Designation: F3147 – 15

Standard Test Method for Evaluating the Reliability of Surface Mounted Device (SMD) Joints on a Flexible Circuit by a Rolling Mandrel Bend[1]

This standard is issued under the fixed designation F3147; 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 a means to test a completed Surface Mounted Device (SMD) joint for bond strength and inter-layer stress compatibility

1.2 A completed SMD joint includes; SMD (LED, resistor, etc), PTF ink land (typically silver), conductive adhesive (typically silver), staking compound (non-conductive), and encapsulant (non-conductive).

2. Referenced Documents

2.1 *ASTM Standards:*

F1996 Test Method for Silver Migration for Membrane Switch Circuitry

F2750 Test Method for Determining the Effects of Bending a Membrane Switch or Assembly

3. Terminology

3.1 *bend, v*—to force from a straight form into a different and especially a curved one.

3.1.1 *Discussion*—In this case, no "hard" or angled crease or fold is to occur. The substrate will only be formed into a radius.

3.2 *bend cycle, n*—a bend of a sample around a specified mandrel which is "rolled" in one direction, followed by rolling in the opposite direction, returning the sample to its original position (see Fig. 1).

3.3 *conductive adhesive, n*—a material used for electrical or mechanical bonding, or both, of the SMD to the substrate and land-pad.

3.4 *encapsulant, n*—a non-conductive adhesive that is applied over or around, or both, the SMD for added bond strength and prevention of silver migration (F1996).

3.5 *land-pad, n*—the printed circuit pattern at the location that interfaces with conductive adhesive, in this case conductive link circuitry (commonly silver) that will make electrical contact to the SMD via conductive adhesive.

3.6 *mandrel, n*—a cylindrically shaped metal rod, such as a brazing or drill rod.

3.7 *SMD, n*—abbreviation for surface mount device (that is, light emitting diode (LED), resistor, capacitor, etc.).

3.8 *SMD joint, n*—the combined interface of silver land-pad, conductive adhesive, staking compound (if included), and encapsulant that holds the SMD in place.

3.9 *SMD-populated flexible printed circuit, n*—flexible substrate with conductive circuitry and electronic components only—not to include other laminates.

3.10 *staking compound, n*—a non-conductive adhesive that is applied at a location directly under the SMD and between conductive adhesive deposits (commonly two or more dispensed dots of conductive adhesive) to provide added bond strength and prevent shorting or silver migration.

4. Significance and Use

4.1 The existing Test Method F1995, while very useful, is difficult to conduct if an encapsulating dome is applied, and does not reveal the possible failures caused by mechanical stress incompatibility in the overall SMT joint. This mandrel bend test will reveal possible mechanical stress incompatibility between the various adhesives which can result in latent field failures during production handling or with thermal cycling in normal use.

4.2 The existing Test Method F2750 does not include specifics for SMD attachments and only addresses the conductivity change of the conductive trace.

4.3 The different combinations of SMD types, attachment medias, circuit substrates and process variation can account for significant variation in test outcome.

4.4 Bending of printed flexible circuit or their components can affect their visual appearance, mechanical integrity or electrical functionality. This test method simulates conditions that may be seen during manufacture, installation, or use.

4.5 Bend testing may be destructive, therefore any samples tested should be considered unfit for future use.

[1] This test method is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.18 on Printed Electronics.

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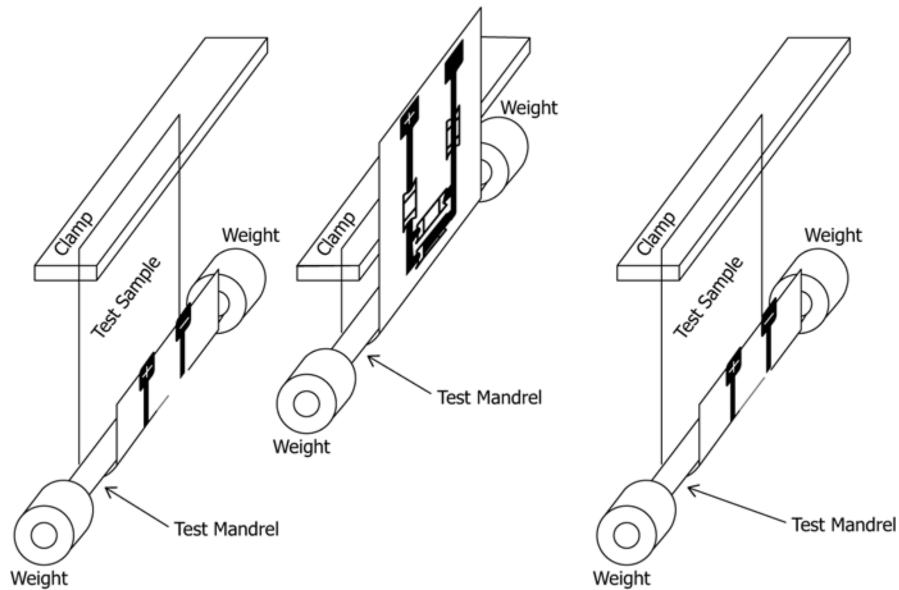
One complete bend cycle is depicted below. The test sample is clamped in a vertical position, the sample is wrapped around the test mandrel, with appropriate test weights applied. The sample is drawn up to a specified distance and returned to the home position.



Depiction of circuit. SMD(s) can be positioned in varied configurations as agreed between parties. The +/– connection pads are best positioned within the fixed clamp with connection to meter and/or voltage.

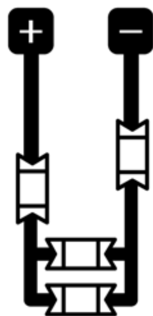


FIG. 1 Bend Cycle

5. Interferences

5.1 The following parameters may affect the results of this test:

5.1.1 Temperature and humidity,

5.1.2 Mandrel diameter,

5.1.3 SMD type, size, orientation to mandrel,

5.1.4 Weight applied,

5.1.5 Land-pad design and proper application of adhesives, and

5.1.6 Lack of 48-h conditioning at room temperature (UV-cure encapsulant continues to cross-link after cure cycle).

6. Apparatus

6.1 *Mandrel,* allowed to rotate smoothly around its longitudinal axis, rigid, low friction smooth surface. Diameter to be specified.

6.2 *Electronic test fixture,* to monitor function of SMDs before and after bending (and during bend if applicable).

6.3 *Weights (mass),* to hold switch onto mandrel in controlled force.

6.4 *Fixture,* to hold test sample securely in place in a vertical manner (see Fig. 1).

6.5 *Mechanism,* capable of providing a consistent force of pull to the sample.

7. Test Samples

7.1 If the sample length is too short for the test fixture, a sample coupon of the same construction should be provided (minimum, 250 mm length by 25 mm width).

7.2 The width of the test sample must not exceed the length of the mandrel.

8. Pretest Setup

8.1 Electrically test SMD components in the flat condition for expected functionality.

8.2 *Visual Inspection*—Note any components for improper SMD alignment, composition.

9. Procedure

9.1 Clamp one end of the test sample to the test fixture – this is the static end of the test sample.

9.1.1 SMD side of the test sample faces away from the mandrel.

9.2 Loop the unsecured end of the test sample around the mandrel – this later becomes the dynamic end of the test sample.

9.3 Clamp the unsecured end of the test sample to the lifting mechanism (no tension).

9.3.1 Ensure that both ends of the test sample remain parallel during motion of the test.

9.4 If test fixture allows testing during bending cycle, connect test sample to allow dynamic monitoring.

NOTE 1—Experience has shown that some conductors recover their conductive properties if allowed to stabilize after the dynamic portion of the test. Therefore, continuous monitoring is recommended.

9.5 Apply the minimum tension load of sufficient magnitude such that the test sample contacts approximately 50 % of the circumference surface of the mandrel. (Typically, this is a kg mass providing the tension load).

9.6 Adjust the test fixture to achieve maximum travel of the mandrel by pulling the unsecured end (dynamic end) of the test sample while maintaining 50 % contact with the mandrel.

9.7 If monitoring, dynamically verify test sample is functional.

9.8 Start test.

9.8.1 Run mandrel test a specified number of cycles.

9.8.1.1 A cycle is defined as travel from maximum extension to minimum extension and back to maximum extension.

9.8.1.2 Time between cycles shall not exceed 3 s.

9.8.1.3 The linear speed of the dynamic end of the test sample should not exceed 50 mm/s.

9.9 During the flex cycle, monitor and record any changes in resistance for SMD such as resistors, and any flickering of light for powered LEDs.

9.10 Remove test sample from test fixture.

9.11 Electrically test SMD components in the flat condition for functionality.

10. Report

10.1 Report the following information:

10.1.1 Temperature,

10.1.2 Humidity,

10.1.3 Results of visual inspection before and after cycle.

10.1.4 Number of cycles per specimen,

10.1.5 Part number or description of specimen,

10.1.6 Date of test,

10.1.7 Orientation of SMDs to mandrel,

10.1.8 Diameter of mandrel,

10.1.9 Load weight.

10.1.10 Electrical test change – static (before and after bend cycle),

10.1.11 Linear test sample speed, and

10.1.12 Electrical test variations – dynamic (during bend cycle).

11. Precision and Bias

11.1 *Precision*—It is not possible to specify the precision in Test Method F3147 for measuring bend because interlaboratory studies have proven inconclusive due to insufficient participating laboratories with the appropriate equipment.

11.2 *Bias*—No information can be presented on the bias of the procedure in Test Method F3147 for measuring bend because no standard sample is available for this industry.

12. Keywords

12.1 bend; conductive adhesive; encapsulant; land-pad; mandrel; printed flexible circuit; SMD; staking compound

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