbonded test pieces are used. Frictional losses are avoided by secure clamping of the test piece.

To approach these ideal conditions in a practical apparatus, limitations are put upon the hardness (see ISO 48) of the rubber that can be tested: on the hard side to avoid unusual requirements of rigidity in the apparatus; on the soft side to avoid difficulties in clamping.

If a defined set of mechanical conditions and an appropriate apparatus are selected, a standard value of rebound resilience at any temperature can be obtained with a satisfactory degree of reproducibility.

Rubber, vulcanized or thermoplastic — Determination of rebound resilience

WARNING 1 — Persons using this document should be familiar with normal laboratory practice. This document 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.

WARNING 2 — Certain procedures specified in this document might involve the use or generation of substances, or the generation of waste, that could constitute a local environmental hazard. Reference should be made to appropriate documentation on safe handling and disposal after use.

1 Scope

This document specifies two methods for determining the rebound resilience of rubber the hardness of which lies between 30 IRHD and 85 IRHD. They are the pendulum method and the tripsometer method.

With the pendulum method, a mass with a spherical end impacts a flat test piece, firmly held but free to bulge. The kinetic energy of the impacting mass is measured immediately before and after impact.

With the tripsometer method, a flat test piece is impacted by a hemisphere mounted on the periphery of a disc which is supported on an axle and caused to rotate by an off-axis mass. The kinetic energy of the impacting mass is measured immediately before and after impact.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

rebound resilience

ratio between the returned and the applied energy of a moving mass which impacts a test piece

Note 1 to entry: It is usually expressed as a percentage.

4 Principle

A test piece with plane, parallel surfaces is impacted on one surface by a linearly or circularly oscillating body, the impacting surface of which is spherical. The rebound resilience is determined by measurement of the energy of the impacting mass immediately before and after impact.

NOTE Conventionally, the input and output energies of the moving mass have been determined by observing the potential energy of the mass when at rest before moving to impact the test piece and on reaching zero velocity after rebound. The detailed descriptions of the apparatus described in this document follow this convention. However, it is equally acceptable to measure the input and output energies of the moving mass by observing its velocity immediately before and after impact and calculating the kinetic energies.

5 Pendulum method

5.1 Apparatus

5.1.1 General

The rebound resilience shall be measured by means of an apparatus consisting of a pendulum-like one-degree-of-freedom mechanical oscillatory device and a heavy and secure test piece holder.

The two items shall be suitably fixed together for rebound resilience measurements, and either item can be removed for purposes of adjustment or checking of the oscillatory device.

Means shall be provided for measuring the rebound of the pendulum, either using a calibrated scale or an electrical signal.

Various practical designs of apparatus which conform to these specifications are available (see [Annex B](#) and [Annex C](#)).

NOTE 1 The various types of apparatus designed to operate within the ranges specified for the various parameters (see below) and correctly calibrated give substantially the same values of rebound resilience.

The apparatus and impacted test piece characteristics shall be such as to fall within the following specified ranges:

- indenter diameter (D): 12,45 mm to 15,05 mm;
- test piece thickness (d): $(12,5 \pm 0,5)$ mm;
- impacting mass (m): 0,25 kg to 0,35 kg;
- impact velocity (v): 1,4 m/s to 2,0 m/s;
- apparent strain energy density (mv^2/Dd^2): 324 kJ/m³ to 463 kJ/m³.

NOTE 2 The conditions and apparatus specified in this document involve the selection of a spherical indenter and of a flat test piece and are assumed to be essentially dependent on the fundamental parameters D , d , m and v listed above. In addition, the ratio of impact energy to an equivalent volume or “apparent strain energy density” (mv^2/Dd^2), which under simplifying assumptions is related to impact strain, has to be maintained within the narrow range specified.

NOTE 3 The ranges are such that they embrace the requirements for the Lüpke pendulum method (12,5 mm, 12,5 mm, 0,35 kg, 1,4 m/s, 351 kJ/m³) and the modified Schob pendulum method (15,0 mm, 12,5 mm, 0,25 kg, 2 m/s, 427 kJ/m³).

In addition, allowance has been made for

- a) a small tolerance ($\pm 0,05$ mm) to allow for mechanical imperfections of spheres of 12,5 mm and 15 mm nominal diameter;

- b) an additional tolerance ($^{+112}_{-27}$ kJ/m³) on mv^2/Dd^2 to allow for the effect of variation in test piece thickness ($\pm 0,5$ mm).

5.1.2 Oscillatory device

The oscillatory device shall consist of a rigid body or hammer terminating in an indenting spherical surface, supported so as to oscillate linearly or circularly under the action of a restoring force which can be due to gravity or produced by the elastic reaction of springs or by a wire in torsion. The velocity of the indenting spherical surface at the point of impact shall be in the horizontal direction and perpendicular to the surface of the test piece.

5.1.3 System for following the motion of the hammer

The motion of the hammer shall be followed either by means of a system comprising a pointer and a fixed scale or by a system which measures the position or velocity of the hammer to furnish electrical signals.

For pendulums in which the restoring force is due to gravity, the rebound resilience, R , is given by [Formula \(1\)](#):

$$R = \frac{h}{H} \quad (1)$$

where

h is the height of rebound;

H is the drop height.

It is usually convenient for the scale to measure either the horizontal rebound distance or, for rigid-arm pendulums in particular, the angle of rebound. For pendulums in which the restoring force is due to a torsion wire or to the elastic reaction of springs, the rebound resilience is given by [Formula \(2\)](#):

$$R = \frac{\alpha_R^2}{\alpha_I^2} \quad (2)$$

where

α_R is the angle of rebound;

α_I is the angle of impact.

For this form of apparatus, it is convenient for the scale to be used to measure the angle of rebound.

The scale can be graduated uniformly or be calibrated directly in units of resilience. For uniformly graduated scales, conversion equations, charts or tables to allow the determination of the resilience are also necessary.

5.1.4 Test piece holder

The disc-shaped test piece shall be securely held during mechanical conditioning and rebound measurement.

The surface against which the back of the test piece is applied shall be metallic, flat and smoothly finished, vertical and perpendicular to the impact velocity direction.

This backplate is part of an anvil which shall either be free (in which case, it shall have a mass of at least 200 times the impacting mass) or shall be rigidly fastened to a very rigid system, such as a masonry structure.