Designation: D 2632 – 96 01

Standard Test Method for Rubber Property—Resilience by Vertical Rebound[1]

This standard is issued under the fixed designation D 2632; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of impact resilience of solid rubber from measurement of the vertical rebound of a dropped mass.

1.2 This test method is not applicable to the testing of cellular rubbers or coated fabrics. Note 1—A

1.3 A standard test method for impact resilience and penetration of rubber by a rebound pendulum is described in Test Method D 1054.

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

1.45 *This standard does not purport to address all of the safety concerns, 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:*

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[1] This test method is under the jurisdiction of ASTM Committee D-11 on Rubber and is the direct responsibility of Subcommittee D11.14 on Time and Temperature-Dependent Physical Properties.

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D 61832 Practice for Rubber Conditioning Plastics for Low-Temperature Testing[2]
D 1054 Test Method 832 Practice for Rubber Property—Resilience Using a Rebound Pendulum[2] Conditioning for Low-Temperature Testing[3]
D 1349 Practice 1054 Test Method for Rubber—Standard Temperatures for Testing[2] Rubber Property—Resilience Using a Rebound Pendulum[3]
D 3182349 Practice for Rubber—Materials, Equipment, and Procedures Rubber—Standard Temperatures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[2] Testing[3]
D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products[2] 1566 Terminology Relating to Rubber[3]
D 44833182 Practice for Rubber—Materials, Equipment, and Procedures for Mixing Standard Compounds and Preparing Standard Vulcanized Sheets[3]
D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products[3]
D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries[3]
2.2 *Military Standard:*[3]

[2] *Annual Book of ASTM Standards*, Vol 098.01.
[3] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.
[3] *Annual Book of ASTM Standards*, Vol 09.01.

MIL-STD 45662A Calibration Other Documents:[4]

ISO-10012-1 Quality Assurance Requirements for Measuring Equipment—Part 1: Metrological Confirmation System for Measuring Equipment[5]

ANSI/NCSL-Z540-1 American National Standard for Calibration—Calibration Laboratories and Measuring and Test Equipment—General Requirements[6]

3. Summary of Test Method

3.1 Resilience is determined as the ratio of rebound height to drop height of a metal plunger of prescribed weight mass and shape which is allowed to fall on the rubber specimen.

4. Significance and Use

4.1 Resilience is a function of both dynamic modulus and internal friction of a rubber. It is very sensitive to temperature changes and to depth of penetration of the plunger. Consequently, resilience values from one type of rebound instrument may not, in general, be predicted from results on another type of rebound instrument.

4.2 This test method is used for development and comparison of materials. It may not directly relate to end-use performance.

5. Apparatus

5.1 A diagram of the essential features and dimensions of the apparatus appears in Fig. 1. Basically it It includes means for suspending a plunger at a given height above the specimen, for releasing the plunger, its release, and for measuring its the subsequent rebound height.

5.1.1 Each resilience instrument shall have a unique identification number assigned and permanently and visibly imprinted or affixed upon it.

5.2 The plunger dimensions are also given in Fig. 1. Its mass shall be 28 ± 0.5 g.

5.3 The height of the drop point and of the resilience scale above the base of the instrument should shall be adjustable so that the drop height is always 400 ± 1 mm (16 ± 0.04 in.) above the specimen surface. The resilience scale should shall be marked in 100 equally spaced divisions. Note 2—The

5.3.1 The top of the plunger should be in line with 100 on the scale when the plunger is locked in the elevated position. Some early commercial models of the apparatus do not meet this requirement, but can may be modified to do so.

5.4 The descent of the plunger fall and its ensuing ascent (rebound) is guided by a vertical rod (plunger guide). In order to minimize friction between the plunger and the guide, vertical rod, a means must shall be provided for leveling the base of the instrument.

Note 3—The instrument and adjusting the perpendicularity of the vertical rod to the instrument base.

5.4.1 The bottom of the guide vertical rod has shall have a 4- mm diameter sharp point formed by a 60° angle, to secure the location of the free bottommost end of the guide vertical rod. This point should penetrate indent the test specimen and, provideing a firm secure location for the free end of the guide rod.

5.4.2 The plunger may shall be allowed to rest at the lowest point of travel and will act as a guide to position the rod exactly in the center of the stabilizer, as is visually practical under 10× magnification, as it is lowered onto the test specimen. Note 4—For a pass-or-fail measurement, an

5.5 An opaque shield may be mounted between the operator's eye operator and the plunger scale to be used for pass-fail test determinations. In use, the shield is set with adjusted so that its upper edge (or central-most graduation within a range) is even with the specified scale reading. desired test determination. If the top of the rebounding plunger is visible above the shield (or within graduations demarcating a predetermined range of acceptability), the specimen passes.

6. Test Specimen

6.1 Mixing, sheeting, and curing shall be performed in accordance with Practices D 3182 and D 3183, unless otherwise specified.

6.2 The standard test specimen shall have a thickness of 12.5 ± 0.5 mm (0.50 ± 0.02 in.). The specimen shall be cut from a slab or specifically molded so that the point of plunger impact is a minimum distance of 14 mm (0.55 in.) from the edge of the specimen. T

6.2.1 Any variation from the standard test specimen may shall be molded or cut from a slab. reported (see 11.3).

6.3 Alternative specimens may be prepared by plying up samples cut from a standard test slab. These samples shall be plied, without cementing, to the thickness required. Such plies shall be smooth, flat, and of uniform thickness. The results obtained with these specimens so prepared will not necessarily be identical with those obtained using a solid specimen of the same material and state of cure. Note 5—A

[4] This test method previously referenced MIL-STD-4662a *Military Standard: Calibration System Requirements*, which was subsequently canceled by the Department of Defense in February 1995. These are the DoD recommended replacement documents.

[5] Available from the International Organization for Standardization, 1 rue de Varembé, Case postale 56, CH-1211, Geneva 20, Switzerland.

[6] Available from the American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

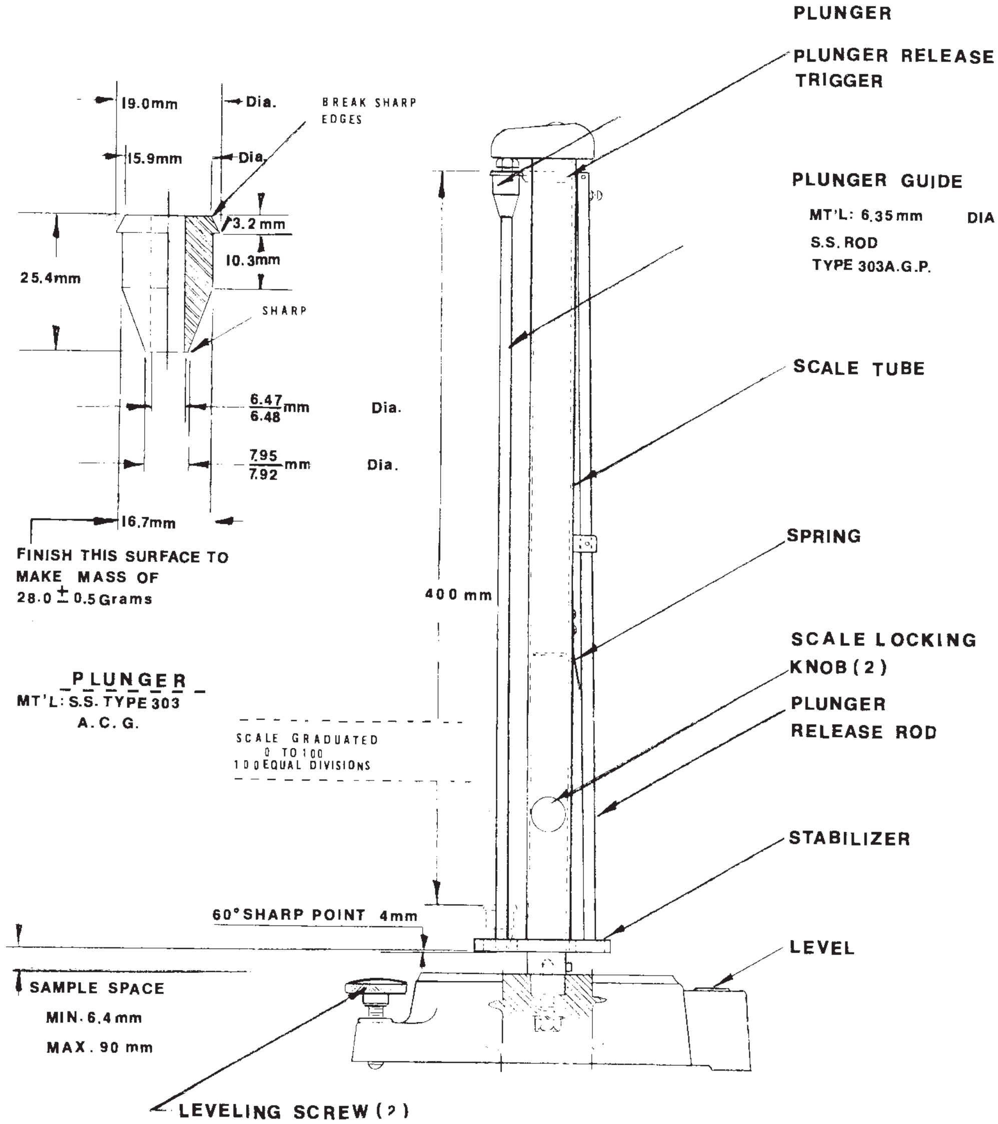

FIG. 1—1 Vertical Reboun. = 25.4 mm.d Apparatus

6.3.1 A thin specimen reaches a higher state of cure at a given time and temperature of cure than does a thicker specimen. Therefore, if plied-up plied specimens are used, their cure time should be appropriately lower than that for a single-piece specimen of unplied specimens used for comparison.

6.4 Specimens may be prepared from finished products by cutting and buffing to the required dimensions, making sure that the opposing faces are parallel.

NOTE 6—If parallel and that grain direction, where applicable, is uniform.

6.4.1 When buffing is required, it is recommended that only one side be buffed and the unbuffed side tested or, if both sides must be buffed, comparisons should not be made between buffed and unbuffed specimens.

7. Calibration

7.1 SAll materials, instruments, or equiplment used for the determination of force, mass, or dimension in the material being tested are not a valid calibration criteria.

7.2 A of this instrument or mechanical spring calibration device with a known rebound value must shall be traceable to the National Institute for Standards and Technology (NIST) or other internationally recognized organization parallel in nature and scope.

7.2 *Calibration Device*:

7.2.1 A mechanical spring calibration device (see Fig. 2) shall be used to calibrate this instrument. [7]

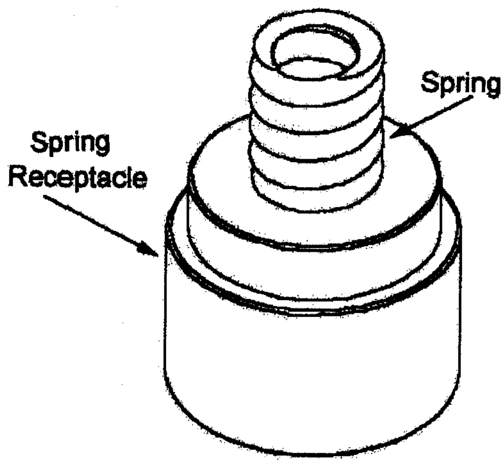

FIG. 2 Spring Calibration Device

7.2.2 The force required to fully compress the spring, prior to being mounted in the receptacle, shall be 8.06 ± 0.081 N (822 ± 8.22 g).

7.2.3 The mechanical spring calibration device shall have a unique identification number assigned and permanently and visibly imprinted or affixed upon it.

7.2.4 The resilience values assigned to an instrument may using the mechanical spring calibration device shall be established at the time of calibration.

7.3 *Calibration Procedure*:

7.3.1 The instrument shall be situated on a flat, level, vibration-free platform. The instrument shall be adjusted so that it is plumb and level, verified either by the integral level or by an external device designed for this purpose and in accordance with the manufacturer's instructions.

7.3.2 Perpendicularity of the vertical rod (plunger guide) to the support surface shall be verified by a device designed for this purpose and in accordance with the manufacturer's instructions.

7.3.3 The dimensions and mass of the plunger (see 5.2 and Fig. 1), the scale graduations, height of the drop point, and of the resilience scale above the base of the instrument (see 5.3 and Fig. 1) shall be verified by devices designed for this purpose.

7.3.4 The calibration if procedure shall be performed in the stavndard laboratory atmosphere as defined in Practice D 618. The instrument, mechanical spring calibration device, and any instrument or equipment used in the calibration procedure shall equilibrate at the standard laboratory temperature for a minimum of 12 h prior to performing the calibration.

7.3.5 Situate the mechanical spring calibration device securely in the instrument as described in Section 5 and in accordance with the manufacturer's instructions.

7.3.6 Make three sets of five readings t, akven fraging each set. Each set becomes a test determination. Average the three test determinations to the nearest whole number. This whole number becomes the resilience calibration value for the instrument.

7.3.7 The instrument fall within shall be considered in calibration if the resilience calibratiound value is within ±2 points of the resilience calibration value established for the mechanical spring calibration device.

7.43.8 The resilience calibration device values are value is assigned to the mechanical spring calibration device by the manufacturer or by the calibration service supplier using an identical resilience instrument, following the procedure outlined herein.

7.3.9 If the instrument is provided with a mechanical spring device, this dervice shall have a resilience calibration value assigned, following the procedumren outlined herein. Theise devices may be verified by used to determine the manufacturer as required state of calibration of the instrument during routine testing at a frequency determined by the user.N It shall not be– used as a calibration device.

7—.3.10 Calibration frequencies and calibration records should be kept in accordance with procedures outlined in MIL-STD 45662a. the documents described in 2.2 or as required by the user's proprietary quality system.

7.4 The calibration report shall contain the following information:

7.4.1 Date of calibration.

7.4.2 Date of last calibration.

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[7] The calibration device is available from Wilson-Shore Instrument Company, Division of Instron Corporation, 100 Royall St., Canton, MA 02021, or from CCSi, Inc., 1145 Highbrook Ave., Suite 500, Akron, OH 44301.

7.4.3 Manufacturer, type, model, and serial number of the instrument.
7.4.4 Manufacturer, type, model, and serial number of the mechanical spring calibration devices.
7.4.5 Values obtained (pre- and post-calibration results), following the procedure outlined in 7.3.
7.4.6 Ambient temperature.
7.4.7 Relative humidity.
7.4.8 Technician identification.
7.4.9 Applicable standards to which the instrument is calibrated.
7.4.10 Calibrating instrument information to include type, serial number, manufacturer, date of last calibration, and a statement of traceability of standards used to NIST or other acceptable organization. See 7.1.

8. Test Temperature

8.1 Test procedures shall be performed in the standard laboratory atmosphere as defined in Practice D 618 unless otherwise agreed upon between customer and supplier or between laboratories.

8.2 The instrument and test ~~temperature is 23 ± 2°C (73.4 ± 3.6°F). Other~~ specimens shall be conditioned in the standard laboratory atmosphere as described in Practice D 618 unless otherwise agreed upon between customer and supplier or between laboratories.

8.3 When test procedures are conducted at temperatures ~~may~~ or conditions other than those specified in 8.1 and 8.2, they shall be ~~specified, preferably~~ chosen from those ~~given~~ enumerated in Practices D 618, D 832, or D 1349 and the procedures described therein shall be followed unless otherwise agreed upon between customer and supplier or between laboratories.

9. Procedure

~~9.1 If tests are to be made at temperatures lower than 23°C~~

9.1 Level the ~~specimens should be conditioned in accordance with Practice D 832 and the tests shall be conducted at the conditioning temperature.~~

~~9.2 Level the~~ instrument (see 7.3.1) and raise the plunger to the top of its guide rod.

9.32 Position the resilience scale (see 5.3) so that its full ~~weight~~ mass rests upon the specimen (see 5.3.1). Lock it in this position.

9.43 Release the plunger, ~~making sure~~ ensuring that it slides freely on ~~its guide.~~

~~9.5 Do not record~~ the ~~first three rebounds. Record the height of each of the next three rebounds.~~

~~9.6 Test three specimens.~~

~~NOTE 8—Any side pressure~~ vertical rod (plunger guide) (see 5.3.1).

9.3.1 Lateral force or impact on the guide rod may ~~bend it with a resulting~~ result in the hindrance ~~on~~ of the ~~free fall~~ descent of the plunger. Do not ~~oil~~ lubricate any part of the instrument. Always keep a standard test specimen ~~of rubber~~ under the stabilizer when not in use to avoid damage to the plunger.

9.4 Test three specimens from the same sample, making six test determinations on each specimen. Refer to Terminology D 1566 for definitions of specimen and sample and to Practice D 4483 for definitions of determinations and results.
9.4.1 Do not reposition the specimen once the initial test determination has been made.
9.4.2 Do not record the first three test determinations, as these condition and stabilize the specimen.
9.4.3 Record the last three test determinations.

10. Calculations

~~10.1 Since the resilience~~

10.1 The instrument scale is divided into 100 ~~parts the rebound height~~ equal parts, therefore a test determination is equal to the resilience value in percent.

10.2 Average the 4th, 5th, and 6th test determinations (see 9.4.3) from a specimen to calculate the test result from the specimen.

10.3 Average or alternatively, determine the median, the test results from the three specimens to the nearest whole number. This whole number is the resilience value of the sample. The median may also be used.

11. Report

11.1 Report the ~~average resilience recorded~~ test results from the ~~4th, 5th, and 6th impacts.~~ specimens (see 10.2).
11.2 Report the ~~medium~~ average or alternatively, the median, of the three ~~specimens.~~
~~11.3 Report~~ test results (see 10.3).
11.3 Describe and report any variation from standard test specimen ~~construction~~ or standard ~~test temperature.~~ conditions.

12. Precision and Bias

12.1 This precision and bias section has been prepared in accordance with Practice D 4483. Refer to this practice for terminology and other statistical calculation details.

12.2 A Type 1 (interlaboratory) precision was evaluated in 1987. Both repeatability and reproducibility are short term, a period of a few days separates replicate test results. A test result is the average value, as specified by this test method, obtained on ~~3~~ three determination(s) or measurement(s) of the property or parameter in question.

12.3 Three different materials were used in the interlaboratory program~~,~~; these were tested in ~~6~~ six laboratories on ~~2~~ two different days.

12.4 The results of the precision calculations for repeatability and reproducibility are given in Table 1, in ascending order of material average or level, for each of the materials evaluated.

12.5 The precision of this test method may be expressed in the format of the following statements that use an appropriate value of *r*, *R*, (*r*), or (*R*), that is, that value to be used in decisions about test results (obtained with the test method). The *appropriate value* is that value of *r* or *R* associated with a mean level in the precision table closest to the mean level under consideration at any given time, for any given material in routine testing operations.

12.6 *Repeatability*—The repeatability, *r*, of this test method has been established as the *appropriate value* tabulated in the precision table. Two single test results, obtained under normal test method procedure, that differ by more than this tabulated *r* (for any given level) must be considered as derived from different or non-identical sample populations.

12.7 *Reproducibility*—The reproducibility, *R*, of this test method has been established as the *appropriate value* tabulated in the precision table. Two single test results obtained in two different laboratories, under normal test method procedures, that differ by more than the tabulated *R* (for any given level) must be considered to have come from different or non-identical sample populations.

12.8 Repeatability and reproducibility expressed as a percentage of the mean level, (*r*) and (*R*), have equivalent application statements as above for *r* and *R*. For the (*r*) and (*R*) statements, the difference in the two single test results is expressed as a percentage of the arithmetic mean of the two test results.

12.9 *Bias*—In test method terminology, bias is the difference between an average test value and the reference (or true) test property value. Reference values do not exist for this test method since the value (of the test property) is exclusively defined by the test method. Bias, therefore, cannot be determined.

13. Keywords

13.1 impact; rebound; resilience; rubber

TABLE 1 Type 1 Precision

NOTE 1—
Sr = repeatability standard deviation.
r = repeatability.
(r) = repeatability (on relative basis, %).
S_R = *reproducibility standard deviation.*
R = reproducibility.
(R) = reproducibility (on relative basis, %).

Material	Average Test Level[A]	Within Laboratories			Between Laboratories		
		Sr	*r*	(*r*)	S_R	*R*	(*R*)
RA	37.9	0.48	1.36	3.58	2.65	7.50	19.8
RE	45.7	0.53	1.50	3.28	1.41	3.99	8.73
RF	48.5	0.59	1.66	3.42	1.37	3.89	8.02

[A] Resilience value, scale reading.