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Standard Test Method for Flexural Strength of Adhesive Bonded Laminated Assemblies[1]

This standard is issued under the fixed designation D 1184; 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 Department of Defense.

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 by the manufacturer and the purchaser, the bonding conditions shall 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 shall furnish numerical values and other specific information for each of the following variables:

(*1*) Procedure for preparation of surfaces prior to application of the adhesive, including the moisture content of wood, the cleaning and drying of metal surfaces, and special surface treatments such as sanding that are not specifically limited by the pertinent test method.

(*2*) Complete mixing directions for the adhesive.

(*3*) Conditions for application of the adhesive including the rate of spread of thickness of film, number of coats to be applied, whether to be applied to one or both surfaces, and the conditions of drying where more than one coat is required.

(*4*) Assembly conditions before application of pressure, including the room temperature, length of time, and whether open or closed assembly is to be used.

(*5*) Curing conditions, including the amount of pressure to be applied, the length of time under pressure, and the temperature of the assembly when under pressure. It should be stated whether this temperature is that of the glue line or of the atmosphere at which the assembly is to be maintained.

(*6*) Conditioning procedure before testing, unless a standard procedure is specified, including the length of time, temperature, and relative humidity.

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 comparative properties of either metal or wood adhesive bonded assemblies when subjected to flexural stresses with standard shape specimens and under defined conditions of pretreatment, temperature, relative humidity, and testing technique. The test specimen and testing technique were designed to develop a large portion of shear forces between the laminae of the test piece when the load is applied, rather than to reduce shear stress to a minimum as is done in other ASTM test methods for flexural properties. This method is not applicable to assemblies made with nonrigid adherends. The data obtained are not suitable for design work.

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

[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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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:* [2]

D 907 Terminology of Adhesives

E 4 Practices for Force Verification of Testing Machines

3. Terminology

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

4. Summary of Test Method

4.1 Test a specimen composed of eight bonded plies as a simple beam loaded at the mid-span. Test at conditions of standard temperature and humidity. Specimen flexural properties are compared by generating maximum shear stress in metal specimens and flexural strength of wood specimens using standard formulas.

5. Significance and Use

5.1 This test method is designed for both wood and metal bonded specimens.

5.2 The test method provides a means to compare flexural properties between assemblies.

5.3 The data are reduced to a comparable basis by means of the formulas given in 11.1 and 11.2. It is recognized that these formulas do not apply rigidly to tests made in the manner described in this method, but serve only to reduce the data to a comparable basis.

6. Apparatus

6.1 *Testing Machine*—Use a properly calibrated testing machine, capable of maintaining a specified rate of approach of the two loading parts. The error for indicated load to not exceed ±1 %. The stiffness of the testing machine is such that the total elastic deformation of the system does not exceed 1 % of the total deflection of the test specimen. The load-indicating mechanism is essentially free from inertia lag at the specified rate of testing. The accuracy of the testing machine is verified in accordance with Practices E 4.

6.2 *Loading Piece*—The center loading piece, which is attached to one loading part of the testing machine, has a radius of at least 0.075 mm (1⁄32 in.). The rounded nose is at least 25 mm (1 in.) long. If significant indentation occurs, a radius of one and one-half times the specimen depth for a chord length of not less than twice the specimen depth is used.

6.3 *Supports*—A pair of round-nosed supports of the same radius as that on the loading piece is used. The span is adjustable to ±0.13 mm (0.005 in.) within the range of eight times the thickness of the test specimens (usually a span of 13 to 38 mm (0.5 to 1.5 in.)). The support device is mounted on the one loading part of the testing machine so that the rounded nose of the loading piece on the other loading part is centered between the supports.

6.4 *Micrometers*—Suitable calibrated micrometers, reading to at least 0.025 ± 0.001 mm (0.001 ± 0.0005 in.) is used for measuring the width and thickness of the test specimen.

6.5 *Conditioning Room or Desiccators*—A conditioning room capable of maintaining a relative humidity of 50 ± 2 % at 23 ± 1.1°C (73.4 ± 2°F), or desiccators filled with a saturated salt solution (Note 1) to give a relative humidity of 50 ± 2 % at 23 ± 1.1°C (73.4 ± 2°F).

NOTE 1—A saturated solution of calcium nitrate will give approximately 51 % relative humidity at 23°C in a closed container.

7. Test Specimens

7.1 The specimen is a rectangular piece 38 mm (1.5 in.) long and 19.1 mm (0.75 in.) wide. The length of the specimen is sufficient to allow an overhang of between 2.5 and 3.8 mm (0.1 and 0.15 in.) on each end. The specimens are machined from laminated panels consisting of eight plies of 0.3-mm (0.01-in.) thick adherend material. Each ply is coated with adhesive on both sides with an even spread, and bonded. The mixing procedure, weight of spread, drying conditions, and assembly time conforms to the manufacturer's directions. The maximum shear stress is developed at the neutral surface approximately midway between the top and bottom of the beam. Thus it is important to have an even number of plies of adherend material, so that the adhesive is in the center. Since failure by delamination probably begins in the center layer of adhesive, special care should be exercised in the preparation of this part of the specimen.

7.2 *Wood Specimens*—The wood panel specimens are prepared from 0.2 mm (0.01-in.)-thick quarter-cut veneers. Only straight-grain veneers shall be selected. Veneers are conditioned at 50 ± 2 % relative humidity and 23 ± 1.1°C (73.4 ± 2°F) for at least one week before bonding. Panels are constructed by arranging the grains of the veneers symmetrically about the center so that the two core veneers are parallel. All the other veneers are arranged so that the grain directions of adjacent veneers are perpendicular to one another. This will result in the grains of the face veneers being parallel to each other. The grain on the face plies is parallel to the length of the specimen.

7.3 *Metal Specimens*—The metal panel specimens are prepared from 0.2 mm (0.01-in.)-thick sheets.

7.4 *Panels*—Four panels are prepared with each adhesive-adherend combination, and at least five specimens shall be cut from each panel for this test. The cutting of metal specimens is done so as to avoid overheating or mechanical damage to the joints.

NOTE 2—A fine-toothed typesetters' circular saw has been found suitable for such purposes.

8. Conditioning

8.1 Condition all specimens prior to test at 23 ± 1.1°C (73.4 ± 2°F) and 50 ± 2 % relative humidity for 48 h for metal and plastics, and 7 days for wood.

[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.

9. Procedure

9.1 Test in an atmosphere maintained at 23 ± 1.1°C (73.4 ± 2°F) and 50 ± 2 % relative humidity. Test the specimen as a simple beam loaded at mid-span. The span-depth ratio shall be 8 to 1. Measure the span length to the nearest 0.13 mm (0.005 in.) and the width and thickness of the specimen to the nearest 0.03 mm (0.001 in.) at the center of the span.

9.2 *Speed of Testing*—Calculate the rate of approach of the loading parts for testing the specimens as follows:

$$N = ZL^2/6d \quad (1)$$

where:

N = rate of approach of the loading, mm/min (or in./min),
L = span, mm (or in.),
d = depth of beam, mm (or in.),
Z = unit rate of fiber strain, mm/mm (or in./in.) of outer fiber length per minute, the constant is 0.01. This constant is the approximate calculated rate of fiber strain for a rate of cross-head motion of 1.3 mm (0.05 in.)/min, a span length of 100 mm (4 in.) and a span length of 100 mm (4 in.), and a depth of 13 mm (0.5 in.) such as have been used with the 130 by 13 by 13-mm (5 by 0.5 by 0.5-in.) test specimen.

For the conditions of test described in this method, this formula reduces to $N = 0.107\ d$. The rate of approach of the loading parts is as near as possible, but to not exceed, the value calculated from this formula. This permits the use of a constant rate of straining, provided the resultant rate of approach does not exceed the value calculated from the above formula.

10. Retests

10.1 Unless otherwise specified, results that deviate from the mean value of all tests should be rejected if the deviation of the doubtful value is more than five times the average deviation from the mean obtained by excluding the doubtful value. Discard such doubtful values and retest, unless the degree of variability is a factor that is being studied.

11. Calculations

11.1 For metal specimens reduce the data to a comparable basis by means of the maximum shear stress formula, as follows:

$$S_s = 3P/4bd \quad (2)$$

where:

S_s = maximum shear stress, MPa (or psi),
P = breaking load, N (or lbf),
b = width of beam, mm (or in.), and
d = depth of beam, mm (or in.).

11.2 For wood specimens, reduce the data to a comparable basis by means of the flexural strength formula, as follows:

$$S = 3PL/2bd^2 \quad (3)$$

where:

S = flexural strength, MPa (or psi),
P = breaking load, N (or lbf),
L = distance between supports, mm (or in.),
b = width of beam, mm (or in.), and
d = depth of beam, mm (or in.).

11.3 For each series of tests, calculate the arithmetic mean of all values obtained to three significant figures and report as the“ average value” for the particular property in question.

11.4 Calculate the standard deviation of each “average value.”

12. Report

12.1 The report includes the following:

12.1.1 Complete identification of the material tested, including type, source, manufacturer’s code number, form, principal dimensions, and previous history,

12.1.2 Method of preparing test specimens,

12.1.3 Direction of cutting and loading specimens,

12.1.4 Conditioning procedure,

12.1.5 Average depth and width of specimen,

12.1.6 Radius of supports and nose,

12.1.7 Rate of approach of loading parts in inches per minute,

12.1.8 Average value of stress calculated in accordance with 11.1 and 11.2, and the standard deviation, and

12.1.9 Type of failure, that is, delamination, breaking or buckling.

13. Precision and Bias

13.1 No precision or bias exists for this test method, as the necessary resources have not been forthcoming.

14. Keywords

14.1 adhesive bonded assemblies; flexural strength; laminates

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