ASSOCIATION CONNECTING
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IPC-TM-650
TEST METHODS MANUAL

Number **2.6.3.5**	
Subject **Bare Board Cleanliness by Surface Insulation Resistance**	
Date **01/04**	Revision
Originating Task Group **Bare Board Cleanliness Assessment Task Group (5-32c)**	

1 Scope This test method is used to characterize the cleanliness of printed wiring board fabrication processes by determining the degradation of electrical insulation resistance under conditions of high temperature and humidity.

This test method examines the cleanliness of a test substrate prior to solder mask application, after solder mask application, and after any final metalization and/or surface finish operation (e.g., HASL or OSP), and may be used to demonstrate the cleanliness of internal layers of a mulitilayer board prior to lamination.

2 Applicable Documents

GR-78-CORE Telcordia Technologies (Formerly Bellcore)

2.1 Master Drawings

Telcordia Technologies Test Pattern (GR-78-CORE, Figures 14.1 and 14.2)

IPC-B-50 Standard Test Board (Figure 3)

3 Test Specimens The test specimen for this test method is the interdigitated comb pattern shown in Figures 1 and 2. This test pattern can be produced in a number of formats, but exists as one of the stock patterns of the IPC-B-50 standard test board (see Figure 3).

This comb pattern has 0.65 mm [0.025 in] lines and 1.27 mm [0.050 in] spacings. This test pattern is also commonly referred to as the Bellcore pattern. When used for qualification purposes, the base laminate will be FR-4 epoxy-glass with 17 µm [0.5 oz equivalent] unprotected copper metalization.

4 Apparatus

4.1 Clean test chamber capable of producing and recording an environment of 35°C ± 2°C [95°F ± 3.6°F] and 87.5% ± 2.5% relative humidity, and that allows the insulation resistance of the patterns to be measured under these conditions. The chamber must be capable of holding these conditions under load (i.e., with samples in place).

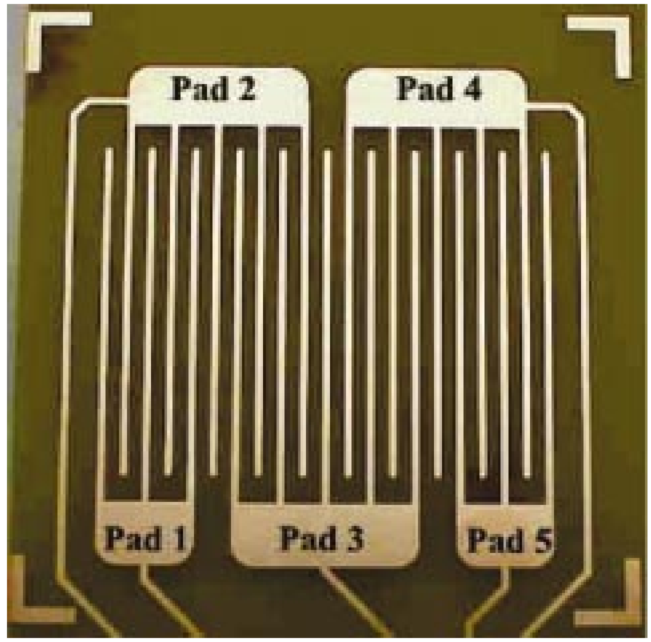

Figure 1 Interdigitated Comb Pattern

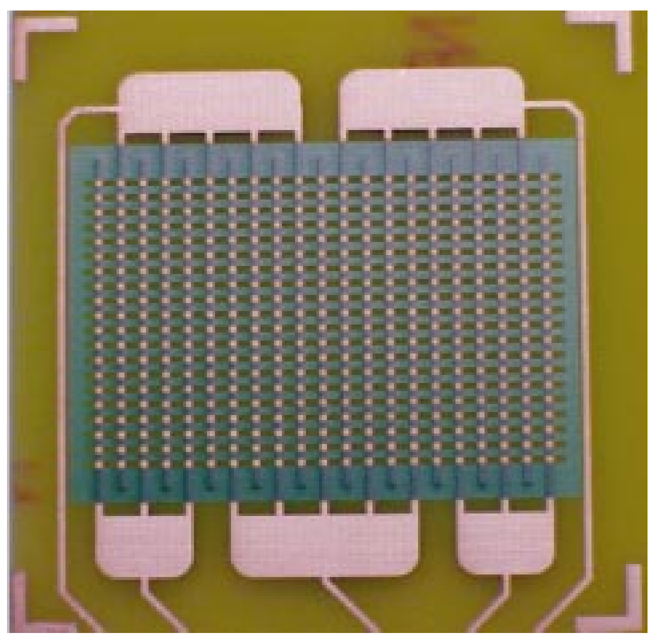
Figure 2 With Solder Mask

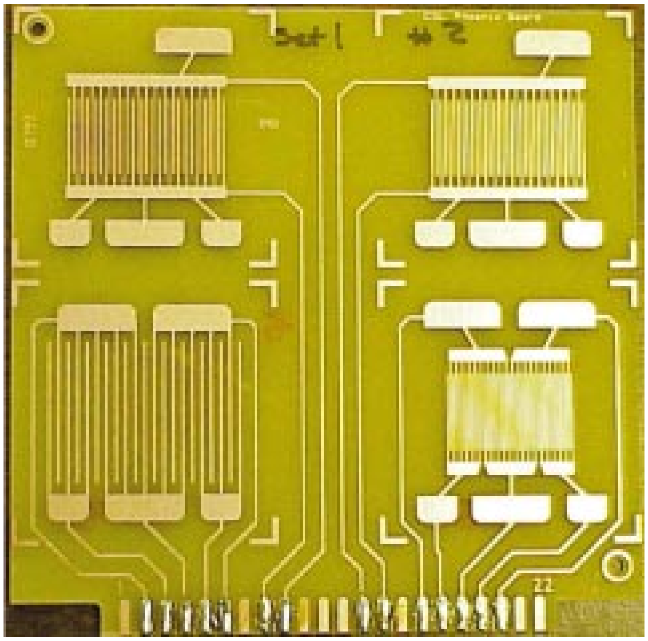

Figure 3 IPC-B-50

4.2 A resistance meter capable of reading high resistance (10^{12}ohms) with a test voltage of 100 ± 2 volts DC or an ammeter capable of reading 10^{-10} amperes in combination with 100 volts DC power supply. Standard resistors should be used for routine calibration.

5 Test

5.1 Sample Sizes

- Eight test patterns are produced for test with no applied solder mask (Figure 1).
- Eight test patterns are produced for test with solder mask applied, imaged, and cleaned (Figure 2).
- Eight test patterns are produced for test with solder mask applied and the final finish in place (e.g., HASL).

5.2 Specimen Identification Use a noncontaminating method for identifying the test specimen (e.g., vibrating scribe). During this process, handle the specimens by the edges only or using noncontaminating gloves.

5.3 Wire Attach Cover the test patterns with noncontaminating barrier, such as aluminum foil or plastic film, to prevent flux spattering during the wire attach process. Use water white rosin to solder PTFE-insulated wires to the connection points of the specimens. Do not attempt to remove the flux residues. Alternatively, connections may be made by mechanical pressure connections (e.g., alligator clips).

NOTE: Because of the very high resistance levels typically used as pass-fail criteria for this method, a connector-based or other fixtured setup is not recommended, due to leakage currents, unless these systems can be shown to have no signal degradation compared to hardwiring.

5.4 Placing in Chamber Place the specimens in the environmental chamber in a vertical position such that the airflow is parallel to the direction of the board in the chamber. Allow at least 2.5 cm [0.98 in] between each test sample. Dress all wiring away from the test patterns. Route the wires to the outside of the chamber. Set the chamber temperature to 35°C [95°F] and 85% minimum relative humidity, with a ramp time of not less than one hour. There is no electrical potential applied to any test pattern during the first 24 hours of test exposure.

5.5 Resistance Measurements After 24 hours of test exposure with no applied electrical potential, measure the insulation resistance of each pattern using an applied voltage of 100 ± 2 volts DC and an electrification time of 60 seconds.

NOTE: It is recommended that the temperature and humidity levels be verified to be within the recommended limits prior to beginning the resistance measurements.

Each comb pattern represents four test measurements. Measurements are made between (see Figure 1):

- Pad 1 to Pad 2
- Pad 3 to Pad 2
- Pad 3 to Pad 4
- Pad 5 to Pad 4

Pads 2 and 4 are at one potential and Pads 1, 3, and 5 are at the opposite potential (see Note 6.3).

All measurements are to be taken with the specimens at the test conditions and inside the chamber (in-situ).

Determine the means of the dataset as outlined in 5.6.

If, after 24 hours, the results conform to the specification, record the values and terminate the test.

If, after 24 hours, the results do not conform to the specification, then the test may be extended to 96 hours of exposure to the test conditions with no applied electrical potential.

After 96 hours total, repeat the measurement series. Regardless of the outcome of the measurements, the test terminates after this measurement series.

5.6 Data Analysis The average insulation resistance (IR_{avg}) is calculated as follows:

$$IR_{avg} = 10\left[\frac{1}{N}\sum_{1}^{N}\log_{10}(IR)_i\right]$$

Where:
N = Number of Test Points (32 nominal for each set of eight patterns)
IR_i = individual insulation resistance measurements
See 6.4 for an example

No individual insulation resistance value may be more than a factor of 10 below the specified minimum value.

Where an assignable cause of low insulation resistance, which is properly attributable to the laminate itself, or to the process used to produce the PWB, can be found, then such a value can be excluded from calculating the average value, provided that at least 30 test points are included in the average. Such assignable causes include the following:

- Contamination on the insulating surface of the board, such as lint, solder splines or water droplets from the chamber.
- Incompletely etched patterns that decrease the insulating space between the conductors by more than the amount allowed in the appropriate design requirements drawing.
- Scratched, cracked, or obviously damaged insulation between conductors.

6 Notes

6.1 If condensation occurs on the test specimens in the environmental chamber while the samples are under voltage, dendritic growth will occur. This can be caused by a lack of sufficient control of the humidification of the oven. Water spotting may also be observed in some ovens where the airflow in the chamber is from back to front. In this case, water condensation on the cooler oven window can be blown around the oven as microdroplets which deposit on test specimens and cause dendritic growth if the spots bridge the distance between two electrified conductors. Both of these conditions must be eliminated for proper testing.

6.2 Tight control of the test humidity is critical for this test method. A difference of 5% relative humidity can result in a 0.5 - 1.0 decade difference in the measured resistance. The uniformity of the environment is also important. A fully loaded chamber, where airflow is severely impeded, may have a 30-40% RH range within the chamber workspace.

6.3 The polarity of the applied voltage is not important as long as the application is consistent (e.g., Pads 1, 3, 5 are positive and 2, 4 are at opposite potential, vs. Pads 2 and 4 positive, and Pads 1, 3, 5 at opposite potential).

6.4 Example of Numerical Calculations

Eight 5-point test patterns (4 measurements each)
LogOhms = base-10 logarithm of measured resistance
Average of LogOhms = 11.62
IR_{AVE} = Antilog (11.62) = 4.19E+11 ohms
IR_{AVE} = Geometric Mean

NOTE: 3.98E+11 = 3.98 x 10^{11}

NOTE: In many spreadsheet software packages (.e.g, Excel®), a Geometric Mean function will yield the same results as IR_{AVE}.

No.	Pattern	Resistance (Ohms)	LogOhms
1	1-2	3.98E+11	11.60
2	3-2	1.58E+11	11.20
3	3-4	6.31E+11	11.80
4	5-4	7.94E+11	11.90
5	1-2	1.00E+12	12.00
6	3-2	1.00E+12	12.00
7	3-4	3.98E+11	11.60
8	5-4	1.58E+12	12.20
9	1-2	1.26E+12	12.10
10	3-2	1.26E+12	12.10
11	3-4	1.00E+12	12.00
12	5-4	3.98E+11	11.60
13	1-2	5.01E+11	11.70
14	3-2	2.00E+11	11.30
15	3-4	1.26E+11	11.10
16	5-4	1.26E+11	11.10
17	1-2	2.51E+11	11.40
18	3-2	1.58E+11	11.20
19	3-4	2.51E+11	11.40
20	5-4	3.98E+11	11.60
21	1-2	1.26E+12	12.10
22	3-2	5.01E+11	11.70
23	3-4	2.00E+11	11.30
24	5-4	2.00E+11	11.30
25	1-2	7.94E+11	11.90
26	3-2	1.00E+12	12.00
27	3-4	3.98E+11	11.60
28	5-4	7.94E+11	11.90
29	1-2	1.26E+11	11.10
30	3-2	6.31E+11	11.80
31	3-4	2.00E+11	11.30
32	5-4	1.00E+11	11.00