

JIS

JAPANESE INDUSTRIAL STANDARD

**Test methods of copper-clad
laminates for flexible printed
wiring boards**

JIS C 6471—1995

Translated and Published

by

Japanese Standards Association

Printed in Japan

In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

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Test methods of copper-clad laminates
for flexible printed wiring boards

C 6471-1995

1. Scope This Japanese Industrial Standard specifies test methods of copper-clad laminates for flexible printed wiring boards (hereafter referred to as "copper-clad laminates").

Remarks 1. The standards cited in this Standard are shown in Attached Table 1.

2. The International standard corresponding to this Standard is given below.

IEC 249-1 (1982) Base materials for printed circuits. Part 1: Test methods.

2. Definitions For the purpose of this Standard, in addition to the definitions in JIS C 0010 and JIS C 5603, the following definitions shall apply:

(1) symbols of base film (hereafter called "film") The symbols of base film are given below:

PET: polyethylene terephthalate film

PIA: pyromellitic acid polyimide film

PIB: biphenyl tetracarboxylic acid polyimide film

(2) symbols of copper foil The symbols of copper foil are given below:

E1: standard electrodeposited copper foil

E2: electrodeposited copper foil with high elongation at ordinary temperature

E3: electrodeposited copper foil with high elongation at 180°C

R1: cold rolled copper foil (without annealing)

R2: lightly cold rolled copper foil (without annealing)

R3: annealed rolled copper foil

(3) MD Longitudinal direction at the time of continuous manufacture of film, copper foil or copper-clad laminate.

Remarks: MD is the abbreviation of "Machine Direction".

(4) TD Lateral direction at the time of continuous manufacture of film, copper foil or copper-clad laminate. Direction perpendicular to MD.

Remarks: TD is the abbreviation of "Transverse Direction".

3. Conditions for testing

3.1 Standard test conditions Unless otherwise specified in the detail specification, tests excluding electrical performance tests shall be carried out under the standard atmospheric conditions for testing specified in 5.3 of JIS C 0010 (temperature: 15°C to 35°C, relative humidity: 25 % to 75 %, air pressure: 86 kPa to 106 kPa). When any doubt arises on the decision made under the standard test conditions or when especially required, the conditions stated in 3.3 shall be employed.

If it is difficult to carry out the tests under the standard test conditions, the tests may be carried out under the conditions other than the standard test conditions unless any doubt arises on the decision.

3.2 Electrical performance test conditions The electrical performance test conditions shall be as stated in 3.3.

3.3 Referee test conditions The referee test conditions shall be the standard atmospheric conditions for referee tests specified in 5.2 of JIS C 0010 (temperature: $20 \pm 2^\circ\text{C}$, relative humidity: 60 % to 70 %, air pressure: 86 kPa to 106 kPa).

3.4 Brightness of testing place The brightness shall be illumination 200 lx (illuminance range 150 lx to 300 lx) or more according to JIS Z 9110.

4. Specimen

4.1 Preparation of specimen Unless otherwise specified in the detail specification, specimen shall be cut from the end of product. If the tolerances on dimensions of specimen are not specified, ± 5 % of the specified dimension shall be taken as the tolerances.

Care shall be taken on the handling of specimen so as not to stain the surface by oils, sweat or other foreign substances.

4.2 Test pattern The shapes and dimensions of test patterns shall be as given in Attached Figs. 1 to 9.

The test pattern shall be dried in a thermostatic chamber at a temperature $80 \pm 5^\circ\text{C}$ for approximately 30 min after etching.

5. Preconditioning The specimens shall be allowed to stand under the standard test conditions for 24 ± 4 h for preconditioning.

6. Appearance and dimension tests

6.1 Appearance

6.1.1 Device A magnifying lens with magnification of approximately 3 shall be used.

6.1.2 Specimen The sizes of specimens shall be as stated in (1) and (2) below.

(1) For pinhole test

- (a) Product of 480 mm width: 480 mm (width as received) × 520 mm (length)
- (b) Product of 240 mm width: 240 mm (width as received) × 1040 mm (length)
- (c) Product of other width: width as received × length which gives an area of 0.25 m² at that width

(2) For dent test

- (a) Product of 480 mm width: 480 mm (width as received) × 260 mm (length)
- (b) Product of 240 mm width: 240 mm (width as received) × 520 mm (length)
- (c) Product of other width: width as received × length which gives an area of 0.125 m² at that width

6.1.3 Test Examine the conditions of specimen surfaces visually or by using a magnifying lens.

6.2 Dimensions6.2.1 Thickness

- (1) Device The device shall be the electrical comparator with minimum indication of 0.1 μm specified in JIS B 7536.
- (2) Specimen Use the copper-clad laminate as received as the specimen.
- (3) Measurement
 - (a) Set the measuring force to 5 ± 1 N, carry out the measurement on 3 points 1 m or more apart each other in the MD for rolled copper-clad laminates, or 5 points covering the whole width in TD at almost equal intervals on each of three sheet form specimens.
 - (b) Take the average of all the measured values as the thickness.

6.2.2 Width

- (1) Device The device shall be the metal rules of grade 1 specified in JIS B 7516 or at least the equivalent in accuracy.
- (2) Specimen Use the copper-clad laminate as received as the specimen.
- (3) Measurement
 - (a) Carry out the measurement on 3 points 1 m or more apart each other in the MD for rolled copper-clad laminate, or the length in TD on each of three sheet form specimens, to a unit of 1 mm while the specimens are held horizontally.
 - (b) Take the average of the measured values as the width.

6.2.3 Length(1) Direct method

- (a) Device The device shall be as specified in 6.2.2 (1).
- (b) Specimen Use the copper-clad laminate as received as the specimen.
- (c) Measurement Hold the specimen horizontally by a suitable method and measure the length in MD.

(2) Weighing method(2.1) Device

- (a) The metal rule specified in 6.2.2 (1).
- (b) A balance of accuracy 0.001 g.
- (c) A balance which can measure the mass of one product roll.

(2.2) Specimen Three pieces of a size $100 \pm 0.5 \text{ cm}^2$ cut out from optional three positions 1 m or more apart each other in the MD of copper-clad laminate roll as received shall be used as the specimens.(2.3) Measurement

- (a) Weigh the net mass of the roll in the unit of 100 g.
- (b) Put the specimen on the balance, and weigh to the nearest 0.001 g.
- (c) Calculate the length L (m) from the following formula and take the average of the calculated values as the length:

$$L = \frac{W \times a}{g \times B}$$

where,

- W : net mass of roll (kg)
- B : width of roll (mm)
- g : total mass of specimens (g)
- a : total area of specimens (mm^2)

7. Electrical performance tests7.1 Volume resistivity7.1.1 Device The device shall be as follows:

- (1) The high insulation resistance meter specified in JIS C 1303 or a resistance measuring device consisting of a standard resistance, universal shunt and a galvanometer calibrated to accuracy $\pm 10 \%$.
- (2) The electrical comparator specified in JIS B 7536 or that at least equivalent in accuracy.
- (3) The vernier calliper with minimum reading of 0.05 mm specified in JIS B 7507 or that at least equivalent in precision.

7.1.2 Specimens Cut the sample to 100 mm square with the thickness as original and prepare the electrodes shown in Attached Fig. 1 by etching.

Set the form and dimensions of electrodes so that the centers of main, counter and guard electrodes coincides as far as possible. However, the counter electrode is allowed to cover the whole rear surface.

In the case of single sided copper-clad laminate, either the conductive coating or adhered copper foil may be used for the counter electrode.

When the conductive coating is used as electrode, it shall have been coated before the preconditioning is made.

7.1.3 Preconditioning The preconditioning shall comply with the specification of 5.

7.1.4 Tests The tests shall be as follows:

(1) Normal state

- (a) Measurement When the measurement is made under normal state, measure the thickness of specimen after preconditioning by the electrical comparator to the nearest 0.1 μm and measure the inside diameter of ring shape clearance of upper electrode by the vernier calliper to the nearest 0.05 mm.

Apply d.c. voltage of 500 ± 5 V and measure the volume resistivity after elapse of one min.

- (b) Calculation Calculate the volume resistivity ρ_v ($\Omega\cdot\text{cm}$) from the following formula:

$$\rho_v = \frac{\pi d^2}{4t} \times R_v$$

where, d : external diameter of circle of surface electrode (cm)

t : thickness of insulation substrate (cm)

R_v : resistance (Ω)

π : ratio of circumference to its diameter

(2) After humidifying treatment

- (a) Treatment Measure the dimensions of the preconditioned specimen same as in the case of normal state test, then put the specimen in thermohygrostatic chamber at a temperature $40 \pm 1^\circ\text{C}$ and relative humidity 90 % to 95 %, leave it for 96 ± 2 h, then take it out and put, for cooling, in a desiccator in which the humidity is controlled by the saturated water solution of sodium tartrate dihydrate specified in JIS K 8540, and the temperature is held at $20 \pm 2^\circ\text{C}$.
- (b) Measurement Take the specimen out of chamber within one h from the end of treatment and complete the measurement of volume resistivity within 3 min in the same way as in the case of (1) (a) normal state.

(c) Calculation Comply with (1) (b).

7.2 Insulation resistance, surface layers

7.2.1 Device The device shall be the same as the volume resistivity testing device of 7.1.1.

7.2.2 Specimen Prepare the specimens by making the electrode shown in Attached Fig. 2, by means of etching.

For double sided copper-clad laminates, prepare specimens of two kinds, i.e., the conductive pattern is formed on front surface and on rear surface.

7.2.3 Preconditioning The preconditioning shall comply with the specification of 5.

7.2.4 Test The test shall be as follows:

(1) Normal state Apply a d.c. voltage of 500 ± 5 V to the specimen and measure the insulation resistance after elapse of 1 min with the voltage applied.

(2) After humidifying treatment

(a) Treatment The treatment shall comply with 7.1.4 (2) (a).

(b) Test The test shall comply with (1).

7.3 Voltage proof, surface layers

7.3.1 Device The device shall be that specified in 6.2 of JIS C 2110 or a device at least equivalent.

7.3.2 Specimen The specimen shall comply with 7.2.2.

The specimens which cause mechanical damage, flashover (surface discharge), sparkover (discharge through air) or dielectric breakdown in this test shall not be used for other tests.

7.3.3 Preconditioning The preconditioning shall comply with the specification of 5.

7.3.4 Test Apply a voltage of 500 V to the specimen by using d.c. voltage or a.c. voltage at a frequency of 50 Hz or 60 Hz. Raise the voltage gradually to the specified voltage in about 5 s, maintain the voltage for 1 min and then examine existence or nonexistence of such abnormalities as mechanical damage, flashover, sparkover and dielectric breakdown.

7.4 Voltage proof between layers

7.4.1 Device The device shall be the same one specified in 7.3.1.

7.4.2 Specimen The specimen shall comply with 7.1.2.

The specimens which cause mechanical damage or dielectric breakdown in this test shall not be used in other tests.

7.4.3 Preconditioning The preconditioning shall comply with the specification of 5.

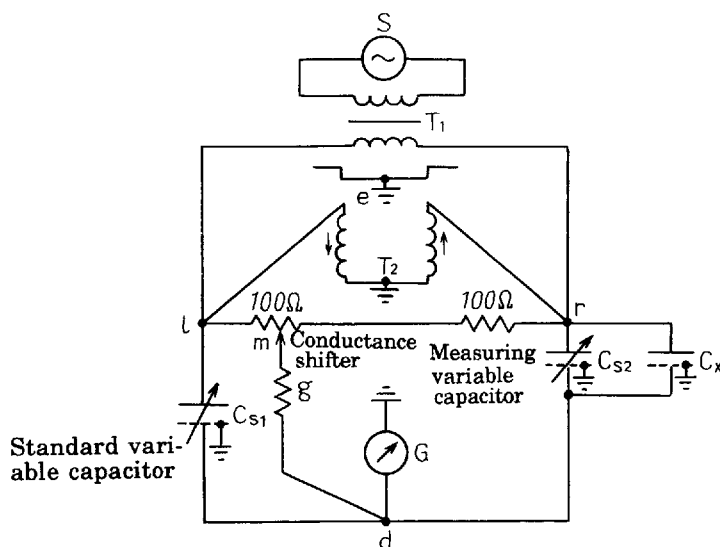
7.4.4 Test Carry out the test as specified in 7.3.4 and examine existence or nonexistence of such abnormalities as mechanical damage and dielectric breakdown.

7.5 Relative permittivity and dissipation factor

7.5.1 Devices The devices shall be as follows:

- (1) Power source (S in Fig. 1) The power source shall be able to generate a frequency of 1 MHz and to apply specified voltage in sinusoidal wave with distortion factor 5 % or under to the specimen and shall be shielded electrostatically and electromagnetically in order to avoid the direct connection of power source and balance detector.
- (2) Bridge
 - (a) Shielding transformer (T_1 in Fig. 1) This is a transformer intended for matching of the internal impedance of power source and the impedance of bridge (about 200 Ω) in which the windings in the bridge side are shielded by earthed conductor. The windings in bridge side shall be split and balanced winding.
 - (b) Ratio arm (T_2 in Fig. 1) Make the ratio arm as described below. Connect non-inductively the primary and secondary windings of a transformer with a turn ratio 1 : 1 (error 0.2 % or less) and small leakage inductance and winding resistance as far as possible, earth the connecting point as shown in e of Fig. 1 and connect other two terminals with l and r.

Fig. 1. Example of transformer bridge method measuring circuit for relative permittivity and dissipation factor tests



- (c) Standard variable capacitor (C_{S1} and C_{S2} in Fig. 1) Prepare two air capacitors equipped with guard and total capacitance of about 200 pF, employ one as standard capacitor C_{S1} and the other as measuring capacitor C_{S2} and insert the specimen C_x parallel to the latter. It is desirable that the capacitance changes slowly in the range of small capacitance and rapidly with increase of capacitance in order to determine the capacitance precisely.

Moreover, it is desirable that the residual resistance and residual inductance of C_{S1} and C_{S2} do not exceed 0.1 Ω and 0.1 μH respectively.

- (d) Conductance shifter A component of bridge in which a constant conductance (g in Fig. 1) is inserted between m and d of Fig. 1, the resistance between l and r is constant (200 Ω) irrespective of the position of m , and the resistance between l and m is variable in the range 100 Ω to 0 Ω and the resistance between m and r is variable in the range of 100 Ω to 200 Ω .

- (3) An equilibrium detecting device G which is responsible only to fundamental wave of power supply voltage applied to the bridge.
- (4) The electrical comparator specified in JIS B 7536 or a meter at least equivalent in accuracy.
- (5) The vernier calliper with minimum reading of 0.05 mm specified in JIS B 7507 or a measuring apparatus at least equivalent in precision.

7.5.2 Specimen Cut the sample into a square of 50 mm with original thickness, and make the electrode shown in Attached Fig. 3 by etching to prepare a specimen.

Arrange the form and dimensions of electrodes so that the centers of main counter and guard electrodes coincide as far as possible, and further make the clearance of ring form between main electrode and the guard to 1 ± 0.1 mm.

In the case of single-sided copper-clad laminates, prepare the specimen in the same way as in 7.1.2

7.5.3 Preconditioning The preconditioning shall comply with the specification of 5.

7.5.4 Test The test shall be as follows:

- (1) Measurement Measure the thickness of the specimen after preconditioning to the nearest 0.001 mm by the electrical comparator.

Measure the external diameter of main electrode by the vernier calliper to the nearest 0.05 mm and further, confirm that the ring form clearance between main electrode and guard is 1 ± 0.1 mm uniformly.

Next, connect the specimen after preconditioning, under the referee conditions specified in 3.3, to the position of C_x as shown in Fig. 1, and measure the value of standard capacitor C_{S1} and the measuring capacitor C_{S2} , the resistance between m and d of conductance shifter, the resistance between l and m and the resistance between m and r when the bridge is brought to equilibrium by adjusting measuring capacitor C_{S2} and the conductance shifter.

The measuring frequency shall be 1 MHz.

- (2) Calculation Calculate the relative permittivity ϵ_r , and dissipation factor $\tan \delta$ from the following formulae:

- (a) Relative permittivity

$$\epsilon_r = \frac{C_x}{C_0}$$

where, C_x : difference in capacitance between standard capacitor C_{S1} and measuring capacitor C_{S2} when the bridge is in equilibrium (pF) ($C_{S1} - C_{S2}$)
 C_0 : capacitance at $\epsilon_r = 1$ calculated from area of main electrode and thickness of specimen (pF) which is calculated by the following formula:

$$C_0 = \frac{r^2}{3.6t}$$

r : radius of main electrode (cm)

t : thickness of specimen (cm)

- (b) Dissipation factor

$$\tan \delta = \frac{G_x}{2\pi f C_x}$$

where, G_x : conductance of specimen (S) which is calculated by the following formula:

$$G_x = G \frac{S}{100}$$

G : conductance between m and d of Fig. 1 (S)

S : resistance between m and r of Fig. 1 (Ω) – 100 (Ω)

$\frac{S}{100}$: resistance ratio at equilibrium point of conductance shifter

f : measuring frequency (Hz)

π : circular constant

8. Mechanical performance test

8.1 Peeling strength of copper foil