



Designation: D 6515 – 00

Standard Test Method for Rubber Shaft Seals Determination of Recovery From Bending¹

This standard is issued under the fixed designation D 6515; 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 This test method covers a procedure to determine the recovery response of rubber after particular bending deformation, subsequent to aging in selected media at a specified temperature, and for a specified time period, thus providing a measure of the relative performance potential of compounds used in the manufacture of shaft seals.

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 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:

- D 412 Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension²
- D 471 Test Method for Rubber Property—Effect of Liquids²
- D 1349 Practice for Rubber—Standard Temperatures for Testing²
- D 3183 Practice for Rubber—Preparation of Pieces for Test Purposes from Products²
- D 4483 Practice for Determining Precision for Test Method Standards in the Rubber and Carbon Black Industries²

3. Summary of Test Method

3.1 The ends of rectangular specimens of candidate shaft seal compounds are clipped together and the specimens exposed under specified conditions of time and temperature in a fluid environment that best simulates anticipated operating conditions. Upon completion of the exposure, the clamps are removed and the specimen are allowed to recover from

bending. After a specified period of time, the distance between ends of the specimens is measured and the amount of recovery calculated.

4. Significance and Use

4.1 Among the factors affecting shaft seal life are, ability to retain elasticity and compensate for shaft eccentricity, ability to recover from bending, and resistance to wear and the swelling effects of contact fluids. In-service testing of candidate materials is time consuming and therefore costly. Measurement of recovery from bending after exposure in fluids at elevated temperatures provides a means of quickly assessing the material's potential and acceptability for use. Comparative recovery data may then be screened and optimum performing compounds selected for further improvement or seal fabrication. It has been found that good to excellent correlation exists between a material's ability to recover from bending and sealing effectiveness.

4.2 This method is designed to measure the recovery of different rubber compounds after aging in any liquid medium, including hydraulic oils and water. This method can also be used to test rubber compounds after aging in air. Test liquids should be chosen based on the intended end use.

5. Apparatus

- 5.1 *Glass Test Tubes*, 300 by 38 mm (12 by 1-½ in.)
- 5.2 *Specimen Hangers*.
- 5.3 *Binder Clips*.
- 5.4 *Aluminum Block Heater*.
- 5.5 *Aluminum Plate*, 300 by 400 by 2.3 mm (12 by 16 by 0.09 in.) with surface roughness, Ra = 0.4–0.5 μm (16 to 20 μin).
- 5.6 *Tweezers*.
- 5.7 *Oven*.
- 5.8 *Ruler*, graduated in 0.5 mm (0.02 in.).

6. Test Temperatures

6.1 Unless otherwise specified, the standard temperature for testing shall be 23 ± 2°C (73.4 ± 3.6°F). Specimens shall be conditioned for at least 3 h when the test temperature is 23°C (73.4°F). If the material is affected by moisture, maintain the

¹ This test method is under the jurisdiction of ASTM Committee D-11 on Rubber, and is the direct responsibility of Subcommittee D11.36 on Seals.
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² *Annual Book of ASTM Standards*, Vol 09.01.

relative humidity at $50 \pm 5\%$ and condition the specimens for at least 24 h prior to testing. When testing at any other temperature is required, use one of the temperatures listed in Practice D 1349.

7. Test Specimen

7.1 Test specimens shall be cut from test sheets with a thickness of 2.0 ± 0.2 mm (0.080 ± 0.05 in.) of each compound to be evaluated, prepared according to the procedure detailed in Practice 3183. Test sheets shall be vulcanized according to the same conditions of time and temperature as would be used for remolding the sheets for testing physical properties in tension (see Test Method D 412).

7.2 After the test sheets have been conditioned for at least 16 h at 23°C (73.4°F), prepare three 100 ± 0.5 by 10 ± 0.05 by 2.0 ± 0.2 mm (3.937 ± 0.02 by 0.393 ± 0.002 by 0.080 ± 0.008 in) specimens for each material to be evaluated. Specimens shall be cut parallel to the mill grain direction.

8. Procedure

8.1 Mark each of three specimens of one compound type 5 ± 0.5 mm (0.2 ± 0.02 in.) from each end. Bring the ends of a specimen together and place a piece of aluminum foil 10 by 15 mm (0.395 by 0.590 in) between them to prevent sticking. Insert the specimen in a binder clip to a depth of 5 mm (0.2 in) in the lowest position so that the edge of it is even with the end of the clip. This will avoid deforming the specimen when cutting. (see Fig. 1, Fig. 2, and Fig. 3).

8.2 Place each group of three specimens on the hanger shown in Fig. 4 and insert the assembly in a 300 x 38 mm test tube, as in Fig. 5. Do not allow specimens to make contact.

8.3 Add 225 ± 5 cm of test fluid to each test tube, insert a cork stopper and attach an identifying label.

8.4 Place the test tubes in an oven block set at the desired test temperature, and age for the specified time as detailed in Test Method D 471, for suggested durations of 168, 336, and 504 h. Verify the oil temperature periodically during exposure.

8.5 When the specified aging period is completed:

8.5.1 Remove the specimens, leaving them still in the clamps for 15 ± 1 s to allow dripping of excess oil.

8.5.2 Place the specimens on their edge, as shown in Fig. 1, on the aluminum plate, with edge surfaces parallel to the surface of the plate. DO NOT touch the rubber surface. No more than nine specimens (three compounds) shall be placed on an aluminum plate, as shown in Fig. 6.

8.5.3 In sequence, cut each group of three specimens from the clamps with a razor blade, preferably at a distance of about 1.0 to 1.5 mm (0.04 to 0.06 in.) from clamp edges and allow them to relax for 15 ± 1 min. If the aluminum foil sticks to the specimen, do not attempt to remove it, thus preventing specimen distortion.

8.5.4 After the 15 ± 1 min relaxation period at room temperature is complete, place the aluminum plate containing the specimens in a preheated oven at $100 \pm 1^\circ\text{C}$ ($212 \pm 2^\circ\text{F}$) for 30 ± 1 min to allow further relaxation.

8.5.5 Upon completion of the 30 ± 1 min relaxation period in the oven, remove the aluminum plate and allow the specimens and plate to cool to ambient temperature.

8.5.6 Leaving each specimen on its side, measure the distance between inside edges A and B, as shown in Figs. 6 and 7, using a ruler graduated in 0.5 mm (0.02 in.). Do not touch or move specimens during measurement. To maximize measurement accuracy, take all readings using the central portion of the ruler, rather than the end or zero point. Both hands can then be used to stabilize the ruler.

8.5.7 Record the values taken as L_1 (see Fig. 8).



FIG. 1 Placement Binder Clips with Rubber Specimen on the Aluminum Plate

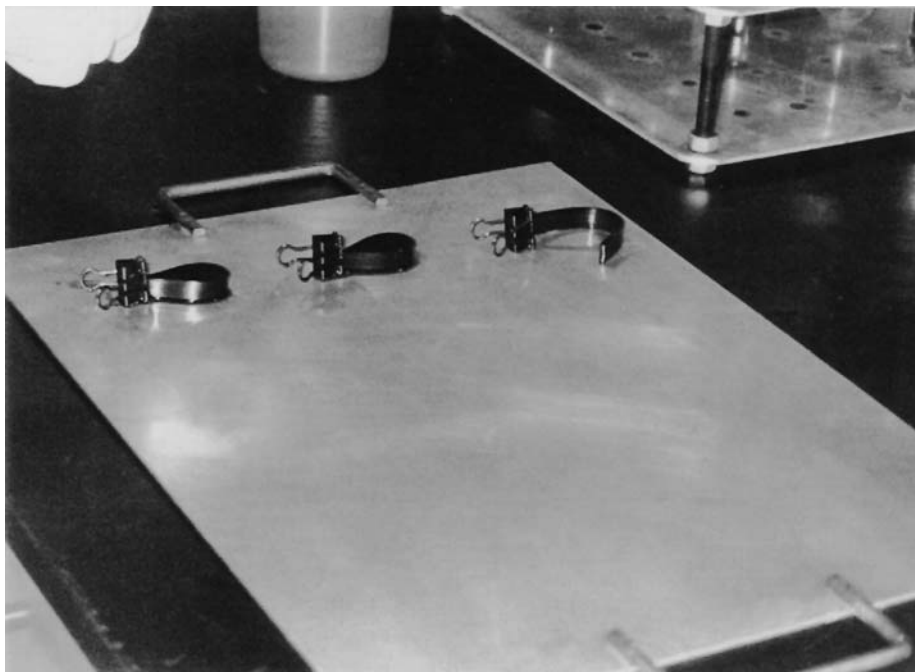
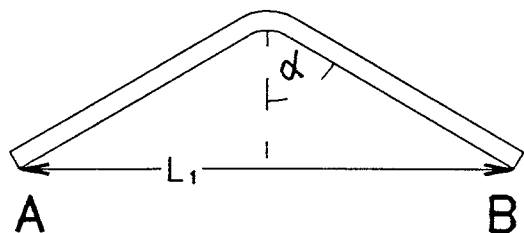


FIG. 2 After Cutting the Specimen



L_1 - length between A and B

L_2 - length of the flat sample

FIG. 3 Measurement of the Angle of Recovery

8.5.8 When all measurements have been completed, remove the specimens from the aluminum plate with the tweezers, holding them at the maximum point of bending. Place the specimens on a cleaned dry surface, flatten them, and measure their length with the ruler, as is shown in Fig. 9.

8.5.9 Record the values taken as L_2 .

9. Calculation

9.1 Calculate the recovery from bending for each specimen as follows:

$$RFB = L_1/L_2 = \sin \alpha \quad (1)$$

$$AOR = 2 \alpha \quad (2)$$

$$P = L_1/L_2 \times 100 \quad (3)$$

where:

RFB = recovery from bending,

AOR = angle of recovery,

L_1 = distance between specimen ends after relaxation for 30 min at 100°C (212°F)

L_2 = length of the flattened specimen, and

P (%) = percent recovery from bending.

9.2 Report results as the mean of the three specimens tested for each material being evaluated.

10. Report

10.1 Report the following information:

10.1.1 Results calculated in accordance with Section 9,

10.1.2 Type or description of the specimen,

10.1.3 Date of test,

10.1.4 Temperature and humidity of test room, if not as specified,

10.1.5 Temperature of conditioning oven, aluminum plate, and test, if other than specified, and

10.1.6 Date of vulcanization and preparation of the specimens, if known.

11. Precision and Bias

11.1 Precision and bias has been determined in accordance with Practice D 4483. Refer to this practice for terminology and other statistical calculation details. Results are contained in the appendix.

11.2 A Type I interlaboratory test program was conducted using three different vulcanized rubber compounds (materials).