



# Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates<sup>1</sup>

This standard is issued under the fixed designation D429; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

## 1. Scope

1.1 These test methods cover procedures for testing the static adhesional strength of rubber to rigid materials (in most cases metals).

*Method A*—Rubber Part Assembled Between Two Parallel Metal Plates.

*Method B*—90° Stripping Test—Rubber Part Assembled to One Metal Plate.

*Method C*—Measuring Adhesion of Rubber to Metal with a Conical Specimen.

*Method D*—Adhesion Test—Post-Vulcanization (PV) Bonding of Rubber to Metal.

*Method E*—90° Stripping Test—Rubber Tank Lining—Assembled to One Metal Plate.

*Method F*—Rubber Part Assembled Between Two Parallel Convex-Shaped Metal Plates

*Method G*—Measuring Bond Durability for Rubber-to-Metal Bonded Components with a Double Shear Cylindrical Specimen

*Method H*—Measuring Bond Durability for Rubber-to-Metal Bonded Components with a Quadruple Shear Specimen

1.2 While the test method may be used with a wide variety of rigid materials, use of materials other than metals is the exception. For this reason, we have used the word “metal” in the text rather than “rigid materials.”

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

1.4 *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.*

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D11 on Rubber and are the direct responsibility of Subcommittee D11.25 on Rubber Adhesive Systems.

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## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

B117 Practice for Operating Salt Spray (Fog) Apparatus

D395 Test Methods for Rubber Property—Compression Set

D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension

D471 Test Method for Rubber Property—Effect of Liquids

D572 Test Method for Rubber—Deterioration by Heat and Oxygen

D573 Test Method for Rubber—Deterioration in an Air Oven

D1149 Test Methods for Rubber Deterioration—Cracking in an Ozone Controlled Environment

E4 Practices for Force Verification of Testing Machines

G153 Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

### 2.2 ASTM Adjuncts:

Holding Fixture Drawings<sup>3</sup>

## 3. Significance and Use

3.1 These test methods are designed primarily for specimens prepared in a laboratory under standardized conditions such as may be used to provide data for development and control of rubber compounds and methods of manufacture. With slight modifications as indicated, Methods A, B, C, D, and E are also used for obtaining comparative adhesion test values of production parts whenever the design permits preparation of suitable test specimens. Methods A, B, C, and D are applicable in the case of many products in which rubber is used for controlling vibration.

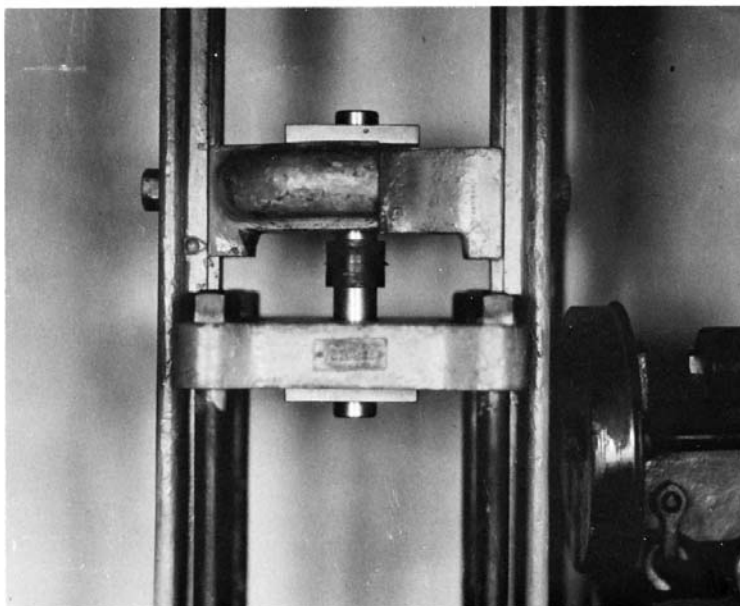
### METHOD A—RUBBER PART ASSEMBLED BETWEEN TWO PARALLEL METAL PLATES

## 4. Adhesion Failure Terminology

4.1 *R* indicates the failure is in the rubber.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

<sup>3</sup> Complete detail drawings of the fixture are available from ASTM International Headquarters. Order Adjunct No. ADJD0429. Original adjunct produced in 1959.



**FIG. 1 An Example of an Adhesion Test Specimen Attached in a Testing Machine**

4.2 *RC* indicates the failure is at the rubber-cover cement interface.

4.3 *CP* indicates the failure is at the cover cement-prime cement interface.

4.4 *M* (can also be denoted as *CM*) indicates the failure is at the metal-prime cement interface.

*NOTE 1—Example*—The percentages of the various types of failure may be estimated as in the following examples:

*R-50, RC-50* means that roughly one half or 50 % of the area showed failure in the rubber and the other 50 % showed failure at the rubber cover cement interface.

*R-25, RC-25, M-50* means three types of failure were present with the *M* indicating 50 % failure at the metal-primer interface. Determining the locus of failure can normally be determined visually, but may require analytical test methods.

## 5. Significance and Use

5.1 Method A is used to determine adhesion values in instances where users feel this design is more reflective of an actual product and where control tests have been set up as a result. The sample also lends itself to testing the effectiveness of different processing techniques and various adhesive systems.

## 6. Apparatus

6.1 *Testing Machine*—A tension testing machine conforming to the requirements of Practices **E4** shall be used for measuring the strength of adhesion. The moving head of the machine shall travel at the uniform rate of  $0.40 \pm 0.04$  mm/s ( $1.0 \pm 0.1$  in./min). The machine shall be provided with a recording device to give the total force in Newtons or pounds-force at the conclusion of the test. A machine with a capacity no greater than 44.5 kN (10 000 lbf) will be found suitable in most cases.

6.2 *Grips*—The fixtures for holding the specimen in the testing machine will depend on the type of specimen, but in all cases shall be provided with ball seats, or another device, to permit centering of the load during the test. A typical adhesion test assembly is shown in **Fig. 1**. Specially molded laboratory specimens shall be attached by means of threaded studs on the metal parts as shown in **Fig. 2**. Specimens cut from production parts may be clamped as illustrated in **Fig. 3**.

## 7. Standard Test Specimens

7.1 After assembly, the standard test specimen shall consist of a cylinder of cured rubber  $3.2 \pm 0.1$  mm ( $0.125 \pm 0.005$  in.) thick and with a diameter of  $39.9 \pm 0.1$  mm ( $1.597 \pm 0.005$  in.), which results in a surface area of  $1250 \pm 5$  mm<sup>2</sup> ( $2.00 \pm 0.01$  in.<sup>2</sup>). This will be attached to the faces of two metal plates, each at least 9.5 mm (0.37 in.) in thickness and of the same diameter as the rubber cylinder. The metal plates shall have flat faces that shall be parallel in the finished specimen. The cylindrical shape is used to eliminate sharp corners and to give uniform distribution of the pulling force.

*NOTE 2*—While a 1250 mm<sup>2</sup> (2 in.<sup>2</sup>) area test specimen shall be considered the standard for reference purposes, it shall be permissible to use a specimen of only 625 mm<sup>2</sup> (1 in.<sup>2</sup>) in area, when it is desirable to prepare and cure a large number of test specimens at one time. The diameter of this test specimen shall be  $28.21 \pm 0.02$  mm ( $1.129 \pm 0.001$  in.) and the unvulcanized piece shall be cut to dimensions of approximately 24 mm ( $1\frac{5}{16}$  in.) in diameter and approximately 5 mm ( $\frac{3}{16}$  in.) in thickness (approximately 10 % volume excess).

## 8. Laboratory Preparation of Standard Test Specimens

8.1 Prepare the standard test specimen to be used for development and control purposes in the laboratory as described in **8.2** through **8.6**. Methods other than those specified in **8.2** to **8.6** may be applied and must be described in the test report.

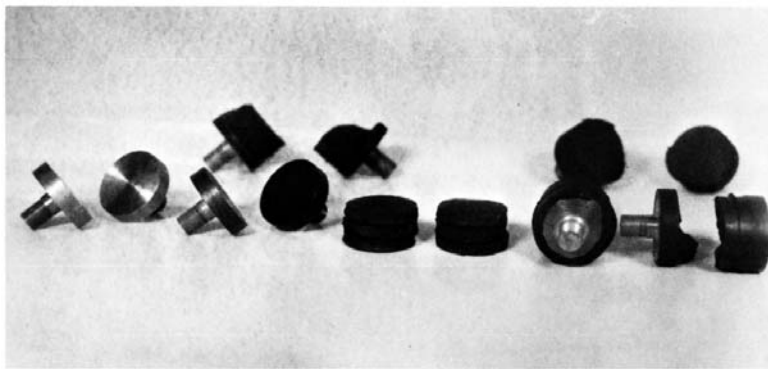


FIG. 2 Views of a Typical Test Specimen Showing Individual Metal Parts and Rubber Cylinders

8.2 Machine circular metal parts of standard dimensions from rolled bar steel SAE No. 1020<sup>4</sup> for standard reference pieces. However, other metals may be used if in conformity with the essential dimensions. Prepare smoothly machined test faces of the metals in accordance with any test method for securing adhesion that may be under investigation.

8.3 Cut unvulcanized rubber pieces to dimensions of approximately 35 mm (1 3/8 in.) in diameter and approximately 5 mm (3/16 in.) in thickness so as to give maximum pressure of the rubber against the metal surface during vulcanization (see Fig. 2). Clean or treat surfaces to be adhered in accordance with the method being investigated.

8.4 Assemble the metal parts and rubber pieces for vulcanization in the mold. A typical mold and test piece are shown in Fig. 4. The assembly is illustrated in Fig. 2. After vulcanization, approximately 0.039 mm (0.0015 in.) of rubber should be over the edge of the metal substrate. Prior to vulcanization, take great care to keep the surfaces to be adhered clean and free of dust, moisture, or other foreign material. Do not touch surfaces.

8.5 Vulcanize by heating the mold for a definite time at a controlled temperature in a hydraulic vulcanization press. Choose the time and temperature of cure according to the rubber compound used. Take care in removing the specimens from the mold to avoid subjecting the adhered surfaces to stress before the specimens have cooled.

8.6 After vulcanization, store the specimens at a temperature of 23 ± 2°C (73.4 ± 3.6°F) at least 16 h prior to testing.

## 9. Test Specimens from Production Parts

9.1 For comparative test of adhesion in production parts, select a portion of the production-made part so that a specimen consisting of a rubber piece sandwiched between two parallel plates of metal may be cut. Hollow-mill a specimen out of the production part and finish the piece either by turning or grinding down to size in such a manner that the surfaces of the rubber and metal shall be free of imperfections, which have a tendency to start a tear in the rubber part during the application of tension while testing.

<sup>4</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D11-1040.

9.2 In routine production testing, it is sometimes necessary to test specimens of different size and shape than those specified as standard. In such cases, the test method of preparation shall be similar to that given in 9.1, but the test results secured shall not be compared with those obtained using the standard test specimen.

## 10. Procedure

10.1 Mount the vulcanized standard test specimen or the specimen cut from a production part in the testing machine, as shown in Fig. 1, so that the tension shall be uniformly distributed. Test at a rate of 0.40 ± 0.04 mm/s (1.0 ± 0.1 in./min), or at 0.083 ± 0.08 mm/s (2.0 ± 0.2 in./min), until the rubber either separates from the metal surface or ruptures. Record the total force at the time of failure. Typically 3 specimens are tested per condition, but other sample sizes can be used, if reported.

10.2 In case of rupture in the rubber, the strength of the adhesion bond is obviously not measured, but is shown to be greater than the strength of the rubber itself. Record the type or types of failure, and express in accordance with the adhesion failure terminology described in Section 4. Estimate and record the percentages of the various types of failures.

## 11. Calculation

11.1 Express the adhesion value in pascals or pounds-force per square inch. Calculate by dividing the tension force causing failure by the original area of the adhered surface. In case of rubber failure, the adhesion value is recognized as being higher than that reported.

## 12. Report

12.1 The report shall include the following:

12.1.1 The result, calculated in accordance with Section 11,

12.1.2 All observed and recorded data including the number of test pieces involved,

12.1.3 Notation of type or types of failure, and the estimated percentages of the various types of failures (Section 10),

12.1.4 A description of the specimen and a notation indicating whether the specimen was molded in the laboratory or prepared from a production part,

12.1.5 Dimensions of the test specimen (comparisons may be made only among specimens of the same size and shape),