ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

2215 Sanders Road
Northbrook, IL 60062-6135

IPC-TM-650
TEST METHODS MANUAL

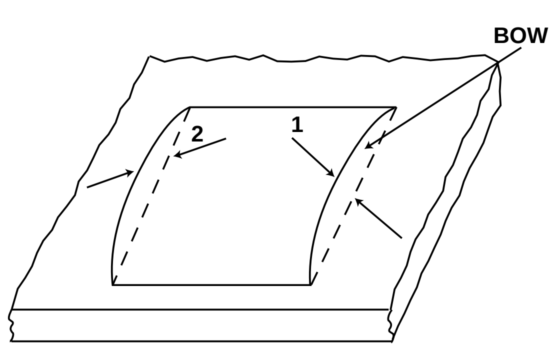
Number	
2.4.22	
Subject	
Bow and Twist (Percentage)	
Date	Revision
6/99	C
Originating Task Group	
Rigid Printed Board Test Methods Task Group (7-11d)	

1 Scope This test method covers three procedures used to determine the bow and twist percentage of individual rigid printed boards, rigid portions of rigid-flex printed boards, and/or multiple printed panels. Measurements on non-rectangular samples pose a unique testing problem and may necessitate careful evaluation of the requirements imposed by the users of this test method. This test method does not describe the special considerations necessary when testing the bow and twist of printed board assemblies (i.e., component placement & weight, edge supports & connectors, etc.).

The first two procedures describe production (Go/No-Go) methods that generally characterize the bow and twist as being no more than a specific value. The other procedure is a referee method used to precisely determine the twist.

1.1 Definitions Bow and twist are defined in IPC-T-50. The definitions are repeated in this test method for convenience.

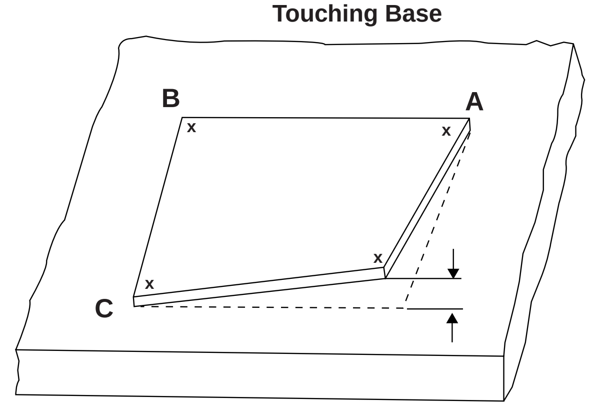
1.1.1 Bow (Sheet, Panel, or Printed Board) The deviation from flatness of a board characterized by a roughly cylindrical or spherical curvature such that, if the product is rectangular, its four corners are in the same plane (see Figure 1).



With constraining force applied to both corners of the same edge. 1 & 2 deflection from surface plane.

Figure 1 Box

1.1.2 Twist The deformation of a rectangular sheet, panel, or printed board that occurs parallel to a diagonal across its surface, such that one of the corners of the sheet is not in the plane that contains the other three corners (see Figure 2).



With constraining force applied to one corner only.

Figure 2 Twist

2 Applicable Documents

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-TM-650 Test Methods

3 Test Specimens The test specimens shall be in the form of either printed boards or multiple printed panels (single-sided, double-sided, multilayer, or rigid-flex boards).

3.1 For non-rectangular test specimens, the most convenient way to measure bow and twist is approximating a rectangle over the test specimen. To accomplish this, an imaginary rectangle that totally encloses the sample must be superimposed over the test specimen. The dimensions of this superimposed rectangle should be the smallest that will fully enclose the specimen. Although this technique will give an approximation of bow and twist, the actual noted values will be less than the actual bow and twist of the sample.

4 Equipment/Apparatus

4.1 Precision surface plate

4.2 Thickness measurement shims (feeler or pin gauges)

4.3 Leveling jacks

4.4 Standard metrology height dial indicator gauge

4.5 Gauge blocks

4.6 Linear measuring devices of suitable accuracy

4.7 Micrometer of suitable accuracy for thickness measurement

5 Procedure Unless otherwise specified, testing shall be performed at standard laboratory conditions (see IPC-TM-650, Section 1.3).

5.1 Production Testing (Bow)

5.1.1 Place the sample on the surface plate. While applying sufficient pressure to flatten the test sample, measure the length and width of the sample and record it as length (L) & width (W) (see Figure 3).

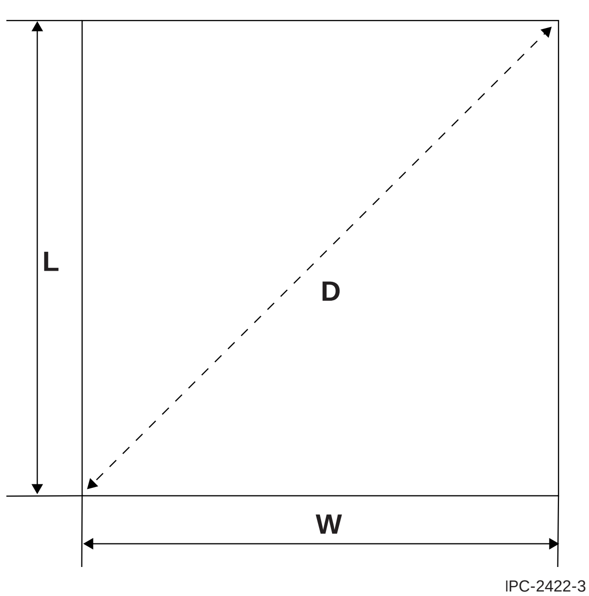


Figure 3 External Measurements

5.1.2 Calculate the size of the feeler/pin gauge (Go/No-Go) to be used for maximum bow percentage using the following formula:

$$R_L = \frac{L\,(B)}{100} \qquad Rw = \frac{W\,(B)}{100}$$

Where:

R_L = Go/No-Go feeler/pin gauge size for sample length
R_W = Go/No-Go feeler/pin gauge size for sample width
L = Length measurement as determined above
W = Width measurement as determined above
B = Maximum allowable bow percentage

5.1.3 Place the sample to be measured on the surface plate with the convex of the sample facing upwards. For each edge, apply sufficient pressure on both corners of the same sample edge to ensure contact with the surface (see Figure 4).

5.1.4 Attempt to slide the feeler/pin gauge of thickness R_L under the length side(s) of the sample and R_W under the width side(s) of the sample. If the Go/No-Go feeler/pin gauge will slide between the sample and the surface plate, the bow in that direction exceeds the allowable percentage used in the calculation above. Repeat this procedure until all sides of the sample have been measured.

5.1.5 If a determination of actual percentage of bow is desired, repeat 5.1.1 through 5.1.4 using a feeler/pin gauge that will easily fit between the side of the sample and the surface plate. Continue to increase the feeler/pin gauge size until the largest feeler/pin gauge that will fit between the sample and the surface plate for both the length (x2) and width (x2) is obtained. Measure this feeler/pin gauge with the micrometer and record as R_L or R_W.

Calculate the percentage for bow as follows:

$$B_L = \frac{R_L}{L} \text{ X } 100 \qquad B_w = \frac{Rw}{W} \text{ X } 100$$

Where:

B_L = Percentage bow in the length direction
B_W = Percentage bow in the width direction
R_L = Measured maximum feeler/pin gauge size across sample length
R_W = Measured maximum feeler/pin gauge size across sample width
L = Length measurement as determined above
W = Width measurement as determined above

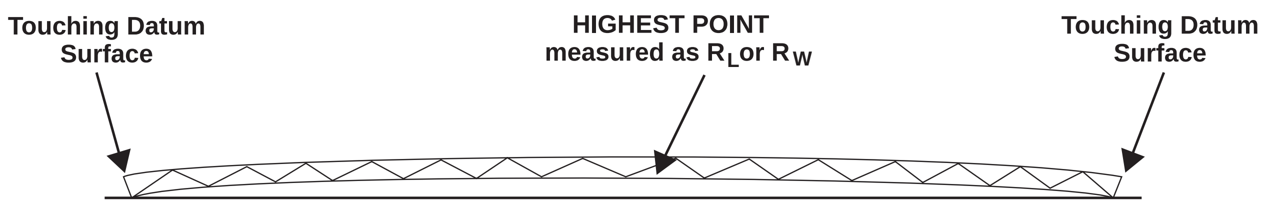


Figure 4 Bow Measurement

5.2 Production Testing (Twist)

5.2.1 Place the sample on the surface plate. While applying sufficient pressure to flatten the test sample, take the diagonal measurement across the sample and record it as D (see Figure 3).

5.2.2 Calculate the size of the feeler/pin gauge (Go/No-Go) to be used for maximum twist percentage using the following formula:

$$R = \frac{2\,(D)\,(T)}{100}$$

Where:

R = Go/No-Go feeler/pin gauge size
D = Diagonal measurement across the sample as determined above
T = Maximum allowable twist percentage

Note: This formula includes a factor of two because, by constraining one corner of the sample on a surface plate, the vertical deflection of twist is approximately doubled.

5.2.3 Place the sample to be measured on the surface plate with any three corners of the sample touching the surface. Apply sufficient pressure (if necessary) to only one corner of the sample to ensure three of the four corners are in contact with the surface plate. It may be necessary to turn the sample over to accomplish this (see Figure 5).

5.2.4 If it is not possible to get three corners of the sample to touch the surface plate by restraining only one corner, this production test is not applicable and the referee test described in 5.3 shall be used.

5.2.5 Attempt to slide the feeler/pin gauge of thickness R under the corner not touching the surface plate. If the Go/No-Go feeler/pin gauge will slide under the corner not touching the surface plate without lifting any of the other three corners of the sample from the surface plate, the twist in that direction exceeds the allowable percentage used in the calculation above. Repeat this procedure until all corners of the sample that can be measured using this technique have been measured.

5.2.6 If a determination of actual percentage of twist is desired, repeat 5.2.1 through 5.2.5 using a feeler/pin gauge that will easily fit under the corner that is not touching the surface plate. Continue to increase the feeler/pin gauge size until the largest feeler/pin gauge size that does not lift any of the three touching corners from the surface plate is obtained. Measure this feeler/pin gauge with the micrometer and record as R.

5.2.7 Calculate the percentage of twist as follows:

$$\text{Percentage Twist} = \frac{R}{2\,(D)} \times 100$$

Where:

R = Go/No-Go feeler/pin gauge size
D = Diagonal measurement across the sample as determined above

Note: This formula includes a factor of two because, by constraining one corner of the sample, the vertical deflection of twist is approximately doubled.

5.3 Referee Method (Twist)

5.3.1 Place the sample to be measured on the datum surface with the two lower opposite corners touching the datum surface or on a raised parallel surface of equal height from the datum surface (see Figure 6).

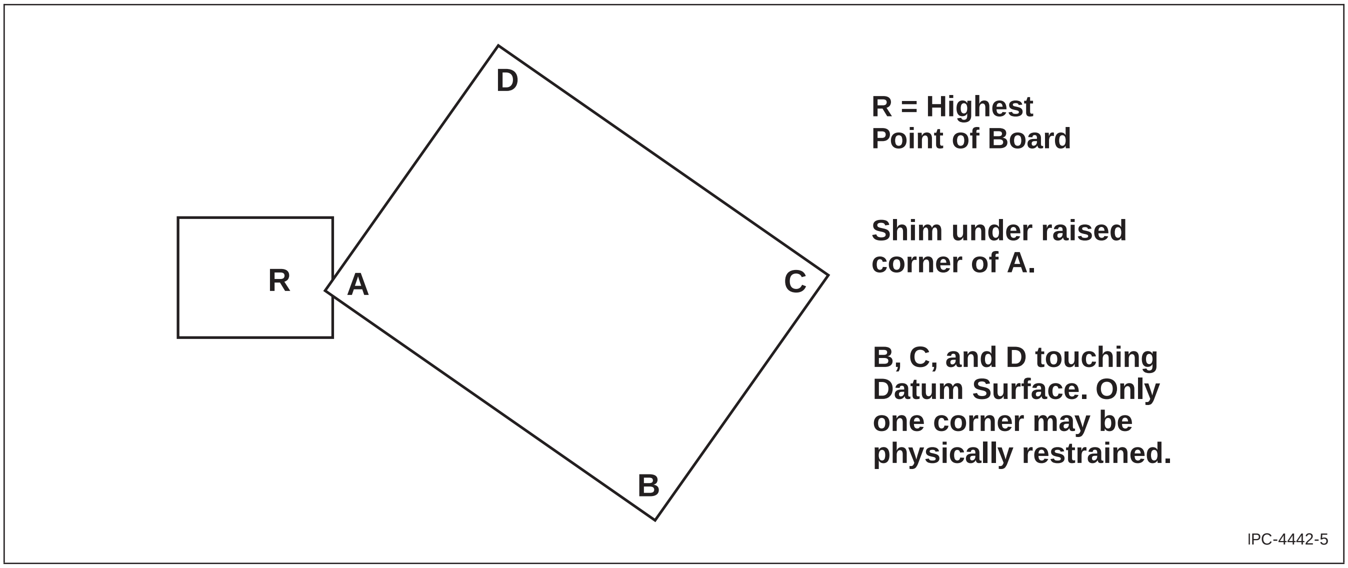


Figure 5 Measurement of Twist

5.3.2 Support the other two corners with leveling jacks or some other appropriate devices, ensuring the two raised corners are of equal height from the datum surface. This may be checked by using the dial indicator (see Figure 7).

5.3.3 Using the dial indicator, measure the highest raised portion on the board and record the reading as R1 (see Figure 8).

5.3.4 Without disturbing the sample, take a reading with the dial indicator on one of the corners contacting the surface (R2) and record the reading (see Figure 8).

5.3.5 Take the diagonal measurement of the sample and record the reading.

5.3.6 Calculation Deduct the measured R2 from the measurement R1. This difference is denoted as twist. Divide the measured deviation by the recorded length and multiply by 100. The result of this calculation is the percentage of twist.

$$\text{Percentage Twist} = \frac{R1 - R2}{L} \times 100$$

6 ***Notes*** None

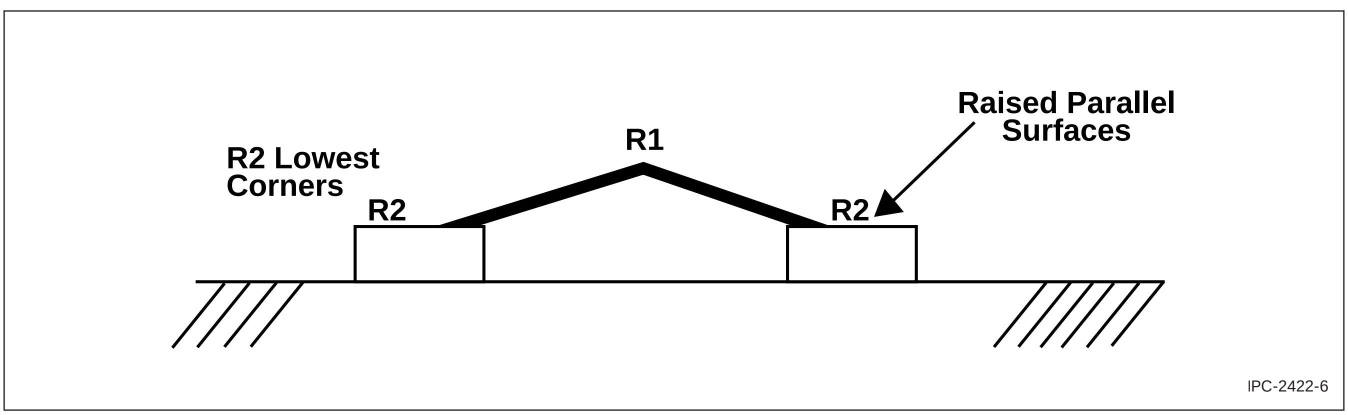


Figure 6 Sample Placement

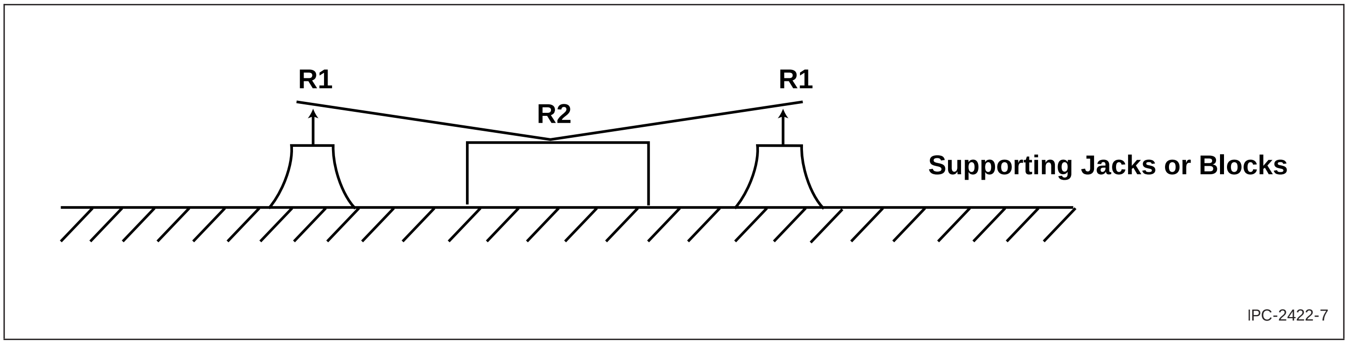


Figure 7 Corners Supports

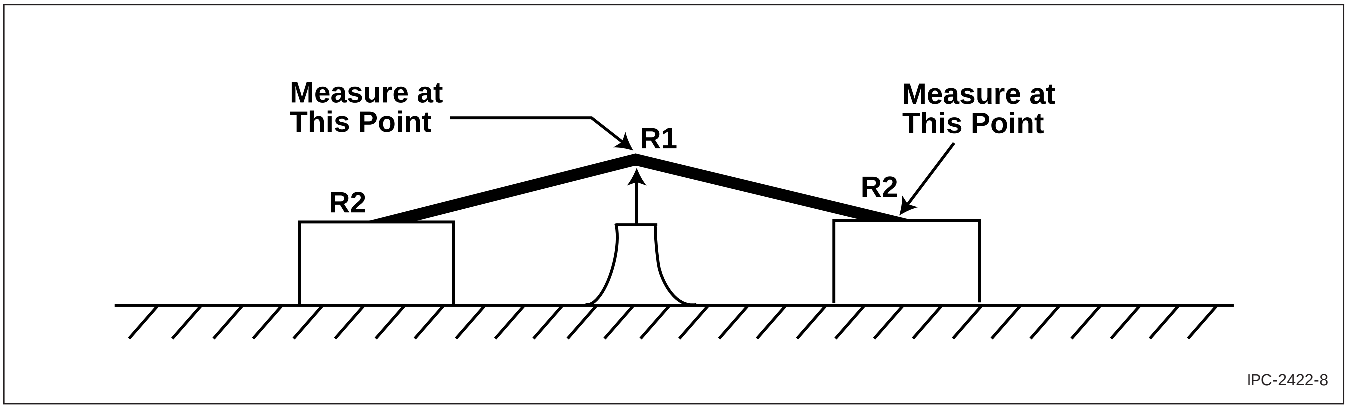


Figure 8 Highest Point Measurement