



# IPC-TM-650 TEST METHODS MANUAL

**1.0 Scope** This method provides a technique for determining the overall thickness of treated or untreated copper foils and for determining the profile factor on foils used for the manufacture of electrical grade laminates and multilayer circuit boards.

The profile factor is the difference between the actual mechanical thickness of the foil and the calculated effective thickness based on the weight and density. This method will define the profile factor to about 0.00025 mm [0.01 mil], however, due to variations within the foil the use of values of increments less than 0.00125 mm [0.05 mil] is seldom necessary on treated foils. This method easily achieves this level of precision.

- A. Background: While for a sample with perfectly flat surfaces the theoretical and actual thickness would be equal, in practice virtually all foils used in such applications are manufactured with one rough surface to enhance adhesion to the substrate. Since this irregular surface reduces the effective electrical thickness of the substrate material and may affect other electrical and mechanical properties, it is often useful to quantify the degree of variation from the theoretical thickness. The technique described herein provides a measure of this variation, which on normal foil generally runs from 0.0025 to 0.025 mm [0.1 mil to 1 mil] and may represent over a 50% increase to the foils theoretical thickness.
- B. Applications: The *effective minimum electrical thickness* of a double-sided laminate may be readily determined by subtracting the overall mechanical thickness of the foil (both sides) from the overall thickness of the laminate at a particular location.

The *actual mechanical thickness* of the base material may be estimated by subtracting the *effective* thickness of the copper foil from the overall mechanical laminate thickness.

The Profile Factor may be used to monitor variations of incoming foils of a particular type without time consuming microsectioning. Comparison of different foil types may be made but judgment or performance should be made using the actual criteria of interest.

**2.0 Applicable Documents** None.

**3.0 Apparatus**

Number <b>2.2.12.1</b>	
Subject <b>Overall Thickness and Profile Factor of Copper Foils Treated and Untreated</b>	
Date <b>9/87</b>	Revision
Originating Task Group <b>N/A</b>	

**3.1 Paper cutter**

**3.2** 25.4 mm [1 inch] precision cutter, 324 mm [12 inches] long minimum.

**3.3** Analytical balance 1 mg. resolution.

**3.4** Standard 25.4 mm [1 inch] ratchet micrometer with 0.0025 mm [0.0001 inch] resolution (or better), 25 psi pressure, 6.4 mm [0.25 inch] anvil.

**3.5** Parallel jaw pliers.

**4.0 Specimen**

**4.1** Number: 3.

**4.2** Form: 324 x 25.4 mm [12.00 x 1.00 inches].

**4.3 Location**

**4.3.1** Roll: Specimens shall cut across the width of the foil from the center and both edges of the roll.

**5.0 Procedure**

**5.1 Test**

**5.1.1** Fold the specimen around itself into a 10 ply 25.4 mm [1 inch] long sample maintaining the treated side out so that there are no treated side to treated side interfaces.

**5.1.2** Weigh the specimen on the analytical balance to the nearest 0.001 gram and record as WI.

**5.1.3** Compress the outer 3.2 mm [1/8 inch] of the specimen using a pair of pliers with parallel jaws or equivalent device.

**5.1.4** Using the micrometer, measure the thickness of the specimen to the nearest 0.0025 mm [0.0001 inch] or better in four locations around the center at least 3.2 mm [1/8 inch] from the compressed edges. Use three clicks of a properly calibrated ratchet micrometer (providing a force of 25 psi  $\pm$ 5 psi on the sample).

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	Thickness Mean (mils)	Microns	Standard Deviation (mils)	Microns	Profile Factor Mean (mils)	Microns	Standard Deviation (mils)	Microns
Treated ED Foil Class 1 1 oz./ft <sup>2</sup>	1.61	40.9	0.015	0.38	0.350	8.89	0.015	0.38
Treated ED Foil Class 3 1 oz./ft <sup>2</sup>	1.62	41.2	0.013	0.33	0.251	6.38	0.013	0.33
Untreated RA Foil Class 7 3/4 oz./ft <sup>2</sup>	1.06	26.4	0.010	0.25	0.061	1.55	0.011	0.28

## 5.2 Calculation

**5.2.1** Calculate the effective thickness of the foil in mils by multiplying the weight of the 324 x 25.4 mm [12 x 1 inch] specimen by 0.572 mil/g.

$$T_e (\text{mil}) = 0.572 \frac{\text{mil}}{\text{g}} \times W (\text{g})$$

$T_e$  = Thickness Equivalent

Sample calculation:

$$W = 2.16 \text{ g}$$

$$T_e = 0.572 \text{ mil/g} \times 2.16 \text{ g} = 0.0031 [1.236 \text{ mil}]$$

**5.2.2** Calculate the average *mechanical* thickness micrometer of each 10 ply specimen from the four values taken on each sample.

**5.2.3** Calculate the average *overall thickness* ( $T_m$ ) for each sample by dividing the average thickness of the specimen by the number of plies.

**5.2.4** Calculate the average profile factor of the foil for each specimen by subtracting the effective thickness from the average mechanical thickness.

$$PF = T_m - T_e$$

**5.2.5** Average the three values of profile factor.

## 5.3 Report

**5.3.1** Report the average profile factor for the three specimens tested.

**5.3.2** Report the average mechanical thickness for the three specimens tested.

## 6.0 Notes

*Thickness of Specimen:* The thickness of the specimen used must be at least 100 times the precision of the thickness measuring device. More plies may be required for lighter foil, e.g. 0.5 ounce per square foot foil if the micrometer precision is 0.0025 mm [0.0001 inch] since a minimum of 0.25 mm [10 mils] is required to fulfill the 1% requirement. If a precision 25.4 mm [1 inch] cutter is not available a paper cutter or punch and die set may be used for sample preparation, however, the areas of the sample used for weight determination must be known to 1% or better and the thickness sample must be free from wrinkles or creases.

*Precision:* A study of various 1 oz./ft copper foils resulted in reproducibility between testers using a hand micrometer with 0.0013 mm [0.00005 inch] resolution.

*Comparison to Other Methods:* The profile factor determined by this test may vary slightly from the actual profile height as estimated from other methods, such as microsectioning or profilometry. The denser the treatment structure the more this technique will underestimate the true profile height. The precision of this method between testers was about 50% better than microsectioning in determining the amount of profile on low profile treated ED copper using the same number of determinations using a single microsection as the test vehicle. The time required by this method is under 5 minutes.