Designation: D 2739 – 97 (Reapproved 2004)

Standard Test Method for Volume Resistivity of Conductive Adhesives[1]

This standard is issued under the fixed designation D 2739; 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 the determination of the volume resistivity of resin-based conductive adhesives in the cured condition. The test is made on a thin adhesive layer as prepared in a bonded specimen. This test method is used for conductive adhesives that are cured either at room temperature or at elevated temperatures.

1.2 *This standard does not purport to address 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.*

1.3 The values stated in either SI or other units shall be regarded separately as standard. SI equivalents to screw threads are shown in the figures.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 618 Practice for Conditioning Plastics for Testing

D 907 Terminology of Adhesives

2.2 *Federal Specification:*

QQ-B-626 Composition 22[3]

2.3 *ASTM Adjuncts:*

Assembly Jig[4]

3. Terminology

3.1 *Definitions*—Many terms in this test method are defined in Terminology D 907.

3.1.1 *conductivity, n*—the ratio of the current density carried through a specimen to the potential gradient paralleling the current. This is numerically equal to the conductance between opposite faces of a unit cube of liquid. It is the reciprocal of resistivity. **D 2864, D27**

3.1.2 *resistivity, volume, n*—the ratio of the electric potential gradient to the current density when the gradient is parallel to the current in the material. **D 1566, D11**

4. Summary of Test Method

4.1 The volume resistivity of adhesive layers cured between metal adherends is measured on a resistance bridge. Tensile adhesion plugs (Fig. 1)[5] are described in this test method. Any other test specimens and materials can be used as long as similar precautions (see Section 7) are observed regarding preparation and tolerances.

5. Significance and Use

5.1 Accurate measurement of the volume resistivity of conductive adhesives is important, particularly with respect to applications in electronic packaging techniques. This method measures the resistance of conductive adhesives used in thin films as part of a bonded assembly. This does not imply that the measured results are applicable to different configurations with different metals. This method may be used for acceptance testing and for screening materials.

6. Apparatus

6.1 *Kelvin (Resistance) Bridge*, calibrated to 1 % accuracy.[6]

6.2 With the agreement of the interested parties, any metal tensile adhesion plugs (Fig. 1) can be used to prepare the tensile adhesion specimens.

NOTE 1—Different metals will inherently provide different resistance values. The measured resistance is dependent on resistance at the adhesive-adherend interface due to metal oxide formation. The extent of oxide formation varies with locality and laboratory conditions. Brass, conforming to Federal Specification QQ-B-626 Composition 22, is a convenient metal. However, in order to minimize oxide formation, especially where measurements are critical, as in referee measurements, it is recommended that the metal plugs be plated with either gold or silver to a thickness of not less than 1 μm (0.000040 in.). Any size plug up to 30

[1] This test method is under the jurisdiction of ASTM Committee D14 on Adhesives and is the direct responsibility of Subcommittee D14.80 on Metal Bonding Adhesives.

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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] Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098

[4] Detailed drawings of the assembly jig are available from ASTM International. Request Adjunct No. ADJD2739.

[5] Plugs to accommodate banana plug—No. 192, Herman H. Smith, Inc., or equivalent.

[6] Satisfactory resistance bridges are made by: Leads and Northup Co. Bridge Catalog No. 4306, Minneapolis Honeywell Division Catalog No. 1622, and Biddle Instruments Catalog No. 603282.

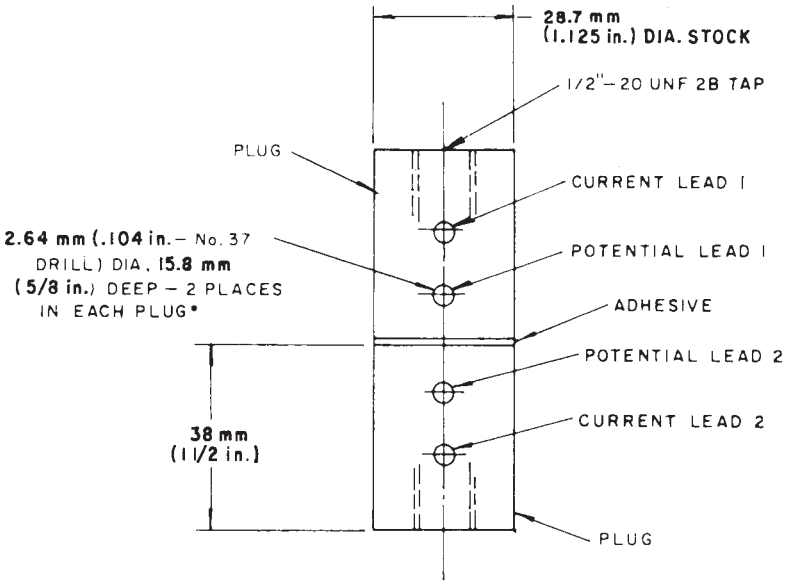

FIG. 1 Brass Tensile Adhesion Specimens with Electrical Connections

mm in diameter can be used with the aid of an alignment jig.[4]

7. Test Specimen

7.1 Thoroughly abrade the face of the specimen to be bonded (other than gold- or silver-plated) with crocus cloth 452[7] or equivalent, and wipe with clean solvent, such as reagent-grade methyl ethyl ketone, immediately prior to bonding.

7.2 Mix the adhesive to be tested in accordance with the manufacturer's instructions, taking care to mix in as little air as possible.

7.3 Coat sufficient adhesive on the surface to be bonded to ensure uniform squeeze-out around the edge of the bonded area. Remove excess adhesive, controlling the bond thickness as shown on an assembly jig.[4]

7.4 Prepare five specimens each for the following two thicknesses: (*1*) 0.13 ± 0.02 mm, and (*2*) 0.51 ± 0.01 mm.

7.5 Cure the adhesives in accordance with the manufacturer's instructions. Curing under other conditions of time and temperature is acceptable by an agreement of the interested parties.

8. Preparation of Apparatus

8.1 Before application of the adhesive, set the adhesive thickness by tightening plugs in place, using a feeler gauge to determine the clearance between plugs.

8.2 Bottom out the top plate on the guide post before and after application of the adhesive.

8.3 After the adhesive has been cured, remove or loosen (at a temperature close to the highest temperature of cure) any remaining shims, screws, or devices of this nature, so that the adhesive layer cools in an unrestrained condition.

[7] Crocus cloth 452 is available from the Carborundum Co., Niagara Falls, NY.

9. Conditioning

9.1 Condition the cured test specimens at 23 ± 1°C (73.4 ± 1.8°F) and 50 ± 5 % relative humidity for at least 88 h prior to the test.

9.2 Test at the conditions specified in 8.1 above.

9.3 If conditions other than those given herein are needed, it is suggested that they be selected from those given in Practice D 618.

10. Procedure

10.1 Make contacts (banana-plug type) so that when the specimen is in the measuring circuit, the potential leads are inside the current leads (for example, potential lead connections are closer to the adhesive bond) (Fig. 1). Make the measurements with the specimen in a stress-free position, since semirigid and flexible formulations are very sensitive to stress change during measurements.

10.2 Measure and record the resistance.[8]

NOTE 2—If the resistance value of the adhesive layer is greater than $10^{-4}\Omega$, the resistance of the plugs can be ignored and the total resistance taken as the resistance of the adhesive layer. The resistivity of copper, silver, and brass are listed for comparison.[9]

Metal	Volume Resistivity at Temperature
Copper	$1.729 \times 10^{-6}\Omega$·cm at 20°C
Silver	$1.629 \times 10^{-6}\Omega$·cm at 20°C
Brass	$3.65 \times 10^{-6}\Omega$·cm at 0°C

11. Calculation

11.1 Calculate the volume resistivity of the test specimen as follows:

[8] A general description of the Kelvin resistance bridge is found in Stout, M. B., *Basic Electrical Measurements*, Par. 4.21 to 4.26, Prentice Hall, Inc., April, 1961.

[9] *American Institute of Physics Handbook*, Second Edition, Gray, E. H., Ph.D., ed., 1957.

$$V = R_0 A/L \quad (1)$$

where:

V = volume resistivity, $\Omega \cdot$ m,
R_0 = observed resistance of the test specimen, Ω (as measured with the bridge), corrected for any error found in the calibration of the bridge, including the resistance metallic plugs cleaned as specified in Section 7,
A = cross-sectional area of the test specimen, m^2, and
L = thickness of adhesive layer, m.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the adherend and adhesive materials tested, including adhesive type, source, and manufacturer's code number,

12.1.2 Curing conditions used,

12.1.3 Conditioning environment and test environment,

12.1.4 Number of specimens tested per sample,

12.1.5 Dimensions of each test specimen including adhesive line thickness,

12.1.6 Corrected resistances of each test specimen,

12.1.7 Volume resistivity, in ohm-centimeters, of each test specimen,

12.1.8 Average volume resistivity of the sample, when more than one test specimen per sample is used, and

12.1.9 Standard deviation of the volume resistivity measurements when more than one test specimen per sample is used.

13. Precision and Bias

13.1 Precision and bias have not been determined for this test method.

14. Keywords

14.1 adhesive; conductive adhesive; conductivity; resistivity; volume resistivity