



Standard Test Method for Strength Properties of Adhesives in Shear by Tension Loading of Single-Lap-Joint Laminated Assemblies¹

This standard is issued under the fixed designation D 3165; 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 (Note 1) is intended for determining the comparative shear strengths of adhesives in large area joints when tested on a standard single-lap-joint specimen and under specified conditions of preparation and testing. Adhesives respond differently in small versus large area joints (Note 2).

NOTE 1—While this test method is intended for use in metal-to-metal applications, it may be used for measuring the shear properties of adhesives using plastic adherends, provided consideration is given to the thickness and rigidity of the plastic adherends. Doublers may be required for plastic adherends to prevent bearing failure in the adherends.

NOTE 2—This variation can be influenced by adhesive density, flow characteristics, cure rate, gel time, carrier composition, entrapped volatiles, volatiles released during cure, etc. and also by cure cycle variables including: temperature, time, pressure, rise rate to temperature, cool-down rate, etc.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information purposes 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:

- A 167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip²
- A 366/A366M Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality²
- B 36 Specification for Brass Plate, Sheet, Strip, and Rolled Bar³
- B 152 Specification for Copper Sheet, Strip, Plate, and Rolled Bar³

- B 209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate⁴
- B 265 Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate⁵
- D 907 Terminology of Adhesives⁶
- D 2093 Practice for Preparation of Surfaces of Plastics Prior to Adhesive Bonding⁶
- D 2651 Guide for Preparation of Metal Surfaces for Adhesive Bonding⁶
- D 3933 Guide for Preparation of Aluminum Surfaces for Structural Adhesives Bonding (Phosphoric Acid Anodizing)⁶
- D 4896 Guide for Use of Adhesive-Bonded Single-Lap-Joint Specimen Test Results⁶
- E 4 Practices for Force Verification of Testing Machines⁷

3. Terminology

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

4. Significance and Use

4.1 This test method is useful in that the joint configuration closely simulates the actual joint configuration of many bonded assemblies and can be used to develop design parameters for such assemblies.

4.2 This test method is also useful as an in-process quality control test for laminated assemblies. In practice the laminated assembly is either made over size and test specimens removed from it or a percentage of the assemblies are destructively tested.

4.3 The misuse of strength values obtained from this test method as design allowable stress values for structural joints could lead to product failure, property damage, and human injury. The apparent shear strength of an adhesive obtained from a given small single-lap specimen may differ from that obtained from a joint made with different adherends or by a different bonding process. The normal variation of temperature and moisture in the service environment causes the adherends and the adhesive to swell and shrink. The adherends and adhesive are likely to have different thermal and moisture

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² *Annual Book of ASTM Standards*, Vol 01.03.

³ *Annual Book of ASTM Standards*, Vol 02.01.

⁴ *Annual Book of ASTM Standards*, Vol 02.02.

⁵ *Annual Book of ASTM Standards*, Vol 02.04.

⁶ *Annual Book of ASTM Standards*, Vol 15.06.

⁷ *Annual Book of ASTM Standards*, Vol 03.01.

coefficients of expansion.

4.3.1 Even in small specimens, short-term environmental changes can induce internal stresses or chemical changes in the adhesive that permanently affect the apparent strength and other mechanical properties of the adhesive. The problem of predicting joint behavior in a changing environment is even more difficult if a different type of adherend is used in a larger structural joint than was used in the small specimen.

4.4 The apparent shear strength measured with a single-lap specimen is not suitable for determining design allowable stresses for designing structural joints that differ in any manner from the joints tested without thorough analysis and understanding of the joint and adhesive behaviors.

4.5 Single-lap tests may be used for comparing and selecting adhesives or bonding processes for susceptibility to fatigue and environmental changes, but such comparisons must be made with great caution since different adhesives may respond differently in different joints. Review Guide D 4896 for further discussion of concepts for interpretation of adhesive-bonded single-lap joint data.

5. Apparatus

5.1 *Testing Machine*, conforming to the requirements of Practice E 4. The testing machine shall be so selected that the breaking load of the specimens falls between 15 and 85 % of the full-scale capacity. The machine shall be capable of maintaining a rate of loading of 8.3 to 9.7 MPa/min (1200 to 1400 psi/min), or, if the rate is dependent on crosshead motion, the machine should be set to approach this rate of loading [approximately 1.27 mm/min (0.05 in./min) crosshead speed]. It shall be provided with a suitable pair of self-aligning grips to hold the specimen. It is recommended that the jaws of these grips shall engage the outer 25.4 mm (1 in.) of each end of the test specimen firmly (Note 3). The grips and attachments shall

be so constructed that they will move into alignment with the test specimen as soon as the load is applied, so that the long axis of the test specimen will coincide with the direction of the applied pull through the center of the grip assembly.

NOTE 3—The length of overlap in the specimen may be varied where necessary. The length of the specimen between the jaws, and the end of the lap however, must not be varied. The distance from the end of the lap to the end of the jaws should be 50.8 to 63.5 mm (2.0 to 2.5 in.) in all tests.

6. Test Specimens

6.1 Test specimens shall conform to the form and dimensions shown in Fig. 1. These shall be cut from test joints Fig. 2, prepared as prescribed in Section 5. The recommended thickness of most metal sheets is 1.62 ± 0.125 mm (0.064 ± 0.005 in.) (Note 4). The recommended length of overlap for most metals of 1.62 mm (0.064 in.) thickness is 12.7 ± 0.3 mm (0.50 ± 0.01 in.) (Note 5).

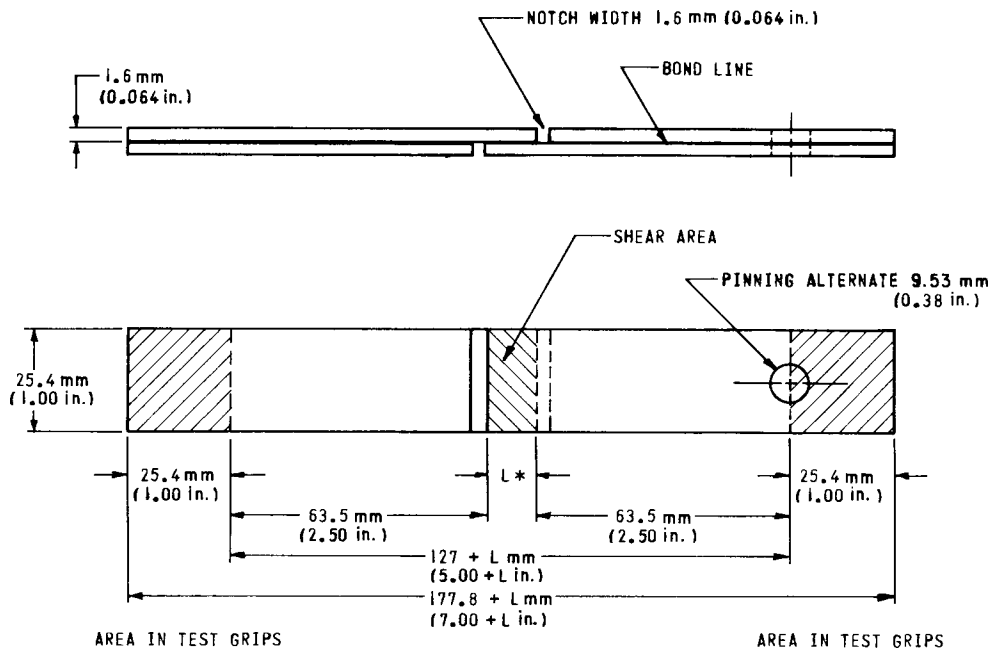
NOTE 4—Since it is undesirable to exceed the yield point of the metal in tension during test, the permissible length of overlap in the specimen will vary with the thickness and type of metal, and on the general level of strength of the adhesive being investigated. The maximum permissible length may be computed from the following relationship:

$$L = F_{ty} T / \tau \quad (1)$$

where:

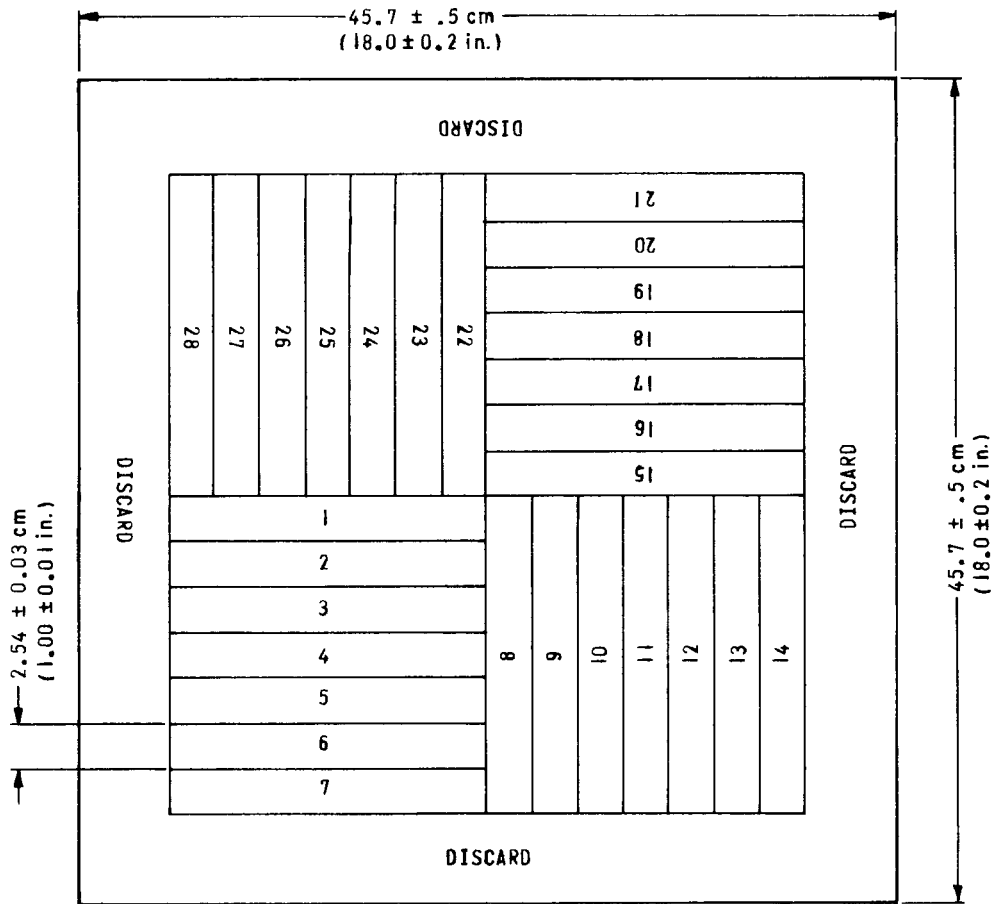
- L = length of overlap, in.,
- T = thickness of metal, in.
- F_{ty} = yield point of metal (or the stress at proportional limit), psi, and
- τ = 150 % of the estimated average shear strength in the adhesive bond, psi.

NOTE 5—A variation in thickness of the metal, and the length of overlap, will likely influence the test values and make direct comparison of data questionable. For this reason, in comparative or specification tests,



NOTE 1—* L = length of test area. Length of test area can be varied. Recommended length of lap is 0.50 ± 0.01 in. (12.7 ± 0.3 mm).

FIG. 1 Form and Dimensions of Test Specimen



NOTE 1—(All discards to be of common width as determined by width of cutting tool.)

FIG. 2 Standard Test Joint

the thickness should preferably be 1.62 ± 0.125 mm (0.064 ± 0.005 in.) and the length of overlap should preferably be 12.7 ± 0.3 mm (0.5 ± 0.01 in.) or not in excess of the value computed in (Note 3). For development tests, values could be different, but should then be constant.

6.2 The following grades of metals are recommended for the test specimens:

Metal	ASTM Designation
Brass	B 36, Alloy 260 (6), Quarterhard Temper
Copper	B 152, Cold Rolled, Type 110, Hard Temper
Aluminum	B 209, Alclad 2024, T3 Temper, Mill Finish
Steel	A 366, Regular Matte Finish
Corrosion-resisting steel	A 167, Type 304, No. 2B Finish
Titanium	B 265, Grade 3

6.3 At least 20 specimens shall be tested, representing at least 4 different joints.

7. Preparation of Test Joints

7.1 Cut sheets of the metals prescribed in 4.1 and 4.2 to recommended size (Fig. 2). All edges of the metal panels and specimens must be flat, free of burrs, and smooth (rms $4.06 \mu\text{m}$ $160 \mu\text{in.}$ maximum) before the panels are surfacetreated and bonded. Clean, treat, and dry the sheets carefully, in accordance with the procedure prescribed by the manufacturer of the adhesive, or as in Guide D 2651 and Practice D 3933. Prepare the adhesive and apply the recommendations of the manufacturer of the adhesive. Apply the adhesive to the faying surface of one or both metal sheets. Assemble the sheets faying surface

to faying surface in pairs, and allow the adhesive to cure under conditions prescribed by the manufacturer of the adhesive. It is recommended that each test joint be made with sufficient area to provide at least five test specimens.

7.2 For plastic materials, clean, treat, and dry the sheets carefully, in accordance with the procedure prescribed by the manufacturer of the adhesive or as in Practice D 2093.

8. Preparation of Test Specimens

8.1 For initial preparation, trim the joint area in accordance with Fig. 2. Cut test specimens, as shown in Fig. 1, from the joints, Fig. 2. Carry out the cutting operation to avoid overheating or mechanical damage to the joints (Note 6). Measure the width of the specimen and the length of the overlap to the nearest 0.01 in. (0.25 mm) to determine the shear area.

NOTE 6—A fine-tooth, typesetter's circular saw has been found suitable for such purposes. Care should be taken to make notch at right angle to the long axis of the specimen and not to score the face sheet under the notch. Notch width (width of the saw) will affect performance level. A notch width of 1.6 mm (0.064 in.) is recommended.

9. Procedure

9.1 Test specimens, prepared as prescribed in Section 7, in an atmosphere maintained at 50 ± 4 % relative humidity and $23 \pm 1^\circ\text{C}$ ($73.4 \pm 1.8^\circ\text{F}$). Tests at other than ambient temperature may be run if desired. It is suggested that

specimens be conditioned for a minimum of 10 min and a maximum of 30 min at the temperature of test to assure equilibrium. The manufacturer of the adhesive may, however, prescribe a definite period of conditioning under specific conditions before testing.

9.2 Pin the specimens or if jaws are used, place in the grips of the testing machine so that the outer 25.4 mm (1 in.) of each end are in contact with the jaws (Note 4) and so that the long axis of the test specimen shall coincide with the direction of applied pull through the center line of the grip assembly. Apply the loading immediately to the specimen at the rate of 8.3 to 9.7 MPa (1200 to 1400 psi) of the shear area per minute (approximately 1.27 mm/min (0.05 in./min)). Continue the load to failure. This rate of loading will be approximated for 312.6 mm² (0.5 in.²) area by a free crosshead speed of 1.27 mm (0.05 in.)/min.

10. Calculation

10.1 Record the load at failure and the nature and amount of this failure (cohesion in adhesive or metal, or apparently in adhesion) for each specimen. Express all failing loads in megapascals (or pounds-force per square inch) of shear area.

11. Report

11.1 Report the following:

11.1.1 Complete identification of the adhesive tested, including type, source, date manufactured, manufacturer's code number, form, etc.

11.1.2 Complete identification of the metal used, its thickness, and the method of cleaning and preparing its surfaces prior to bonding.

11.1.3 Application and bonding conditions used in preparing the specimens.

11.1.4 Length of overlap used.

11.1.5 Conditioning procedure used for specimens prior to testing.

11.1.6 Test temperature.

11.1.7 Loading rate used.

11.1.8 Number of specimens tested.

11.1.9 Number of joints represented.

11.1.10 Bondline thickness (Note 7).

11.1.11 Individual failing load values.

11.1.12 Maximum, minimum, and average values for the failing load.

11.1.13 Nature of the failure, including the average estimated percentages of failure in the cohesion of the adhesive, contact failure, voids, and apparent adhesion to the metal.

NOTE 7—The average thickness of adhesive layer after formation of the joint shall be reported within 0.0127 mm (0.0005 in.). The method of obtaining the thickness of the adhesive layer shall be described including procedure, location of measurements and range of measurement.

12. Precision

12.1 The following data should be used for judging the acceptability of results (95% confidence limits) (Note 8).

12.1.1 *Repeatability*— Duplicate test results by an individual should be considered suspect if they differ by more than 5 %.

12.1.2 *Reproducibility*— The average result reported by one laboratory should be considered suspect if it differs from that of another laboratory by more than 5 %.

NOTE 8—These precision data are approximations based on limited data, but they provide a reasonable basis for judging the significance of results.

13. Keywords

13.1 assemblies; bonds; laminated; lap-joints; shear strength; single-lap; tension

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