



Standard Test Method for Strength Properties of Double Lap Shear Adhesive Joints by Tension Loading¹

This standard is issued under the fixed designation D 3528; 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.

INTRODUCTION

The accuracy of the results of strength tests of adhesive bonds will depend on the conditions under which the bonding process is carried out. Unless otherwise agreed upon between the manufacturer and the purchaser, the bonding conditions should be prescribed by the manufacturer of the adhesive. In order to ensure that complete information is available to the individual conducting the tests, the manufacturer of the adhesive should furnish numerical values and other specific information for each of the following variables:

- (1) Surface preparation
- (2) Mixing directions
- (3) Adhesive application
- (4) Assembly conditions
- (5) Curing conditions
- (6) Testing conditions

A range may be prescribed for any variable by the manufacturer of the adhesive if it can be assumed by the test operator that any arbitrarily chosen value within such a range or any combination of such values for several variables will be acceptable to both the manufacturer and the purchaser of the adhesive.

1. Scope

1.1 This test method covers the determination of the tensile shear strengths of adhesives for bonding metals when tested in an essentially peel-free standard specimen that develops adhesive stress distribution representative of that developed in a typical low-peel production-type structural joint. The reproducibility of the strengths achieved are directly related to conformance with specified conditions of preparation and testing.

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:*

- A 167 Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip²
- 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 618 Practice for Conditioning Plastics for Testing⁶
- D 907 Terminology of Adhesives⁷
- E 4 Practices for Force Verification of Testing Machines⁸

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 08.01.

⁶ *Annual Book of ASTM Standards*, Vol 08.01.

⁷ *Annual Book of ASTM Standards*, Vol 15.06.

⁸ *Annual Book of ASTM Standards*, Vol 03.01.

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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E 122 Practice for Calculating Sample Size, With a Specified Tolerable Error, the Average for a Characteristic of a Lot or Process⁹

E 171 Specification for Standard Atmospheres for Conditioning and Testing Flexible Barrier Materials¹⁰

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 designed to produce shear property data for the process control and specification of adhesives. This test method may also be useful for research and development of adhesives.

4.2 Lap shear properties vary with specimen configuration preparation, speed, and environment of testing. Consequently, where precise comparative results are desired, these factors must be carefully controlled and reported.

5. Apparatus

5.1 *Testing Machine*, conforming to the requirements of Practices E 4. The testing machine should be so selected that the breaking load of the specimens falls between 15 and 85 % of the full-scale capacity. The machine should be capable of maintaining a rate of loading of 8.27 to 9.65 MPa (1200 to 1400 psi)/min, or if the rate is dependent on crosshead motion, the machine should be set to approach the rate of loading. It should be provided with a suitable pair of self-aligning grips to hold the specimen. The grips and attachments should 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 line of the grip assembly.

6. Test Specimen

6.1 The test specimens should conform to one of the alternative types as dimensioned and shown in Fig. 1 or Fig. 2. Cut the specimens from the appropriate test panels that have been prepared as prescribed in Section 7. For aluminum-alloy specimens the recommended thickness of the sheet is 3.24 ± 0.125 mm (0.125 ± 0.005 in.). The recommended test overlap length (*L*) for most metals, with adherends of the prescribed metal thickness and arranged as shown in Figs. 1 and 2, is 12.7 ± 0.25 mm (0.5 ± 0.01 in.).

NOTE 1—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:

$$L = \frac{Fty_1}{\tau} \quad \text{and} \quad L = \frac{Fty_2}{2}$$

⁹ Annual Book of ASTM Standards, Vol 14.02.

¹⁰ Annual Book of ASTM Standards, Vol 15.09.

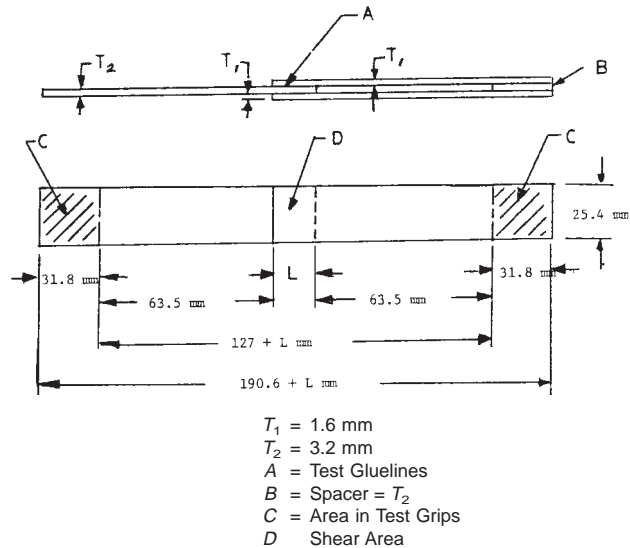


FIG. 1 Form and Dimensions of Type A Specimens

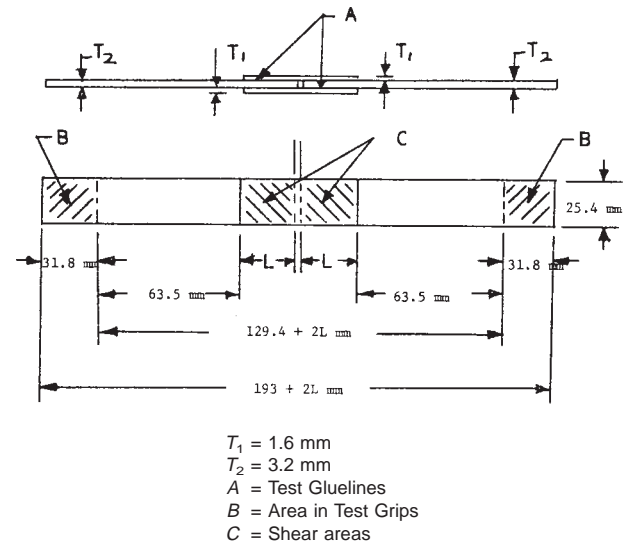


FIG. 2 Form and Dimensions of Type B Specimen

where:

- L* = length of overlap, in., (Figs. 1 and 2),
- t*₁ = thickness of doubler, in., (Figs. 1 and 2),
- t*₂ = thickness of adherend in., (Figs. 1 and 2),
- Fty* = yield point of adherend (or stress at proportional limit), psi, and
- τ = 150 % of the estimated average shear strength of the adhesive bond, psi.

NOTE 2—Variations in adherend thickness, and of the length of the overlap, normally influence the test values and make direct comparison of test data questionable. Therefore, it is preferable for the comparative or specification tests, to standardize on the typical specimen configuration shown with appropriate adherend gages as computed in accordance with Note 1. When specimens incorporating special lap lengths are developed for specific studies, the adherend gage and geometry, once established, should not be altered.

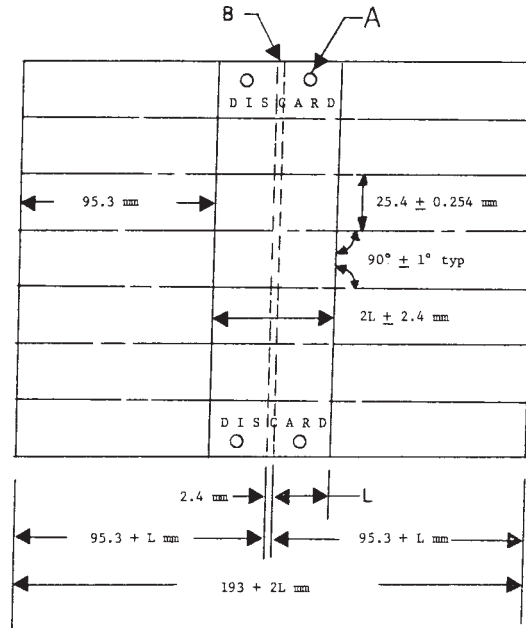
6.2 The following grades of metals are recommended for the test specimens:

Brass	Specification B 36, CDA 268
Copper	Specification B 152, CDA 110
Aluminum	Specification B 209, Alloy 2024, T3 Temper
Corrosion-resisting steel	Specification A 167, Type 302, 2B Finish
Titanium	Specification B 265, Grade 3

6.3 The minimum sample size necessary to develop typical or design values for a given joint geometry should be specified on the test request in accordance with the principles presented in Practice E 122. Because of inherent variations in adhesive properties, due to process variables, specimens should be selected from a minimum of four different test panels.

7. Test Specimens

7.1 It is recommended that the test panels be of a width sufficient to be cut into at least five test specimens unaffected by panel joint edge variables. Do the cutting operation in a manner that will not overheat, damage by exposure to unsatisfactory coolants, or mechanically damage the bonded joints. Panels of two alternative configurations are shown in Figs. 3 and 4 from which the test specimens (Fig. 1 or Fig. 2) may be cut. Vary the adherend sheet length to accommodate changes in bond lap length. Cut sheets of the prescribed adherend metals to suitable size. The edges of the metal panels which will be within (or bound) the lap joints should be free of burrs, deformation, and bevels. The bond faying surfaces should be smooth (rms 160 max) before the panels are surface treated and bonded. Prepare the bond faying surfaces carefully in accordance with the procedure prescribed by the adhesive manufacturer or the governing approved process specification and assemble with adequate spacer sheets to prevent bondline deformation in the lap area. Prepare and apply the adhesive in accordance with the prescribed process specification. The prime coat, if used, apply to a bond area faying surface in sufficient width to extend beyond the lap bond area by



- A =Predrilled Pinholes
(4 required; 2.4-mm diameter)
- B =Suggest TFE-fluorocarbon Filler for Adhesive Flash Control

FIG. 4 Form and Dimensions of Standard Test Panel for Type B Specimens

approximately 6 mm (0.125 in.). The adhesive, liquid or film, apply or position in the bond area limiting its extension beyond the adherends to 1.62 ± 0.25 mm (0.064 ± 0.001 in.) to prevent excessive filleting. Cure the adhesive in conformance with the prescribed process specification.

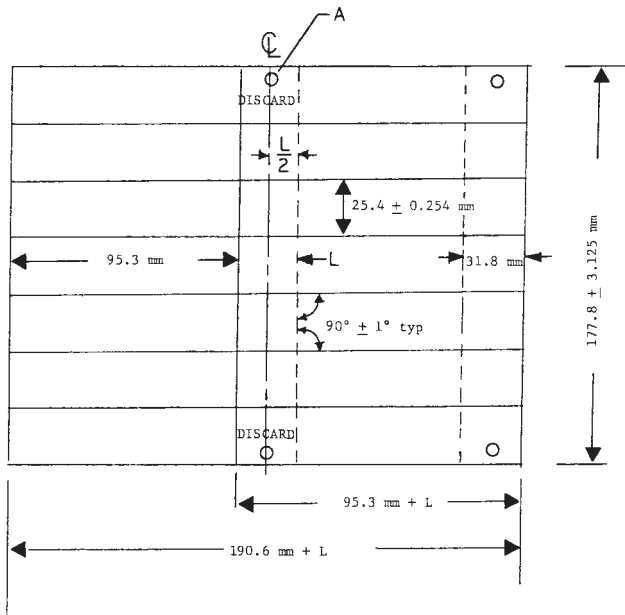
NOTE 3—Bonding specimens in multiple-width panels is believed to produce the most representative individual test specimens. Die-punched panels or individual specimens may be used for special studies; however, fabrication problems will be increased due to inadvertent slippage of the individual adherends.

8. Procedure

8.1 Precondition the finished specimens as specified in the test request. Conduct room temperature tests under controlled temperature and relative humidity conditions in accordance with Specification E 171 ($23 \pm 2^\circ\text{C}$ ($73.4 \pm 3.6^\circ\text{F}$)) and $50 \pm 5\%$ relative humidity.

8.2 Conduct depressed or elevated temperature tests in a controlled chamber. The chamber should be of sufficient size to accommodate the test grips for preconditioning and thermal stability during the test. After the test chamber and grips have been brought to equilibrium, place an instrumented dummy specimen in the grips and calibrate the bondline temperature for each desired test condition.

NOTE 4—It is recommended that the dummy specimen be calibrated by the following procedure. Instrument the specimen with two thermocouples. Position one in the geometric center of the bondline and secure the second to the external surface, in the geometric center of the metal lap area. Position and secure the dummy specimen in the test grips within the thermally stabilized test chamber. Record the time required for the bondline to reach the test temperature. Monitor and simultaneously record the temperature of the surface thermocouple.



- A=Predrilled Pinholes
(4 required; 2.4-mm diameter)

FIG. 3 Form and Dimensions of Standard Test Panel for Type A Specimens

8.3 Measure the width of the specimen and the overlap lengths of the nearest 0.25 mm (0.01 in.) to determine the shear areas.

8.4 Place the specimens in the grips of the test machine so that the terminal 31.8-mm (1.25-in.) ends are engaged firmly and so that the long axis of the test specimen coincides with the direction of the pull.

8.4.1 There should be no slack in the test linkage just prior to applying a load; a preload, if used, shall not exceed 350 kPa (50 psi) during final stabilization and soak.

8.4.2 Control the temperature exposure, where applicable, by the cycle determined with the calibration. A periodic check of the cycle may be made by attaching a thermocouple to the external surface of a test specimen in a manner similar to the calibration test.

8.5 The test temperature tolerance shall be in accordance with Practice D 618.

8.6 Unless otherwise specified, load the test specimen to failure at a rate of 8.27 to 9.65 MPa (1200 to 1400 psi)/min. This rate of loading will be approximated by a free crosshead speed of 1.27 mm (0.05 in.)/min.

8.7 Record the load at failure, the test temperature and soak time, the nature and amount of failure (cohesion in the adhesive, adhesion between adhesive and metal or metal). Failing stresses shall be expressed in kilograms per square centimetre (or pounds-force per square inch) of total shear area (both bond lines) calculated to the nearest 0.06 cm.²(0.01 in.²), and to the third significant figure.

9. Report

9.1 The report should include the following:

9.1.1 Complete identification of the adhesive tested, includ-

ing type, form, source, manufacturer's code numbers, procurement specification number (where applicable), weight per square foot (square metre) at application and cured glue-line thickness,

9.1.2 Complete identification of the adherend material, the individual adherend thicknesses and the heat treat condition (where applicable),

9.1.3 Adherend preparation for bonding,

9.1.4 Adhesive application and bonding conditions used in preparation of the specimens (specification number, where applicable),

9.1.5 Final width of specimen and length of bond overlap measured to the nearest 0.25 mm (0.01 in.),

9.1.6 Conditioning procedures for specimens prior to testing,

9.1.7 Test temperature and soak time,

9.1.8 Number of specimens tested, coded for positions in test panels,

9.1.9 Type of specimen and number of test panels represented,

9.1.10 Maximum, minimum, average, and coefficient of variation for the stress at failure, and

9.1.11 Nature of failure, including the estimated percentage of failure in cohesion and adhesion or metal failure.

10. Precision and Bias

10.1 A precision and bias statement does not exist for this test method because resources necessary for round-robin testing have not been forthcoming.

11. Keywords

11.1 metals; shear; tension; testing

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