Designation: D429 – 14ε1

Standard Test Methods for Rubber Property—Adhesion to Rigid Substrates[1]

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 (ε) 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.

ε[1] NOTE—Corrected 2.2 editorially in March 2021.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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[3]

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

[1] These test methods are under the jurisdiction of ASTM Committee D11 on Rubber and Rubber-like Materialsand are the direct responsibility of Subcommittee D11.25 on Rubber Adhesive Systems.

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[2] 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.

[3] Complete detail drawings of the fixture are available from ASTM International Headquarters. Order Adjunct No. ADJD0429-E-PDF. Original adjunct produced in 1959.

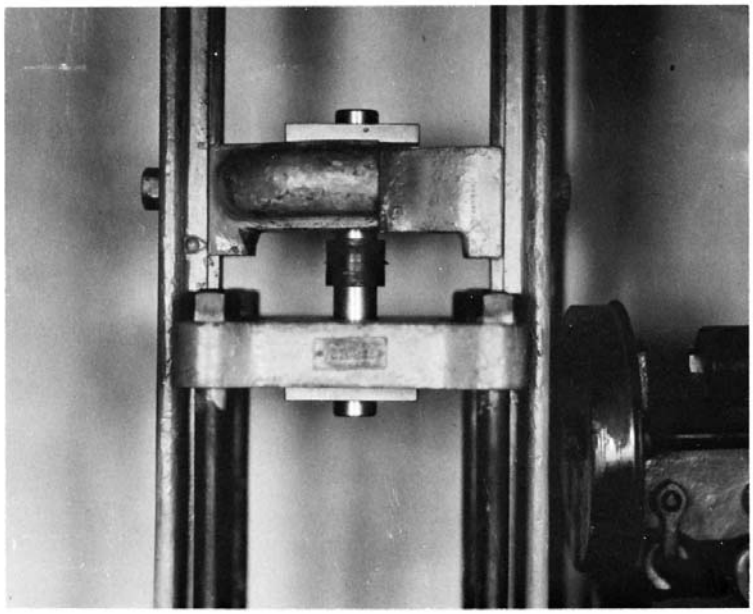

FIG. 1 An Example of an Adhesion Test Specimen Attached in a Testing Machine

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.

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 ± 0.04 mm/s (1.0 ± 0.1 in./min). The machine shall be provided with a recording device to give the total force in Newtons or poundsforce 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 ± 0.1 mm (0.125 ± 0.005 in.) thick and with a diameter of 39.9 ± 0.1 mm (1.597 ± 0.005 in.), which results in a surface area of 1250 ± 5 mm^2 (2.00 ± 0.01 $in.^2$). 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^2 (2 $in.^2$) area test specimen shall be considered the standard for reference purposes, it shall be permissible to use a specimen of only 625 mm^2 (1 $in.^2$) in area, when it is desirable to

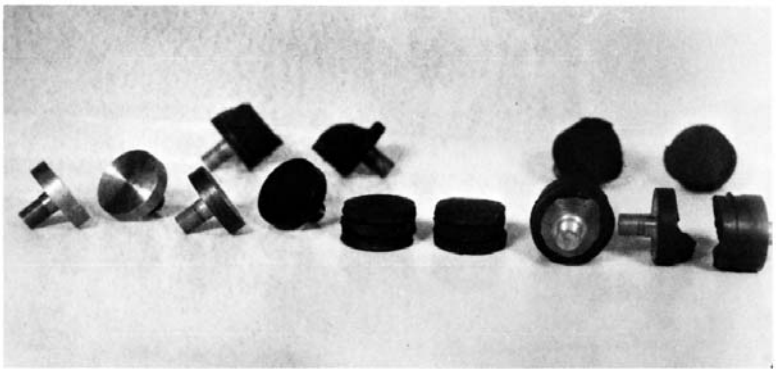

FIG. 2 Views of a Typical Test Specimen Showing Individual Metal Parts and Rubber Cylinders

prepare and cure a large number of test specimens at one time. The diameter of this test specimen shall be 28.21 ± 0.02 mm (1.129 ± 0.001 in.) and the unvulcanized piece shall be cut to dimensions of approximately 24 mm (15⁄16 in.) in diameter and approximately 5 mm (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.

8.2 Machine circular metal parts of standard dimensions from rolled bar steel SAE No. 1020[4] 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.

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

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

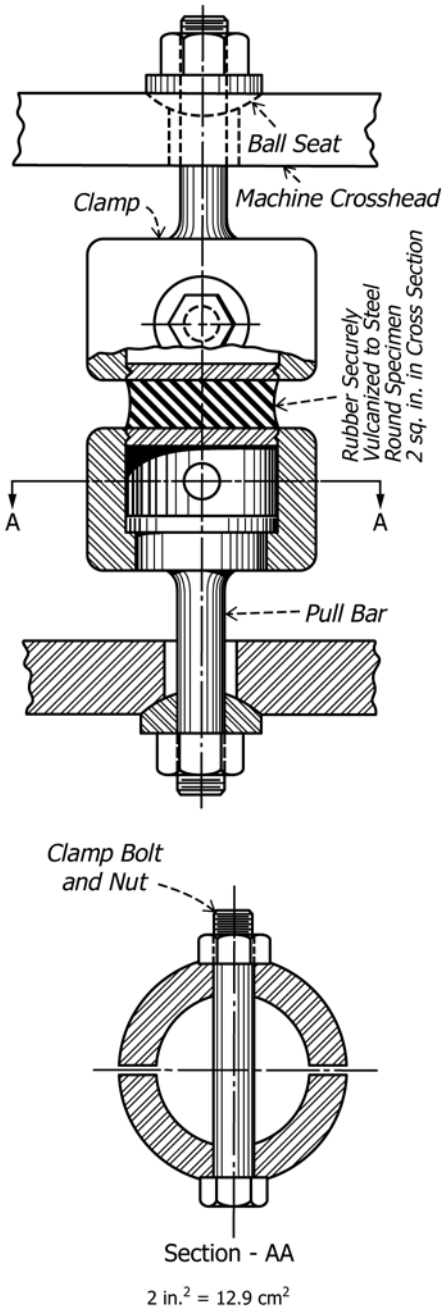

FIG. 3 Method of Testing Adhesion When Sample Section is Taken from Production Parts

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),

12.1.6 Test method used for determining adhesion specified in this standard, including the test rate,

12.1.7 Surface finish of substrate, if known,

12.1.8 Date of manufacture or vulcanization, if known,

12.1.9 Time and temperature of vulcanization, if known,

12.1.10 Temperature and humidity of test room,

12.1.11 Date of test, and

12.1.12 Any deviations from this test method.

13. Precision and Bias[4]

13.1 Precision and bias do not exist for this test method because resources necessary for round-robin testing have not been forthcoming.

METHOD B—90° STRIPPING TEST—RUBBER PART ASSEMBLED TO ONE METAL PLATE

14. Significance and Use

14.1 This test is intended to determine the adhesive strength of rubber-to-metal bonding agents. The results are obtained by measuring the force necessary to separate a rubber from a metal surface. The data obtained indicates the strength of adhesion along a line across the width of the rubber strip being separated from a metal plate at a 90° angle. The test provides valuable data for development and control of rubber compounds and test methods of bonding. It also serves as a screening test for the evaluation of various bonding agents, techniques, or both.

NOTE 3—It is permissible to use a 45° angle to bring about separation, but if this is done, the same should be indicated on the form on which the data are recorded. If this notation does not appear, it must be assumed that the 90° angle has been used. The angle of pull, in this case 45°, merely means that the equipment has been so designed that the angle made by that face of the rubber being stripped from the metal and the metal to which it has been adhered is 45°. Experience indicates a lower force is obtained for the 45° angle than for the 90° angle, and also a break significantly closer to the bond interface.

15. Adhesion Failure Terminology

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

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

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

NOTE 4—Example—The percentages of the various types of failure may be estimated as in the following examples:

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R-25, *RC*-25, *M*-50 means that three types of failure are present with the *M* indicating 50 % failure at the metal-primer interface.