

Physical testing of rubber —

Part A8: Method for determination of rebound resilience

Committees responsible for this British Standard

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- British Railways Board
- British Rubber Manufacturers' Association
- ERA Technology Ltd.
- GAMBICA (BEAMA Ltd.)
- Institution of Mechanical Engineers
- Institution of Water Engineers and Scientists
- Malaysian Rubber Producers' Research Association
- Ministry of Defence
- National College of Rubber Technology
- Rubber and Plastics Research Association of Great Britain
- SATRA Footwear Technology Centre

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Foreword

This Part of BS 903, which has been prepared under the direction of the Rubber Standards Policy Committee, supersedes BS 903-A8:1963, which is withdrawn.

The Dunlop tripsometer described in method A has been retained, since its use is specified for many products and it is useful when small test pieces, such as can be taken from manufactured articles, are required to be tested. To improve reproducibility, the specimen thickness has been increased to 7 ± 1 mm. It is this method which is the preferred method.

Since the last edition of BS 903-A8, the International Organization for Standardization (ISO) has published ISO 4662, which describes an internationally agreed method for the determination of rebound resilience.

The Lüpke pendulum is one of the designs of apparatus which conforms to the specification given in ISO 4662. The text of ISO 4662 has been adopted as far as possible without alteration, as method B and Appendix A and Appendix B. However, the format of method B differs from that of the international standard and some technical information given in clause 3 of the international standard has been re-located within other parts of the text of method B.

Because the text of the international standard has been used as far as possible without alteration, some terminology and certain conventions are not identical with those used in British Standards.

The Dunlop pendulum method described in method C of BS 903-A8:1963 has been deleted, as it has been found to have no widespread use.

Results obtained using method A cannot be compared with results obtained using method B.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 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 and dimensions of the indenter and test piece), 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 also 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 may have a different quantitative influence on resilience; while temperature may critically affect resilience near transition regions of the material tested, factors connected with time and amplitude of indentation have 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. These require secure clamping to avoid frictional movements.

To approach these ideal conditions in a practical apparatus, it is necessary to put limitations upon the hardness of the rubber that may 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.

1 Scope

This Part of BS 903 describes two methods for determining the rebound resilience of rubber the hardness of which, at the test temperature, lies between 30 IRHD¹⁾ and 85 IRHD.

NOTE 1 Care should be taken not to confuse the designations "A" and "B" of the previous editions of this Part of BS 903 with those of this edition.

NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definition

For the purposes of this Part of BS 903, the following definition applies.

rebound resilience

the ratio between the returned and applied energies of a moving mass which impacts a test piece. It is usually expressed as a percentage

NOTE 1 This definition is that given in BS 903-A24:1976, which also gives the relationship of rebound resilience to other dynamic properties.

NOTE 2 This definition differs from that in ISO 4662, in which the definition is for "standard rebound resilience" and which is expressed as a ratio.

3 Method A: Dunlop tripsometer

3.1 Principle

A cylinder of rubber with plane parallel ends is impacted at one end by a hemispherical disc which is supported on an axle and caused to rotate by an off-axis mass. The rebound resilience is determined by measurement of the energy absorbed by the rubber test piece during impact.

NOTE 1 Conventionally, measurement of the input and output energies of the moving mass has been carried out by observing the maximum potential energy in 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 clause 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. Using modern technology the accuracy attainable by either method is adequate.

NOTE 2 Due to the much higher strain energy density appearing in the test piece on impact, when comparing this method with method B, considerably greater deformation of the test piece occurs, causing both the backing material and the test piece, to move relative to the back plate (shuffle), thus affecting the result. The thickness of the standard test piece has been increased from that of previous editions, to 7 ± 1 mm, which largely overcomes these problems.

¹⁾ International rubber hardness degrees.

3.2 Apparatus

3.2.1 A pendulum, consisting of a solid steel disc, 420.0 ± 2.5 mm in diameter and of mass 16.50 ± 0.05 kg. The disc carries on its periphery a bracket holding a steel ball 4.00 ± 0.04 mm in diameter, with its centre 260 ± 0.5 mm from the centre of the disc, the ball and bracket together adding an unbalanced mass of 60.0 ± 0.2 g. The centre of gravity of the unbalanced mass is at such a position that the time of one complete oscillation (amplitude about 45°) of the disc plus unbalanced mass is 10.0 ± 0.5 s. The angular displacement of the disc is measured by a pointer or vernier rigidly fixed to the disc, travelling along a scale carried on the frame of the machine. The scale is graduated in degrees of arc or directly in percentage rebound resilience. The spacing of the graduation marks is such that the rebound resilience can be determined to an accuracy of 1 %, or means are provided to determine the angular velocities of the disc immediately before and immediately after impact.

The disc is mounted on bearings designed to impart a minimum of friction to the system. It swings from an angle of 45° . The release mechanism does not impart any impulse to the disc (see Figure 1).

3.2.2 A test piece holder, such that the test piece is held firmly against a rigid anvil, where the holding force is by either:

- suction acting through holes in the anvil near the periphery of the test piece; or
- a metal clamping ring acting on the front surface of the test piece.

(See Figure 2.)

NOTE If a non-standard test piece is used (see note to 3.3), a holder of the type shown in Figure 3 may be used. This holder is particularly suitable for tests at a series of temperatures, as thermal equilibrium is achieved in a shorter time per test.

In either form of test piece holder, the test piece is so placed that when the pendulum is in its position of equilibrium, the ball just touches the centre of the test surface of the test piece.

3.2.3 Means for determining the temperature of the test piece.

3.2.4 Means for heating or cooling the test piece holder, when tests at a series of different temperatures are required.

3.2.5 Fine wire thermocouple

3.2.6 Solvent

3.3 Test pieces

Each test piece shall consist of a sheet of vulcanized rubber with a uniform thickness of 7.0 ± 1.0 mm and a diameter of 44.6 ± 0.5 mm.

Test pieces shall be prepared either by moulding or by cutting and/or buffing. If test pieces are prepared by cutting and/or buffing, this shall be carried out in accordance with BS 903-A36.

Two test pieces shall be prepared and tested.

NOTE When the amount of available material is limited and the test cannot be conducted in accordance with this Part of BS 903, a test piece $8 \text{ mm} \times 8 \text{ mm} \times (4 \pm 0.1) \text{ mm}$ thick is recommended. This size of test piece is also particularly suitable when a number of tests are being conducted at a series of temperatures, as thermal equilibrium is achieved in a shorter time per test than when the larger and thicker standard test pieces are used.

3.4 Conditioning of samples and test pieces

The properties of vulcanized rubber change continuously with time, these changes being particularly rapid in the period immediately following vulcanization. Therefore, no tests shall be made less than 16 h after vulcanization.

For non-product tests the maximum interval between vulcanization and testing shall be 4 weeks, and for evaluations intended to be comparable the tests shall, as far as possible, be made at the same interval.

For product tests the maximum interval shall be 90 days where the date of vulcanization is known; if this is not known, the interval shall be 60 days from the date of receipt by the testing authority, unless otherwise specified.

Samples and test pieces shall be protected from light as completely as possible during the interval between vulcanization and testing. Test pieces shall be conditioned at $23 \pm 2^\circ \text{C}$ for at least 3 h immediately before being tested.

If the preparation of the test piece involves buffing, the interval between buffing and testing shall be not less than 3 h and not greater than 72 h.

NOTE Attention is drawn to BS 3574.

3.5 Temperature of test

Tests shall normally be carried out at one or more of the following temperatures selected from BS 903-A35: -75°C , -55°C , -40°C , -25°C , -10°C , 0°C , 23°C , 40°C , 55°C , 70°C , 100°C .

For assessment of the variation of resilience with temperature, tests shall be made at closer intervals not exceeding 10°C , or 5°C where resilience is changing quickly.

The tolerance on temperature shall be $\pm 1^\circ \text{C}$.