ASSOCIATION CONNECTING
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IPC-TM-650
TEST METHODS MANUAL

Number **2.6.3.7**	
Subject **Surface Insulation Resistance**	
Date **03/07**	Revision
Originating Task Group **SIR Task Group (5-32b)**	

1 Scope This test method is used to quantify the deleterious effects of fabrication, process or handling residues on Surface Insulation Resistance (SIR) in the presence of moisture. The electrodes are long parallel traces (printed interdigitated comb patterns) on a standardized printed board or assembly. Samples shall be conditioned and measurements taken at a high humidity. Electrodes are electrically biased during conditioning to facilitate electrochemical reactions.

Specifically, this method is designed to:

- Simultaneously assess
  a) leakage current caused by ionized water films and
  b) electrochemical degradation of test vehicle, (corrosion, dendritic growth).
- Provide metric(s) that can appropriately be used for binary classification (e.g., go/no go, pass/fail).
- Compare, rank or characterize materials and processes.

2 Applicable Documents

2.1 IPC

IPC-A-24-G-KIT[1] Surface Insulation Resistance - Gerber Kit

J-STD-004 Requirements for Soldering Fluxes

IPC-A-600 Acceptability of Printed Boards

IPC-9201 Surface Insulation Resistance Handbook

2.2 American Society for Testing and Materials (ASTM)

ASTM D 257 Standard Test Methods for DC Resistance or Conductance of Insulating Materials

2.3 American National Standards Institute (ANSI)/NCSL International

ANSI/NCSL Z540-1 Calibration Laboratories and Measuring and Test Equipment - General Requirements

ANSI/NCSL Z540-2 American National Standard for Expressing Uncertainty - U.S. Guide to the Expression of Uncertainty in Measurement

2.4 International Electrotechnical Commission

IEC-61189-5 Test methods for electrical materials, interconnection structures and assemblies - Test methods for printed board assemblies

3 Test Samples The type and number of test samples (coupons) as well as method of preparation and test requirements should be described in the governing specification (e.g., J-STD-004) or procurement documentation.

If this test method is being used as a stand-alone document, decisions should be made regarding what samples might be the most appropriate for test. This SIR method should not be considered standard unless standard test vehicles are used.

Vehicles prepared for flux qualification shall be handled in a way that minimizes the possibility of ionic contamination. Use of ion-free gloves and wrap/bags is required. If testing a process, standard shipping and handling procedures shall be used.

For further information about sampling and sampling sizes see 7.1 and 7.1.2.

The IPC-A-24-G-KIT artwork package provides the necessary Gerber files for the fabrication of the standard IPC-B-24 test board used with this test method.

3.1 Test Controls Two cleaned bare IPC-B-24 test boards (bare copper on FR-4) shall be used as chamber controls.

3.1.1 Visually inspect the boards for any obvious defects, as described in IPC-A-600. If there is any doubt about the overall quality of any test sample, the board should be discarded.

3.1.2 Clean each control board by using deionized or distilled water and scrubbing with a soft bristle brush for a minimum of 30 seconds. Spray rinse thoroughly with deionized or distilled water. Rinse cleaned area thoroughly with virgin 2-propanol.

An alternative cleaning method is to place the test board in an ionic contamination tester containing 75% 2-propanol, 25% deionized water and process the solution until all ionics have been removed.

1. www.ipc.org/onlinestore

During the remainder of the preparation, handle boards by the edges only and use noncontaminating gloves.

3.1.3 Dry the cleaned boards for two hours at 50 °C.

3.1.4 If boards are to be stored before treatment, place the boards in Kapak™ bags or other contamination-free containers (do not heat seal) in a desiccator. (Kapak™ bags are available from Fischer, VWR and other distributors.)

3.1.5 When measured as described in Sections 4 and 5, if the control board readings are less than 1000 MΩ at any point after the initial 24 hours of SIR exposure, a new set of test coupons shall be obtained and the entire test repeated.

3.2 Blank Process Controls If performing process validation testing, two samples from an unprocessed blank should be run with the samples taken from the processed boards. Values obtained from unprocessed board samples are useful when failure is observed within the processed board sample. Failure of the unprocessed samples may indicate a problem with the incoming bare board rather than an assembly process.

4 Equipment/Apparatus It is the responsibility of the user of this method to verify equipment suitability. This method intends for all tolerances to be interpreted as uncertainties with a confidence interval of 95% as referenced in ANSI/NCSL Z540-1 and ANSI/NCSL Z540-2. Quantitative, qualitative and default information follow in the paragraphs below.

4.1 Electrometer Electrometer, High Resistance Meter, Picoammeter or equivalent as described by ASTM D 257.

a) System must be capable of taking measurements and controlling the switching automatically (unattended).
b) Minimum resistance measurement accuracy (not only meter, but as implemented)
   5% of full scale up to $10^{10}\Omega$ @ 5V
   10% of full scale up to $10^{11}\Omega$ @ 5V
   20% of full scale above $10^{11}\Omega$ @ 5V
c) Accuracy with respect to the ''true'' value requires assessment of stability of the measurement system (after switching from bias voltage to the measurement voltage). Therefore, if the system does not automatically assess stability before logging, use an arbitrary time of one minute.
d) The system described in this section must be able to make all measurements required within a 20 minute period and meet the requirements of 5.3.

It is preferred that the resistance reading be stable before acquiring the readings or data. If after one minute the signal remains unstable, a measurement should still be recorded.

4.2 Switching System

a) Must have a channel-to-channel isolation resistance ten times greater than the resistance of typical SIR requirements, or a default channel-to-channel isolation resistance of $10^{12}\Omega$.
b) <20-minute cycle while obtaining measurements as described above.
c) Unique $10^{6}\Omega$ current limiting capability per channel.

4.3 Wire Attachments

a) Single solid copper wire with PTFE insulation.
b) Preferred solid wire solders (no flux), or nominally 1% by weight rosin nonactivated. See wire attach section of this document for more information.
c) Electrical (EMI) shielding to guard cabling from stray currents.

4.3.2 Alternative Wire attachments such as stranded wire, non-PTFE insulation, edge connectors rather than hard wiring, and guarding techniques may be used provided the system accuracy is not compromised.

4.4 Controlled Temperature and Humidity Chamber

a) Produce 40 ± 1 °C at 90 ± 3% R.H.
b) Continuous or semicontinuous recording of this environment. ± 2 °C and ± 3% R.H.
c) Samples should not significantly impede airflow.
d) Adequate mixing of water vapor and air is imperative to ensure condensation does not occur anywhere in the chamber except on/around cooling or dehumidification coils. If any part of interior of the chamber is below the dew point (possibly due to insulation or control issues), condensation will occur. This is not necessarily a problem as long as the samples are kept above the dew point and are shielded from dripping or flying condensate.

4.5 Camera Camera capable of recording color image.

5 Test Procedure

5.1 Interconnect Samples

5.1.1 Hardwired samples need to be soldered without adverse effect to test vehicles. Common good soldering practice should be followed. Sample should be covered. See IPC-9201 for reference. Heat should not be allowed to damage sample. Flux is of great concern. Often samples can be soldered without the use of flux, so users of this method should have solid wire solder on hand. If flux is deemed necessary by qualitative observation, use rosin nonactivated flux.

Wire all samples and retain relationship of interconnection between test vehicle and testing system (nets, channels, etc.).

5.1.2 Connector interfacing inside the chamber has been shown to be a capable implementation for SIR; however, as the connectors are exposed to high heat and humidity they obviously require a good deal of maintenance and verification.

5.2 Fixture samples in the chamber uniformly, vertically, and parallel to airflow. The minimum spacing between samples shall be 12.5 mm [0.5 in]. If hardwiring is used, dress wires down from samples. Make appropriate connections to switching system.

5.3 Measurement and stress bias voltage are the same.

5.3.1 Apply direct current electrical bias to produce a field strength of 25 ± 1 V/mm between adjacent parallel traces. Assuming that SIR is much greater than current limiting resistance this field corresponds to an applied voltage of 5 ± 0.2 V for 200 µm [0.0079 in] spacing (example is technically equivalent to IEC 61189-5). This bias shall be in place during an aggregate 90% (minimum) of temperature/humidity conditioning (remaining percentage is related to measurement) in order to facilitate electrochemical reactions.

5.3.2 Seal the chamber and ramp from laboratory ambient conditions to 25 °C and 50% R.H. Dwell for one hour. Verify the electrical system setup by taking a series of all measurements at these specified ambient conditions. Because classification or ranking of sample performance by SIR at ambient is not appropriate for these test vehicles, clarity suggests that measurements need not be reported unless ''shorts'' are observed and therefore the corresponding samples are deemed inappropriate for test.

5.4 Increase the temperature to 40 °C while maintaining the humidity at 50% R.H. ± 3% R.H. and dwell at this temperature for 15 minutes. After this period, gradually increase, within 0.5 hour, the relative humidity to 90 ± 3 % R.H. Do not allow the temperature of the samples to drop below the dew point.

5.5 Allow chamber to stabilize at set point for one hour.

5.6 Duration of test shall be not less than 72 hours.

5.7 Take and record all SIR measurements (every unique net or channel) at least once every 20 minutes.

5.8 After conditioning, remove samples from chamber and examine at 30 to 40X in light field and dark field (back light). Record the following:

a) Presence of dendrites: Yes/No
b) Maximum percent reduction of spacing: 0% for no dendrites 1% to 100% for worst-case dendrite. Capture and record image of worst case dendrite.
c) Presence of discoloration between conductors: Yes/No; if yes, capture and record image.
d) Presence of water spots. Yes/No; if yes, capture and record image.
e) Presence of subsurface metal migration. Yes/No; if yes, capture and record image.

6 Reporting

6.1 Deviations from test method or specification shall be recorded. All standard reporting shall be incorporated, including enough information to exactly reproduce the test (equipment, personnel, deviations or options within the method etc.).

6.2 All items listed in 5.8.

6.3 All SIR measurements are to be reported in the form of Log_{10} (R_i), where R_i is the measured SIR of the i^{th} measurement.

7 Notes

7.1 Sampling When using this test method for materials characterization the sample selection, preparation and requirements should follow IPC-J-STD-004.

When using this test method for process characterization the sample selection, preparation and requirements should follow IPC-J-STD-001.

This methodology may also be used with other specifications.

7.1.1 A *test vehicle* should be considered a sample count of one. For example, an IPC-B-24 test vehicle is a sample count of one, even though there are four distinct comb patterns and measurements.

7.1.2 Sample Sizes The number of samples should not be stipulated in the test method. The number should be in the specifications referring to this test method. However, it is recognized that there will be users who are attempting process or material characterization and may be uncertain about how many samples to specify.

With respect to the second bulleted item in the scope, (Provide metric(s) that can appropriately be used for binary classification (e.g., go/no go, pass/fail), a minimum sample size of 10 is suggested.

With respect to the third bulleted item in the scope, (Compare, rank or characterize materials and processes) a minimum sample size of three is suggested.

7.1.3 When characterizing material, samples can be processed on the same panel.

7.1.4 When characterizing process(es), samples should at a minimum be processed on different panels, preferably in different production runs.

7.2 The derived unit of surface resistivity and its expression as ohm/square cannot be defined for this method or similar methodologies due to the nonlinear response of the test vehicles and the assumed nonhomogeneous concentration of ionic contaminates.

7.3 Careful considerations must be used when developing an implementation of this method. Seemingly adequate setups can (and historically have) caused unacceptable uncertainty of results. If the user of this method is not intimately familiar with the technologies involved, ASTM D 257 and IPC-9201 are highly recommended.