

ENGINEERING PRACTICE STUDY

PROJECT NUMBER: 5961-2019-013

TITLE:

MIL-STD-750-2, TEST METHOD 2039:

PROPOSED NEW TEST METHOD FOR MECHANICAL STRESS TESTING
(CTE/FLEX/TWIST) OF CERAMIC BODY SMD PACKAGES MOUNTED TO A
PRINTED BOARD TEST VEHICLE

30 APRIL 2019

FINAL REPORT

STUDY CONDUCTED BY

DLA LAND AND MARITIME
Document Standardization Division (VA)
Active Device Branch (VAC)

Prepared by:
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Electronics Engineer
Active Devices Branch

Approved by:
Thomas Hess
Chief

ATTCH 2

I. OBJECTIVES: The objective of this Engineering Practice (EP) Study was to obtain input from the military services (custodians and review activities), device manufacturers, laboratories, OEMs, and user community concerning a proposed revision to test method 2039 of MIL-STD-750-2 that covers the stress testing of ceramic body SMD packages after they are mounted to an organic printed board test vehicle.

II. BACKGROUND: The proposed test conditions in the new test method were created by an OEM who requested that they be added to test method 2038 of MIL-STD-750-2. Based on the difference of the package designs and materials, the effort to include them in test method 2038 was halted and the EP study final report recommended that a new test method be created to address the new test conditions (documented in EP Study [5961-2016-108](#)). DLA and Maritime edited the proposed test conditions into the format of a new test method 2039.

III. RESULTS: DLA Land and Maritime coordinated an initial draft of the proposed new test method and requested that interested parties that may use it to review the test method and supply either comments or a concurrence. All comments received have been incorporated into the final draft of the test method. The resulting draft has been included as attachment 1.

Both a clean reader draft (see attachment 1) and a mark-up source draft (see attachment 2 for the initial draft with high-lighted changes) have been included.

IV. CONCLUSIONS: The new test method (see attachment 2) should be proposed for incorporation into the next standardization document change action to MIL-STD-750-2.

V. RECOMMENDATIONS: After this EP study has been completed and the final report circulated, an initial draft of MIL-STD-750-2 will be coordinated to include new test method 2039 using the results of this EP study as the basis of the initial draft.

The point of contact for this final report is Mr. David Corbett, DLA Land and Maritime – VAC, P. O. Box 3990, Columbus, OH 43218-3990. Mr. Corbett can also be reached at 614-692-0526 / DSN 850-0526, or by e-mail to: 750.TestMethods@dla.mil.

This draft, dated 30 April 2019, prepared by DLA-CC, has not been approved and is subject to modification.
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METHOD 2039

SURFACE MOUNT DEVICE PACKAGE INTEGRITY

1. Purpose. The purpose of this test method is to verify that the package of a ceramic body surface mount device (hereafter referred to as 'SMD package') can withstand stresses that are likely to experience during assembly, normal operation, or rework.

2. Overview. This test method describes three test conditions by which SMD packages may be evaluated for their ability to withstand various stresses that the SMD package may experience when mounted to a printed board.

2.1 Test condition. The test conditions are as follows:

Test condition C: Printed board to SMD package CTE mismatch (axis X1, X2, Z1 and Z2).

Test condition F: Printed board flex stress (axis Y1 and Y2).

Test condition T: Printed board twist stress (axis Y1 and Y2).

2.2 Test condition classification. All test conditions herein are classified as destructive tests.

3. Definitions. The definitions for all terms used herein shall be as specified in MIL-PRF-19500 and those contained herein. The following definitions shall apply for this test method.

3.1 Ceramic body SMD packages. The SMD packages covered by this test method include those identified as SMD-1 (U1), SMD-2 (U2), SMD-0.5 (U3) and SMD-0.2 (U8). It also includes those identified as U, U4, U5, UA, UB, and their derivatives as described within MIL-PRF-19500 or its related performance specification sheets. The SMD packages covered can also include similar package styles in which the body of a ceramic SMD package is to be soldered directly to a printed board.

3.2 PCB test vehicle. The PCB test vehicle consists of a test printed board with the SMD package soldered to its metallized surface pad areas (hereafter referred to as 'lands'). The test printed board may or may not have wiring areas for attaching test instruments when the electrical parameters are to be monitored during test.

4. General requirements.

4.1 Apparatus. The apparatus used in the SMD package integrity tests shall include the following:

- a. Suitable fixtures for applying the specified stresses to the PCB test vehicle which may result in SMD package failure (see figures [2039-1](#) and [2039-2](#)).
- b. Equipment used for assembling the SMD package to the test printed board.
- c. Magnifier(s) 20X to 40X.
- d. Electrical test equipment for measuring device electrical parameters (when applicable, see [5.2.b](#)).

4.2 Materials. Unless otherwise specified, the following materials shall be used.

4.2.1 Flux and solder. The flux and solder materials used to mount the SMD package to the test printed board lands shall be compatible with the finish of the SMD package terminals and test printed board lands.

4.2.2 Test printed board. Unless otherwise specified, the test printed board shall be constructed of copper clad base material, grade FR-4 in accordance with ASTM D1867 or equivalent. The minimum dielectric thickness shall be .063 inch (1.6 mm) $\pm$.008 inch (0.20 mm) and the starting foil weight of the copper cladding before processing shall be 1-oz/ft².

4.2.3 Hook-up wire. When applicable, the hook-up wire used to connect the PCB test vehicle to the test instruments shall be suitable for the electrical parameters being monitored during test.

4.3 PCB test vehicle.

4.3.1 Design. Unless otherwise specified, the following design details for the test printed board shall apply:

- a. The test printed board shall be a minimum of 4 inch by 4 inch (101 mm by 101 mm) square.
- b. The test printed board shall be prepared with land areas of proper size and spacing to permit mounting of the terminals of the SMD package to the test printed board surface land areas by soldering.
- c. The test printed board surface land areas shall be of sufficient size to not allow the lifting of the SMD package off the test printed board during testing.
- d. If double clad base materials are used, the cladding shall be etched to form a cross-hatch pattern on the back side of the test printed board.

4.3.2 PCB test vehicle assembly. Unless otherwise specified, the SMD packages for all test conditions shall be mounted on a test printed board by soldering the SMD package terminals directly to the test printed board lands. The solder and soldering flux used shall be of such a quality as to enable the SMD package to meet all the requirements of the applicable acquisition document for the SMD package after assembly. The details for the assembly of the SMD package to the test printed board shall be in accordance with the following:

- a. The solder and soldering flux shall be applied to each terminal of the SMD package.
- b. All SMD packages shall be placed across the metallized lands of the test printed board with contact between the SMD package terminals and test printed board land areas only. The use of adhesive to keep the SMD packages in place during mounting operation shall be acceptable.
- c. SMD packages should be soldered to the test printed board using the device manufacturer's recommended soldering reflow profile. The soldering reflow profile used for this test method shall be documented.
- d. Only ambient air cooling after assembly of the SMD package to the test printed board shall be used.

4.3.3 Electrical test connections. When electrical parameter monitoring during test is specified, the test printed board should be designed with traces leading to holes or lands for the hook-up wires that are separated from the lands used for mounting the SMD package.

5. Detailed requirements.

5.1 Sampling. Unless otherwise specified, the minimum sample size shall be 12 SMD packages with no failures allowed.

5.2 Examinations and measurements before test. Prior to testing, the SMD packages shall be inspected in accordance with the following:

- a. Visually inspected in accordance with method 2071 of MIL-STD-750-2 for mechanical damage to the SMD package body, terminals, and body-to-terminal junction. Any occurrence of the failure criterion identified in method 2071 of MIL-STD-750-2 shall be recorded and compared with the post-test inspection results.
- b. When specified, the end-point electrical measurements equivalent to group A, subgroup 2 of the applicable acquisition document shall be recorded.

5.3 Procedure. The SMD package integrity test shall be conducted using the test condition(s) specified (see 6.1.a).

5.3.1 Condition C (printed board to SMD package CTE mismatch).

5.3.1.1 Procedure. The PCB test vehicle shall be sequentially subjected to temperature cycling in accordance with test method 1051 of MIL-STD-750-1, except that the following conditions shall be used until either all SMD packages have failed or the test sequence is completed.

Cycle	No. of temperature cycles	Temperature range
1	10	–20°C, +125°C
2	10	–40°C, +125°C
3	10	–60°C, +125°C
4	10	–80°C, +125°C

5.3.1.2 Monitoring during test. When specified, either continuity or electrical parameters shall be monitored during the temperature cycling.

5.3.1.3 Reporting. The quantity of SMD packages failing at each temperature range shall be recorded.

5.3.2 Condition F (printed board flex in axis Y1 and Y2) (see figure 2039–1).

5.3.2.1 Procedure. The PCB test vehicle shall be placed into a fixture similar to that shown on figure 2039–1 with the SMD package opposite the loading probe. The position of the support rails shall be as specified on figure 2039–1 and the SMD package and loading probe shall be centered between the rails. A force shall be applied which will flex the PCB test vehicle .079 inch (2.0 mm) minimum. Unless otherwise specified, the force shall be applied only once to the PCB test vehicle. At the option of the test facility, the configuration of the PCB test vehicle, test fixture and loading probe may be vertical or horizontal provided the application of force is as specified on figure 2039–1.

5.3.2.2 Duration of force. Unless otherwise specified, the duration of the applied force shall be 60 seconds –0, +5 seconds.

5.3.3 Condition T (printed board twist in axis Y1 and Y2) (see figure 2039–2).

5.3.3.1 Procedure. The PCB test vehicle shall be placed into a fixture similar to the one shown on figure 2039–2. A mechanism that can hold the edges of the PCB test vehicle oriented along the Z axis shall be used. The position of the support rails shall be as specified on figure 2039–2 and the DUT shall be centered between the rails. A twisting motion shall be applied in a manner that results in the diagonal corners of the mounted edges of the PCB test vehicle to twist at least .0625 inches (1.5875 mm) off the Y axis. The twisting motion shall be applied to both sides of the PCB test vehicle simultaneously. A twist cycle consists of two half-cycles as depicted on figure 2039–2. Unless otherwise specified, only one twisting cycle shall be applied to the PCB test vehicle. At the option of the test facility, the configuration of the PCB test vehicle and test fixture may be vertical or horizontal provided the application of force is as specified on figure 2039–2.

5.3.3.2 Duration of force. Unless otherwise specified, the duration of the applied force shall be 30 seconds –0, + 5 seconds at each extreme.

5.4 Examinations and measurements after test.

5.4.1 Visual criteria. After testing, the SMD packages shall be inspected in accordance with method 2071 of MIL-STD-750-2 and SMD packages exhibiting the following conditions shall be counted as rejects.

- a. Brazing, soldering, or welds; showing fractures or fissures.
- b. SMD package body or wall crack; either appearing or have propagated.

5.4.2 End-point electrical measurements (when applicable). If end-point electrical measurements were taken prior to test, any electrical parameters exhibiting the following conditions after test shall be counted as rejects.

- a. Failures exceeding 100 percent of initial value.
- b. Failures exceeding the limits specified in the applicable acquisition document.

6. Notes.

6.1 Summary. The following conditions should be specified in the applicable acquisition document (performance specification sheet or drawing):

- a. Test condition letter.
- b. Design of or materials used for the PCB test vehicle, if other than specified.
- c. For test condition C, the number of temperature cycles and the temperature ranges, if other than specified.
- d. For test conditions F or T, the number of flexing motions or twisting cycles to apply to the PCB test vehicle, if other than specified.
- e. For test condition F or T, the duration of test, if other than specified.
- f. Exceptions or additions to the visual inspection acceptance criteria or method, if other than specified.
- g. When applicable, the requirements for electrical testing (monitoring during test or pre- and post test end-point electrical measurements).

6.2 Usage of test conditions. This test method is currently not required by MIL-PRF-19500 for conformance or qualification inspection. The following should be consider when implementing a SMD package integrity testing regimen.

6.2.1 General use. The test condition(s) of this test method are intended to be a part of group E of MIL-PRF-19500 or used for the characterization of new technology for any SMD package configuration, material or vendor that has not been previously qualified to MIL-PRF-19500.

6.2.2 Condition C (CTE mismatch). In the event of SMD package failure at a specific temperature range, this data can be used by the manufacturer to disclose or add clause in their product drawing limiting the temperature application or exposure range. This data should be made available upon request.

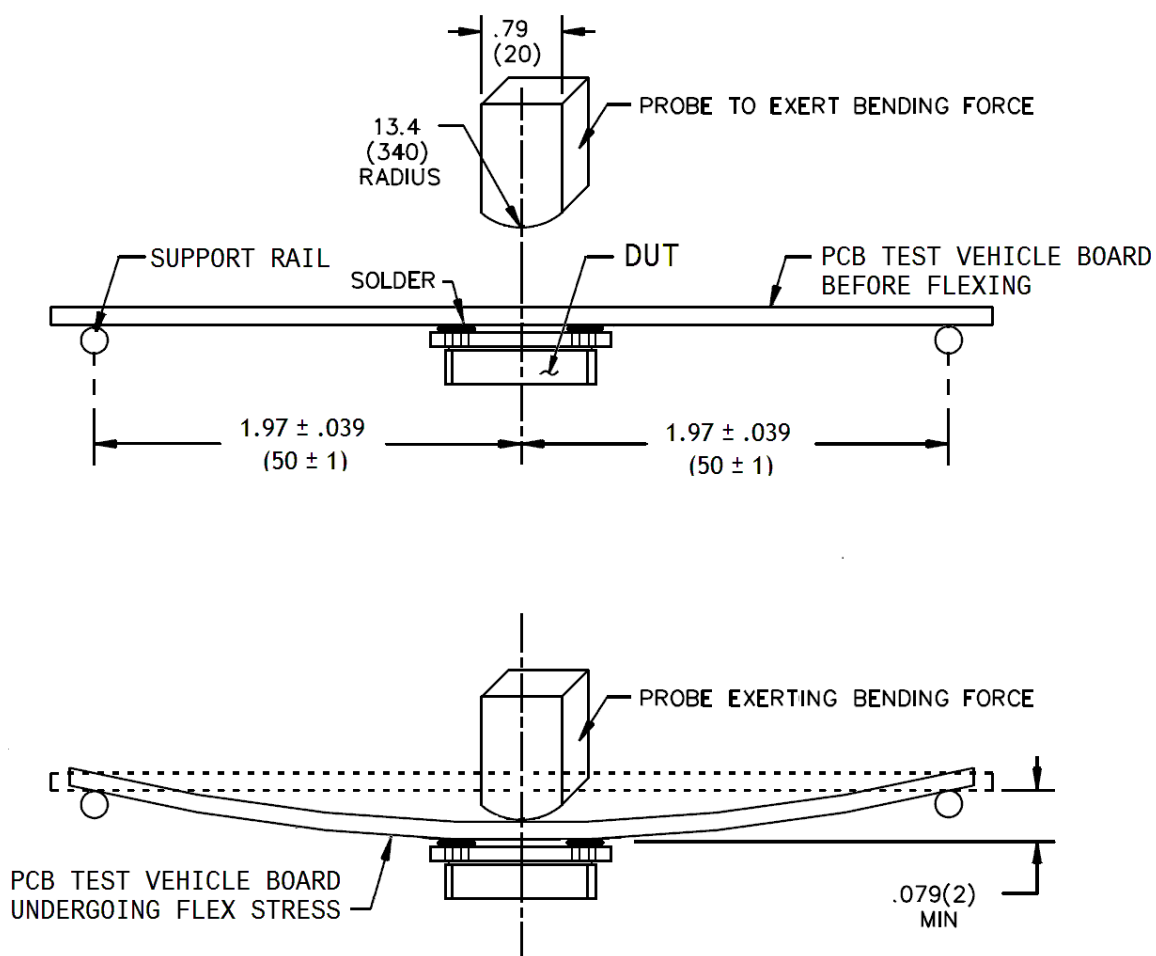


FIGURE 2039-1. Printed board flex apparatus fixture with PCB test vehicle and limits.

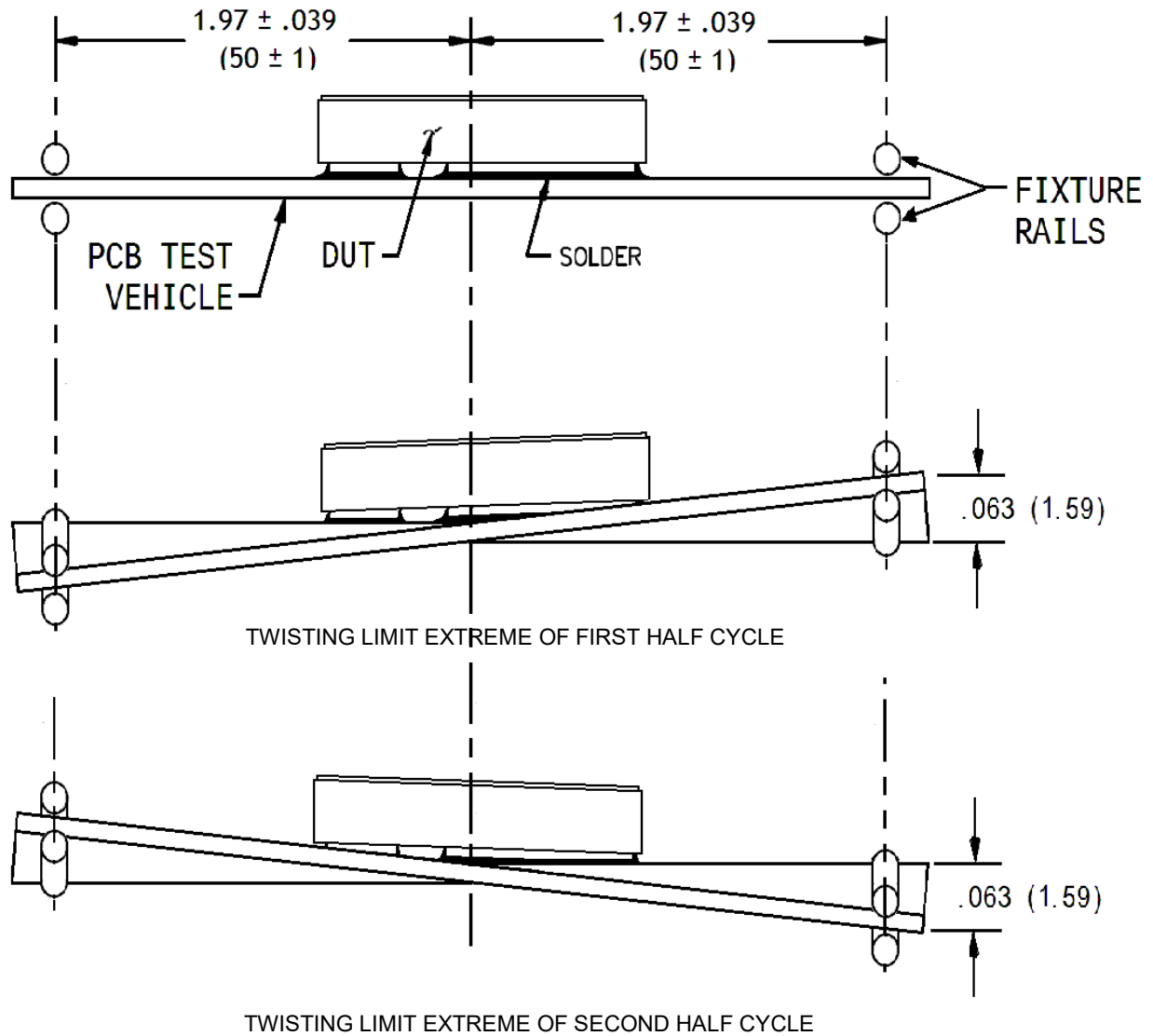


FIGURE 2039-2. Printed board twist apparatus with PCB test vehicle and cycle limits.

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4. General requirements.

4.1 Apparatus. The apparatus used in the SMD package integrity tests shall include the following:

- a. Suitable fixtures for applying the specified stresses to the PCB test vehicle which may result in SMD package failure (see figures 2038-1 2039-1 and 2038-2 2039-2).
- b. Equipment used for assembling the SMD package to the test printed board.
- c. Magnifier(s) 20X to 40X.
- d. Electrical test equipment for measuring device electrical parameters (when applicable, see 5.2.5).

4.2 Materials. Unless otherwise specified, the following materials shall be used.

4.2.1 Flux and solder. The flux and solder materials used to mount the SMD package to the test printed board lands shall be compatible with the finish of the SMD package terminals and test printed board lands.

4.2.2 Test printed board. Unless otherwise specified, the test printed board shall be constructed of copper clad base material, grade FR-4 in accordance with ASTM D1867 or equivalent. The minimum dielectric thickness shall be .063 inch (1.6 mm) $\pm$.008 inch (0.20 mm) and the starting foil weight of the copper cladding before processing shall be 1-oz/ft².

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- d. Only ambient air cooling after assembly of the SMD package to the test printed board shall be used.

4.3.3 Electrical test connections. When electrical parameter monitoring during test is specified, the test printed board should be designed with traces leading to holes or lands for the hook-up wires that are separated from the lands used for mounting the SMD package.

5. Detailed requirements.

5.1 Sampling. Unless otherwise specified, the minimum sample size shall be 12 SMD packages with no failures allowed.

5.2 Examinations and measurements before test. Prior to testing, the SMD packages shall be inspected in accordance with the following:

- a. Visually inspected in accordance with method 2071 of MIL-STD-750-2 for mechanical damage to the SMD package body, terminals, and body-to-terminal junction. Any occurrence of the failure criterion identified in method 2071 of MIL-STD-750-2 shall be recorded and compared with the post-test inspection results.
- b. When specified, the end-point electrical measurements equivalent to group A, subgroup 2 of the applicable procurement acquisition document shall be recorded.

5.3 Procedure. The SMD package integrity test shall be conducted using the test condition(s) specified (see 6.1.a).

5.3.1 Condition C (printed board to SMD package CTE mismatch).

5.3.1.1 Procedure. The PCB test vehicle shall be sequentially subjected to temperature cycling in accordance with test method 1051 of MIL-STD-750-1, except that the following conditions shall be used until either all SMD packages have cracked failed or the test sequence is completed.

Cycle	No. of temperature cycles	Temperature range
1	10	-20°C, +125°C
2	10	-40°C, +125°C
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5.3.1.2 Monitoring during test. When specified, either continuity or electrical parameters shall be monitored during the temperature cycling.

5.3.1.3 Reporting. The quantity of SMD packages failing at each temperature range shall be recorded.

5.3.2 Condition F (printed board flex in axis Y1 and Y2) (see figure 2039-1).

5.3.2.1 Procedure. The PCB test vehicle shall be placed into a fixture similar to that shown on figure 2039-1 with the SMD package opposite the loading probe. The position of the support rails shall be as specified on figure 2039-1 and the SMD package and loading probe shall be centered between the rails. A force shall be applied which will flex the PCB test vehicle .079 inch (2.0 mm) minimum. Unless otherwise specified the force shall be applied only once to the PCB test vehicle. At the option of the test facility, the configuration of the PCB test vehicle, test fixture and loading probe may be vertical or horizontal provided the application of force is as specified on figure 2039-1.

5.3.2.2 Duration of force. Unless otherwise specified, the duration of the applied force shall be 60 seconds -0, +5 seconds.

5.3.3 Condition T (printed board twist in axis Y1 and Y2) (see figure 2039-2).

5.3.3.1 Procedure. The PCB test vehicle shall be placed into a fixture similar to the one shown on figure 2039-2. A mechanism that can hold the edges of the PCB test vehicle oriented along the Z axis shall be used. The position of the support rails shall be as specified on figure 2039-2 and the DUT shall be centered between the rails. A twisting motion shall be applied in a manner that results in the diagonal corners of the mounted edges of the PCB test vehicle to twist at least .0625 inches (1.5875 mm) off the Y axis. The twisting motion shall be applied to both sides of the PCB test vehicle simultaneously. A twist cycle consists of two half-cycles as depicted on figure 2039-2. Unless otherwise specified (see 6.1.e), only one twisting cycle shall be applied to the PCB test vehicle. At the option of the test facility, the configuration of the PCB test vehicle and test fixture may be vertical or horizontal provided the application of force is as specified on figure 2039-2.

5.3.3.2 Duration of force. Unless otherwise specified, the duration of the applied force shall be 30 seconds -0, + 5 seconds at each extreme.

5.4 Examinations and measurements after test.

5.4.1 Visual criteria. After testing, the SMD packages shall be inspected in accordance with method 2071 of MIL-STD-750-2 and SMD packages exhibiting the following conditions shall be counted as rejects.

- a. Brazing, soldering, or welds; showing fractures or fissures.
- b. SMD package body or wall crack; either appearing or have propagated.

5.4.2 End-point electrical measurements (when applicable). If end-point electrical measurements were taken prior to test, any electrical parameters exhibiting the following conditions after test shall be counted as rejects.

- a. Failures exceeding 100 percent of initial value.
- b. Failures exceeding specification limits.

6. Notes.

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- g. When applicable, the ~~electrical test~~ requirements for electrical testing (monitoring during test or pre- and post test end-point electrical measurements), ~~if other than specified.~~

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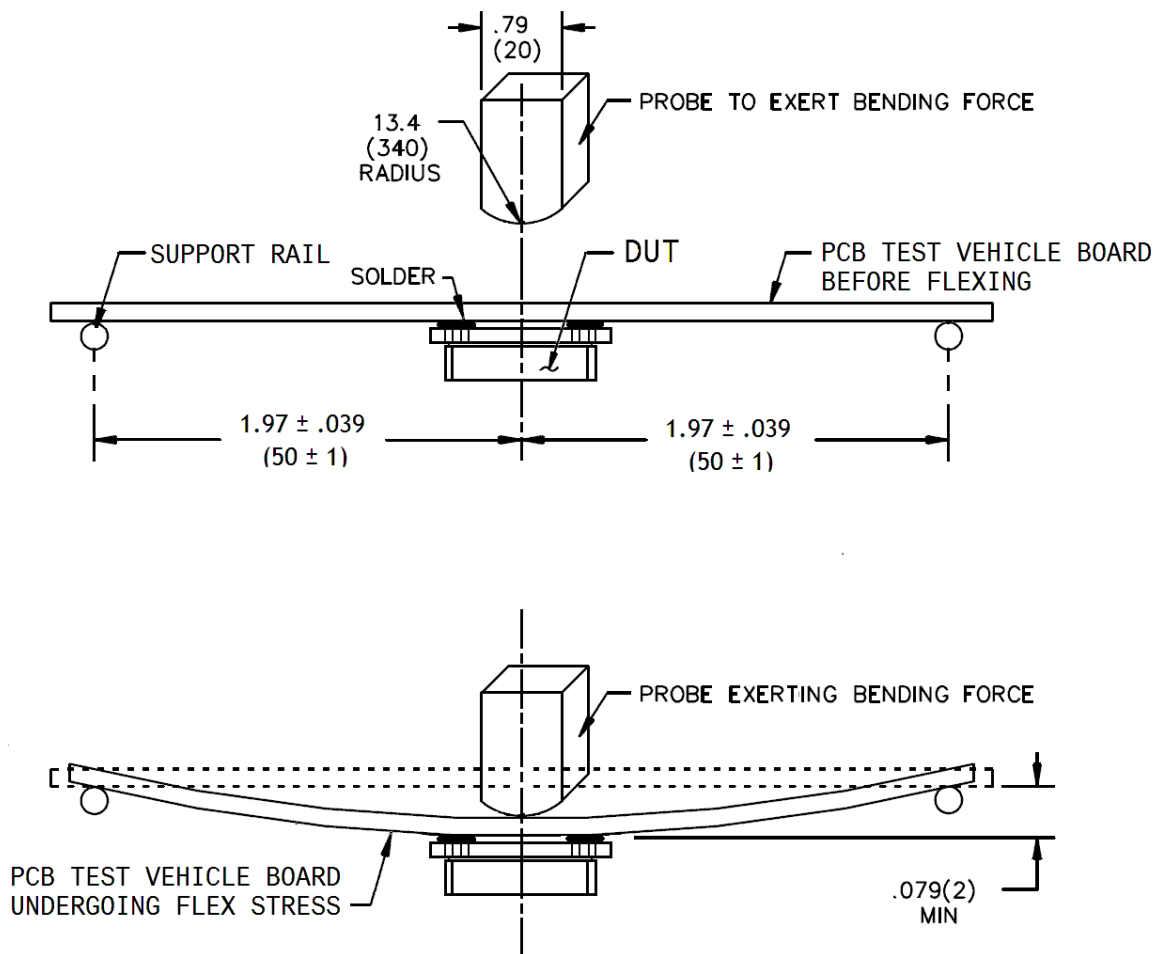


FIGURE 2039-1. Printed board flex apparatus fixture with PCB test vehicle and limits.

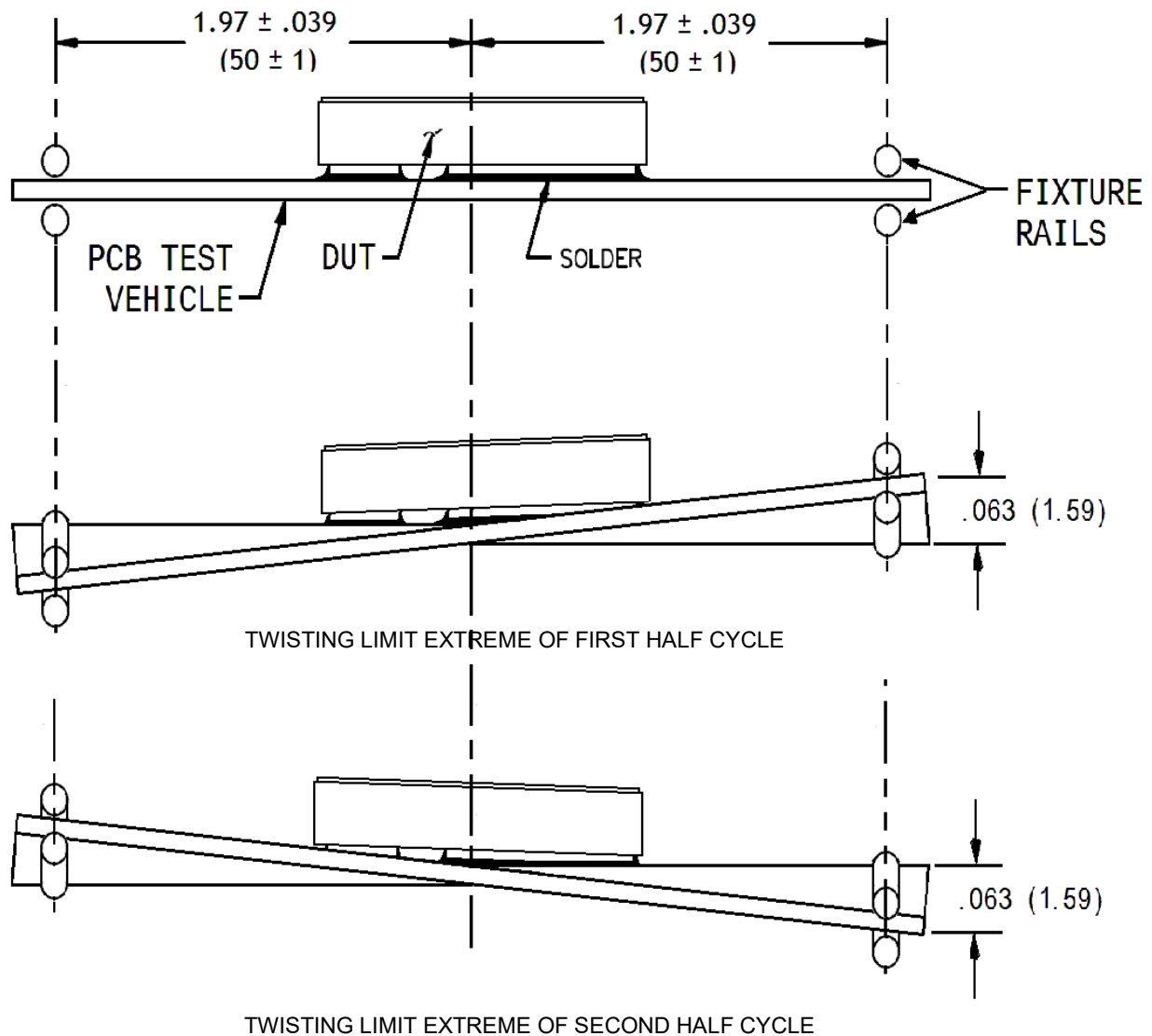


FIGURE 2039-2. Printed board twist apparatus with PCB test vehicle and cycle limits.