

STRESS DURABILITY TEST FOR ADHESIVE LAP-SHEAR BONDS

Application

This method is used to evaluate the relative performance of adhesive bonding systems exposed to simultaneous tensile load and environment. The corrosion option is designed to simulate the corrosive conditions of the Arizona Proving Ground (APG) Vehicle Accelerated Corrosion Test (P3-76A).

Apparatus Required

Stress Durability Fixtures

A set of fixtures made of stainless steel (Figure 1), 635 mm stainless steel bolts, 19.05 mm long with nuts, and nylon washers with 6.35 mm holes, 19.05 mm diameter. Die springs for the fixtures should have an ID of 19.3 mm, a length of 127 mm, and a spring rate approximately 15 kg/mm. These fixtures are not commercially available and should be constructed per the attached drawings.

Compression Testing Instrument

An Instron tensile testing machine or equivalent in compression mode with an accuracy of 0.5 % of the range used.

Modified Vise

A vise of sufficient size as to hold the stress durability fixture and compress the spring. The grips of the vise must be modified to accommodate the fixture (Figure 2). An Armstrong 12.7 cm machinist bench vise is adequate.

Test Coupons, Blanks and End Tabs

Test coupons shall be 25 x 56.25 mm x t where t is the specified thickness of the substrate (Figure 3). The blanks shall be of the same material as the substrate used unless otherwise specified and shall be 25 x 100 mm x t where t is the specified thickness of the substrate. The end tabs are to be the same as the blanks except that the length is to be 52 mm instead of 100 mm (Figure 4).

Humidity Cabinet

Humidity cabinet, with forced air circulation, temperature control of ± 2 °C up to 65 °C, and relative humidity control of ± 0.5 % up to 90 %.

Tank

Polyethylene or plastic lined tank, with cover, of sufficient size and capacity to permit the stress durability fixtures to be immersed in the salt solution to a level covering the top test specimen. For the stress durability fixtures outlined above a 120 liter or equivalent polyethylene trash can is adequate.

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2002 01 10	Revised	Editorial – no technical change A. Cockman
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Drying Rack

A rack for drying the stress durability fixtures such that the fixtures are maintained in a vertical position.

Tensile Testing Instrument

An Instron tensile testing machine or equivalent in tensile mode with an accuracy of 0.5 % of the range used.

Materials Required

Sodium Chloride

Reagent grade.

Distilled or Deionized Water

10 ppm maximum dissolved solids per ASTM D 1888.

Hydrochloric Acid

Reagent grade.

Sodium Hydroxide

Reagent grade.

Glass Beads

Solid glass beads to control bond line thickness can be obtained from Cataphote Inc., Jackson, Mississippi. It is the responsibility of the requestor to define the desired diameter. However, a commonly employed glass bead diameter for metal to metal bonding is 0.25 +/- .01 mm. Occasionally, 0.75 +/- .01 mm diameter glass beads are used especially for bonding composite to composite.

Substrate

Type, thickness, contamination, treatment, and cleaning obtained from requestor.

Adhesive

Material and cure conditions obtained from requestor.

Conditioning and Test Conditions

All test values indicated herein are based on material conditioned in a controlled atmosphere of 23 +/- 2 °C and 50 +/- 5 % relative humidity for not less than 24 h prior to testing and tested under the same conditions unless otherwise specified.

Procedure

1. This test method requires the preparation of 4 lap-shear coupons for initial unexposed load to failure and 6 lap-shear coupons for each load/ environment combination. Prepare lap-shear test coupons as in Figure 5. The coupon overlap is 12.5 mm, the width is 25 mm, and the bondline thickness is maintained with glass beads. Remove squeeze-out with square edge spatula. Cure assembled coupons per adhesive manufacturer's recommendations. All of the above shall be done as indicated unless other-wise specified by requestor. Punch 6.35 mm holes in ends of coupons except for coupons to be pulled for initial failure load. Condition samples 24 h at ambient conditions prior to any testing.
2. Initial tensile testing involves placing bonded coupons in the grips of the tensile testing machine so that the grips hold on to 20 mm of the ends of the coupons. For thick substrates, shims should be used in the grips to keep proper alignment of the specimen. Pull coupons at a constant strain rate of 10 mm per minute. Measure peak load to failure (kN).
3. Bolt coupons together with stainless steel bolts and nylon washers alternating the arrangement of each joint as to keep the bondline aligned along the center of the fixture (Figure 1). Also bolt the end tabs on to the string of coupons.
4. Calibrate springs by measuring the compressed spring length for the desired load. Record spring ID, load (kg), and compressed length (mm). The loads for the testing are to be defined by the requestor. Loads for testing are to be reported as absolute values and as fractions of initial strength as determined in Step 2.
5. Assemble stress fixtures. Load strings of coupons in stress durability fixtures. Compress spring to the desired compression length in the modified vise, see Figure 6. Screw down nut on top of fixture. To avoid twisting of the test specimens, it is essential to compress the spring and tighten the nut with the stress fixture in the vise. **DO NOT TORQUE DOWN ON THE NUT OUTSIDE OF THE VISE.** Release vise. Check compression length. Repeat compression steps until desired length is obtained in the released position.
6. Periodically check displacement of springs. Check daily for the first 10 cycles and thereafter check every 5 cycles.
7. Environmental exposure:

For static humidity exposure follow steps 8 and skip to step 14.

For cyclic corrosion exposure follow steps 9 through 14. The basis for this cyclic corrosion procedure is taken from FLTM BI 123-01 Painted Sheet Metal Corrosion Test (Laboratory-Simulated Arizona Proving Ground Test).

8. Place stress durability fixtures vertically in the temperature/humidity cabinet at 50 +/- 2 °C and 90 +/- 5 % relative humidity for testing. If possible keep the spring out of the humidity cabinet while allowing the samples to be exposed to the environment. On a daily basis check for failure of coupons (see step 14).
9. Prepare a 5 % salt solution as follows:

Dissolve 53 g of sodium chloride per liter of distilled or deionized water. Prepare a sufficient amount to allow for complete immersion of test coupons contained in the stress durability fixtures.

Adjust the solution pH to 6.0 - 8.0 by the addition of sodium hydroxide or hydrochloric acid.

Replace salt solution and clean out tank when appreciable residue accumulates in the bath or when the pH is outside the 6.0 - 8.0 range (do not readjust the pH).
10. Begin the first test cycle on a Monday morning. Immerse the samples in the 5 % sodium chloride solution at 23 +/- 2 °C for 15 minutes. Care should be taken not to get salt solution on the springs.
11. Remove fixtures from salt solution, drip dry vertically at 23 +/- 2 °C for 105 minutes.
12. Place stress durability fixtures vertically in the temperature/humidity cabinet at 50 +/- 2 °C and 90 +/- 5 % relative humidity for 22 h. If possible keep the spring out of the cabinet while allowing the samples to be exposed to the environment. On a daily basis check for failure of coupons.
13. Repeat steps 10 through 12 every 24 hours, Monday through Friday. During weekends and holidays leave the specimens in the temperature/humidity cabinet at 50 +/- 2 °C and 90 +/- 5 % relative humidity.

Note: One test cycle is completed after performing steps 10 through 12. There is a maximum of 5 cycles per week.
14. When failure occurs: Take out failed coupon, replace with blank, and reload fixture (see step 5). When 4 of the 6 coupons have failed the testing is complete.

Report

1. Adhesive identification including: Manufacturer, code number, type, date manufactured, etc.

2. Substrate identification including: Manufacturer, code number, type, thickness, treatment, contamination, cleaning, etc.
3. Bond geometry including: Bondline thickness, overlap length, bond width.
4. Conditioning procedure for specimens prior to testing.
5. Initial loads to failure (peak load (kN)) for each substrate/adhesive combination, average and standard deviation.
6. Stress durability exposure conditions: APGE cyclic corrosion, static humidity (temperature/relative humidity), or other.
7. Time to failure (cycles APGE or days static humidity) for each specimen, and total number of specimens tested (including number of unfailed specimens and number and time of termination of specimens removed prior to the conclusion of the test).
8. Specimen location in fixture (sample 1 top through sample 6 at bottom).
9. Estimated failure loci percentages: Cohesive with adhesive, interfacial between adhesive and substrate, substrate failure, or other.

Chemicals, materials, parts, and equipment referenced in this document must be used and handled properly. Each party is responsible for determining proper use and handling in its facilities.

LIST OF FIGURES

Figure 1	Assembly - Humidity Cabinet Lap Shear Test Fixture RAD/XRL-641A
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Figure 1b	Threaded Rod - Humidity Cabinet Lap Shear Test Fixture RAD/XRL-643
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Figure 3	Test Coupon - Humidity Cabinet Lap Shear Text Fixture RAD/XRL-649
Figure 4	End Link - Humidity Cabinet Lap Shear Text Fixture RAD/XRL-647C
Figure 5	Assembly - Lap Shear Coupon RAD/XRL-650
Figure 6	Load Setting - Humidity Cabinet Lap Shear Text Fixture RAD/XRL-658

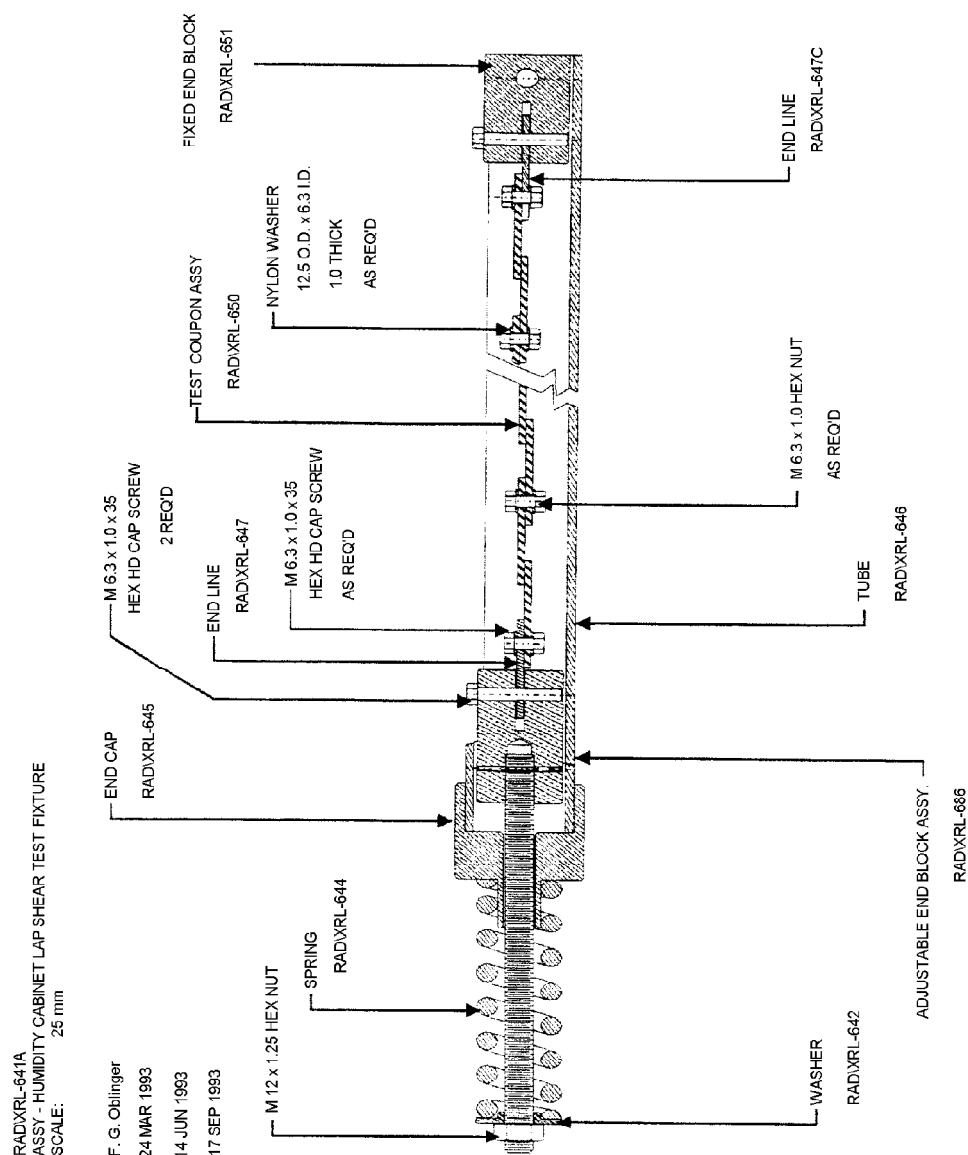


Figure 1