



IPC-TM-650 TEST METHODS MANUAL

1 Scope With this test method, the flexural fatigue life for any given bend radius, the flexural fatigue behavior, and the ductility of the conductor metal in percent deformation after tensile failure can be determined.

Note: The indirect determination of foil ductility by using a fatigue test is made necessary by the geometry and dimensions of the foil samples, which make tensile elongation and rupture tests inadequate for ductility determination.

2 Applicable Documents

IPC-TM-650 Test Methods Manual

2.1.1 Microsectioning

2.4.18 Tensile Strength and Elongation, Copper Foil

3 Test Specimen Flat cable sections of 63.5 mm in length and containing at least four conductors shall be used.

4 Equipment/Apparatus

4.1 Ductility Flex Tester, Universal Mfg., Model FDF or 2FDF or equal (see Figure 2 and 6.3)

4.2 Micrometer tool capable of measurement to the nearest 0.0025 mm

4.3 Programmable Calculator, Hewlett Packard HP-67 or equal (see 6.3.2)

4.4 Sample holders, 203.2 x 12.7 mm, of very flexible material, e.g., epoxy-impregnated glass cloth, paper, etc.

4.5 Microscope

5 Procedure

5.1 Preparation of Samples

5.1.1 The samples should be smooth and undistorted.

5.1.2 Cut the samples about 63.5 mm long. Cut between conductors to obtain specimens with at least four parallel conductors. Care has to be taken to keep cut clear of conductors.

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5.1.3 Use the micrometer to determine the specimen thickness, t , and the conductor thickness, t_M (see Figure 1), to the nearest 0.0025 mm.

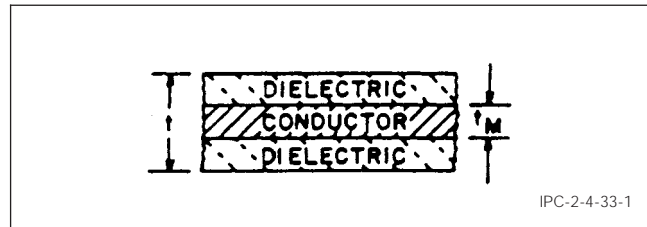


Figure 1 Specimen and Conductor Thickness

Note: Thickness is a critical parameter in the determination of fatigue ductility. A 10% error in t_M , results in a 14% error in D_f .

Note: Most conductors in flat cables are smooth on both surfaces. If not, the core thickness, t_M , is preferably determined as a fraction of the specimen thickness, t , from a microsection prepared per IPC-TM-650, Method 2.1.1, and measured with a metallurgical microscope at 200X minimum with a suitable filar eyepiece or reticle. The measurement is to be made from the valley of the rough surface to the smooth surface, or valley to valley where both surfaces are rough. The t_M is to be made once on a batch or lot basis, and this fractional value of t_M/t is then multiplied by all other micrometer, t , values to achieve the core values for all samples.

5.1.4 Connect all conductors to be tested and monitored in a series and attach thin relay leads to the two free ends.

5.1.5 Attach the test specimen to the ends of two sample holders with adhesive tape and clamp 224 grams of circuit weight to the free ends of the sample holders to form a loop (see Figure 2).

Note: For flexural fatigue tests lasting in excess of 1000 cycles, the adhesive tape attachment needs to be substantial enough to prevent relative sliding of the specimen and sample holder as a result of the cyclic flexure movement.

5.2 Test Procedure

5.2.1 Mount mandrels to the flex tester and adjust the support roller positions for a clearance of 1.27 mm (shim provided) between rollers and mandrels.

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Figure 2 Fatigue Ductility Flex Tester

Note: For the ductility test, it is important that the specimens fail between 30 and 500 cycles. The 6.35 mm diameter is suggested for mandrels but, for some samples, different mandrel diameters might be necessary. Larger mandrel diameters result in longer cyclic life and smaller diameters result in shorter life.

5.2.2 Mount the test specimen between mandrels, attach relay leads into relay jacks, set counter to zero, and start flex tester.

5.2.3 Electrical discontinuity constitutes failure and the flex tester stops automatically.

5.2.4 Record cycles-to-failure indicated on counter.

5.3 Evaluation

5.3.1 Ductility Test

5.3.1.1 Calculate the ductility for each specimen by iteratively solving the formula below:

$$N_f^{-0.6} D_f^{0.75} + 0.9 \frac{S_u}{e} \left[\frac{\exp(D_f)}{0.36} \right]^{(0.175 \log \frac{10^5}{N_f})} - \frac{2t_M}{2e+t} = 0$$

where:

D_f = fatigue ductility, (x100%)

N_f = cycles-to-failure

S_u = ultimate tensile strength

E = modulus of elasticity

t_M = core thickness

t = specimen micrometer thickness

p = mandrel radius of curvature, within 0.005 mm

Note: Determine S_u as per IPC-TM-650, Method 2.4.18. Determine E during the test for S_u by unloading and reloading after about 2% elongation and measuring the slope of the reloading curve.

5.3.1.2 Report the average ductility from at least three specimens.

5.3.2 Fatigue Test The number of cycles to failure is the flexural fatigue life in fully reversed bending for the bend radius corresponding to the radius (1/2 diameter) of the test mandrels used. An average flexural life from at least three specimens should be reported.

5.3.3 Fatigue Behavior The fatigue behavior of a sample can be obtained by determining the flexural fatigue life with a number of different diameter mandrels. Plotting the results in a strain range versus fatigue life Manson-Coffin plot $\log \Delta \epsilon = (2t_M / (2p + t))$ versus $\log N_f$ allows intra- and extrapolation to other bend radius or fatigue lives.

5.3.4 The flexural fatigue life at bend radii other than the mandrel radius can also be obtained by evaluating the ductility formula for the flex life in cycles-to-failure using the fatigue ductility determined in 5.3.1.2 and the desired bend radius.

6.0 Notes For further technical details, reference the material shown below.

IPC-TP-204 "A New Ductility and Flexural Fatigue Test Method for Copper Foil and Flexible Printed Wiring," Engelmaier, W., Apr. 1 1978

"Fatigue Ductility Flex Tester," Drawing L520163, Engelmaier, W., Bell Telephone Laboratories, Inc., Whippany, NJ, 1978.

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6.1 Test Equipment Sources The equipment sources described in 6.1.1 and 6.1.2 represent those currently known to the industry. Users of this test method are urged to submit additional source names as they become available, so that this list can be kept as current as possible.

6.1.1 Fatigue Ductility Flex Tester, Universal Mfg. Co., Inc., 1168 Grove St., Irvington, NJ 07111; 201-374-9800.

6.1.2 "Fatigue Ductility for Foils and Flexible Printed Wiring." Program No. 1883D HP-67/97, Engelmaier, W., User's Library, Hewlett Packard Co., Corvallis, Ore., 1978.