Designation: D 1054 – 91 (Reapproved 2000)

# Standard Test Method for
# Rubber Property—Resilience Using a Rebound Pendulum[1]

This standard is issued under the fixed designation D 1054; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 These test methods cover the determination of impact resilience and penetration of rubber by means of a rebound pendulum.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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 of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 3182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[2]

D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products[2]

D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries[2]

## 3. Summary of Test Method

3.1 Test Method A covers the use of the Goodyear Healey rebound pendulum. See Fig. 1.

3.2 Test Method B covers the use of the SCHOB rebound pendulum.

3.3 *Impact Resilience*—A freely falling pendulum hammer that is dropped from a given height impacts a test specimen and imparts to it a certain amount of energy; a portion of that energy is returned by the specimen to the pendulum and may be measured by the extent to which the pendulum rebounds. Since the energy of the pendulum is proportional to the vertical component of the displacement of the pendulum, it may be expressed as 1 − cos (of the angle of displacement) and impact resilience. *RB*, is readily determined from the equation.

$$RB = \frac{1 - \cos\text{ (angle of rebound)}}{1 - \cos\text{ (original angle)}} \times 100 \quad (1)$$

3.3.1 The value *RB* is commonly called percentage rebound.

3.4 *Penetration*— Dynamic stiffness is a factor that influences impact resilience. A convenient index of stiffness is the depth to which the pendulum striker penetrates the test specimen upon impact.

3.5 *Rebound Resilience*—The apparatus for indicating the rebound resiliance should permit the most friction-free possible measurement of the angle of rebound $\alpha$. From the rebound angle $\alpha$, the rebound resilience in percent is obtained according to the following formula:

$$R = (1 - \cos \alpha)\cdot ICU \quad (2)$$

## 4. Significance and Use

4.1 The rebound pendulum is designed to measure percent resilience of a rubber compound as an indication of hysteretic energy loss that can also be defined by the relationship between storage modulus and loss modulus. The percent rebound measured is inversely proportional to the hysteretic loss.

4.2 Deflection is determined by measuring the depth of penetration of the rebound ball into the rubber block under test.

4.3 Percent resilience and deflection are commonly used in quality control testing of polymers and compounding chemicals, especially reinforcing material.

## 5. Apparatus

5.1 *General*—The rebound resilience is measured with a mechanical vibration device with one degree of freedom. Various practical designs of these devices are on the market. Regardless of the form, these devices essentially provide the same values of the rebound resilience if the parameters of the instruments lie within the limits reported in 5.2.5 (Test Method B).

5.2 *Description of Apparatus*:

5.2.1 The apparatus[3] consists of a frame with an anvil, a holder for the specimen, a pendulum with a hammer peen, and a device for indicating the rebound resilience, see Fig. 2.

5.2.1.1 The frame with anvil together must have a mass that is at least 100 times greater than the striking mass of the pendulum.

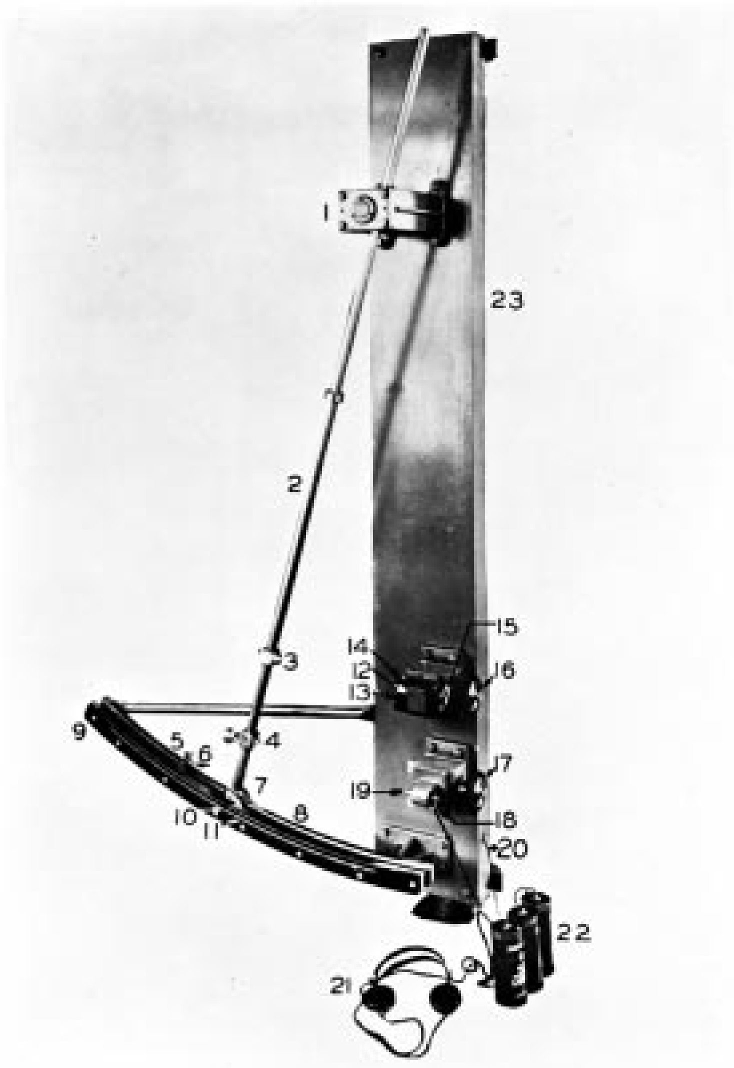
---

[1] This test method is under the jurisdiction of ASTM Committee D11 on Rubber and is the direct responsibility of Subcommittee D11.14 on Time and Temperature-Dependent Physical Properties.

Current edition approved March 15, 1991. Published May 1991. Originally published as D 1054 – 49T. Last previous edition D 1054 – 87.

[2] *Annual Book of ASTM Standards*, Vol 09.01.

[3] Typical apparatus can be obtained from Zwick of America, L. A. Anderson Co., PO Box 5400, Akron, OH. Request Model 5109.01.




NOTE 1—Except where rough finish is indicated, all surfaces shall be machined to a smooth finish within the dimensions and tolerances indicated. Boiler-plate steel is suitable material.

**FIG. 1 Goodyear-Healey Rebound Pendulum**

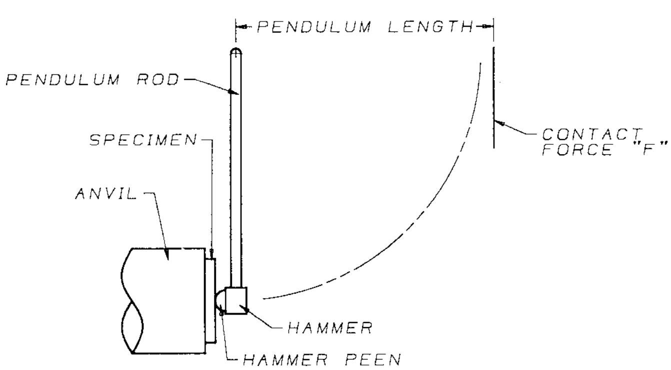



**FIG. 2 Schematic Representation of a Testing Device**

5.2.1.2 The holder must ensure a fixed position of the specimen not tapering to the side. The holder should have the same effect as that achieved by gluing the specimen to the striking surface. The difference between the rebound resilience of the held specimen compared to that of the glued specimen should be less than two units of rebound resilience. This condition must be satisfied both in the case of highly elastic specimens (rebound resilience around 90 %) and in the case of very hard (hardness 80 to 85 IRHD) samples. The holder may be designed as a mechanical clamping device or as a vacuum holder or combination of the two.

5.2.1.3 The pendulum consists of a pendulum rod, hammer, and a hammer peen, see Fig. 2. The pendulum is suspended in such a way that under the influence of gravity, it rotates in a planar path. When the pendulum is hanging vertically, the hemispherical hammer peen should just touch the surface of the specimen. The striking direction of the hammer peen must be perpendicular to the specimen surface.

5.2.2 The testing parameters with their tolerances are as follows:

| | |
|---|---|
| Hemisphere diameter, *D*, of hammer peen: | 12.45 to 15.05 mm |
| Effective mass of pendulum, *m*, | 0.247 to 0.35 kg |
| Striking velocity, *v*, and | 1.45 to 2.04 m/sec. |
| Apparent deformation energy density ( *D***d* ). | 325 to 465 kJ/m |

5.2.3 The original apparatus had the following parameters:

$D$ = (15.00± 0.05) mm
$m$ = (0.250± 0.003) kg
$v$ = (2.00± 0.04) m/sec

With these parameter values and the specified specimen thickness $d$ = 12.5 ± 0.5 mm, the apparent deformation of energy density is 427 kJ/m. The Schob pendulum thus mounted has a working capacity $A$ = 0.5 J.

5.2.4 The difference between pendulum length $L$ and reduced pendulum length "L red" is given by $h = L - L\ red$ = (0 ± 4) mm. "L red" corresponds to the length of a methematical pendulum with the same oscillation time (see 6.2.)

## 6. Verification of Testing Apparatus

6.1 *Pendulum Mass*— Verify the effective pendulum mass by striking the specimen. The application force, $F$, is determined on the horizontally positioned pendulum at the distance, $L$, from the axis of rotation of the pendulum (see Fig. 2.) The application of the force is given by the following:

$$F = (2.45 \pm 0.03)N \tag{3}$$

6.2 The reduced pendulum length $L$ red is determined with the aid of the oscillation time $T$ as follows:

$$L\ red = \frac{gT^2}{4^2}\ \text{mkg} = 9.8\ \text{m/s}^2 \tag{4}$$

6.2.1 The mean oscillation time, $T$, of an oscillation is found from the average oscillation time for a total of 50 oscillations.

6.2.2 To obtain $T$, the device is placed on a slope of about 45° with the pull indicator pushed aside and the pendulum set in oscillation with a 5° initial deflection. The working capacity $A_N$ of the pendulum is given from the mass and the reduced pendulum length as follows:

$$A = mg\ L\ red = mv^2/2 \tag{5}$$

## 7. Test Specimens

7.1 Use specimens with a thickness of 12.5 ± 0.5 mm and a diameter of 41 ± 12 mm. Vulcanize the specimens in a mold or cut directly out of finished parts (see Fig. 3). Give particular attention to a smooth surface and plane parallelism. If the rubber surface that the hammer strikes is sticky, it should be lightly dusted with talcum. A stacking of no more than three cylindrical discs of finished parts is possible, requiring no cementing or lubrication, or both, between specimens. This stacking, however, is permissible only in the case of plane parallel discs of discs of uniform thickness over the entire area. The specimen should contain no fabric of any other reinforcing materials. If the surface is not uniformly smooth, it should be worked by grinding.

NOTE 1—In the case of below standard value specimen thickness, the deformation of the specimen is disturbed by the hard surface of the anvil; lower values of the rebound resilience will be obtained.

7.2 At least two samples must be tested.

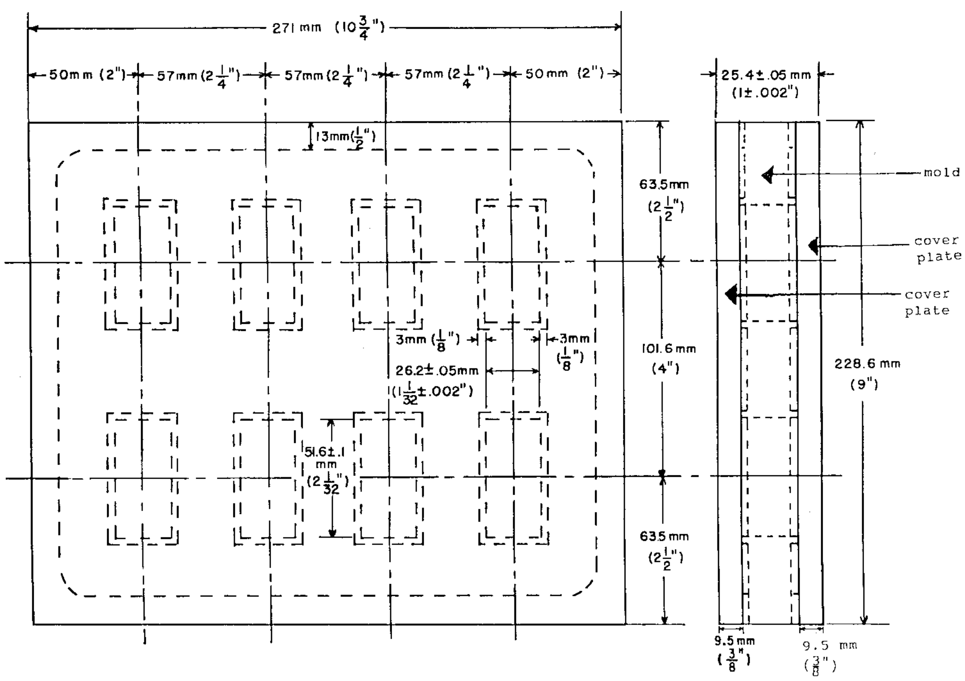
7.3 Perform the test no earlier than 16 h and no later than four weeks after vulcanization. During the last 3 h of this time the samples shall be stored at a temperature of 23 ± 2°C.

7.4 For finished articles the time between vulcanization and the beginning of the test shall not exceed three months if possible, otherwise the test should be begun no later than two months after the delivery to the customer.

## 8. Test Conditions

8.1 The test is generally performed at a temperature of 23 ± 2°C. For tests at other temperatures, the temperatures may be selected from the following series:
− 70, − 55, − 40, − 25, − 10, 0, 40, 55, 70, 85, 100°C

8.1.1 Both the specimen and the anvil are brought to the test temperature and held there. The permissible deviation from




NOTE 1—Dimensions unless otherwise specified are to be ± 0.05 mm (± 0.002 in.).

**FIG. 3 Mold for Test Specimens**

these temperatures is ±1°C.

8.2 The conditioning time, (the time on the anvil prior to impact), of the specimen depends on the conditions of the temperature control device and the shape of the specimen, whether they are stacked or not. The specimens may, however, alternatively be brought to the test temperature separately in a heating cabinet or a cooling chamber and placed in the properly temperature adjusted testing device. In this case, the conditioning in the holder can be shortened before the test to 3 min. In the case of specimens 12.5 mm thick and a test temperature of 100°C, generally 30 min of conditioning time are necessary.

NOTE 2—At low temperatures, precautions must be taken so that no cracks form on the specimen.

## 9. Procedure

9.1 After the specimen has been placed on the anvil in the holder and the thermal conditioning completed, the pendulum is allowed to fall six times from the horizontal position onto the same place on the specimen and caught each time before it strikes the sample once more. The first of these three blows constitute the mechanical conditioning of the specimen. The rebound resistance is read on the fourth, fifth, and sixth strokes. The median of the three readings is recorded.

## 10. Calculation

10.1 The arithmetic mean is computed as the rebound resilience *R*, from the median values of at least two individual specimens.

## 11. Report

11.1 Report the following information:

11.2 Nature and designation,

11.3 Pretreatment of specimen,

11.4 Number of specimens,

11.5 Sample thickness in millimetres,

11.6 Prehistory, for example, vulcanization conditions,

11.7 Conditioning time in minutes and temperature in° C,

11.8 Test temperature in °C,

11.9 Testing machine used and type of sample holding,

11.10 Rebound resilience, *R*, in percent of arithmetic mean, and

11.11 Date of test.

## 12. Precision and Bias

12.1 Precision and bias evaluations have not been conducted for this test method. When such data are available, a precision and bias section will be added.

## 13. Keywords

13.1 pendulum; rebound; resilience