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Second edition
2024-01

Soft soldering fluxes — Test methods —

Part 17: Surface insulation resistance comb test and electrochemical migration test of flux residues

Flux de brasage tendre — Méthodes d'essai —

Partie 17: Essai au peigne et essai de migration électrochimique de résistance d'isolement de surface des résidus de flux

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 12, *Soldering materials*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 121, *Welding and allied processes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 9455-17:2002), which has been technically revised.

The main changes are as follows:

— in Clause 1 the applicability was clarified;

— in 6.5 the test coupon was aligned with IPC B53 from IEC 61189-5-501;

— in 9.5 the duration of the test was changed from 21 days to 1 000 h.

A list of all parts in the ISO 9455 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html. Official interpretations of ISO/TC 44 documents, where they exist, are available from this page: https://committee.iso.org/sites/tc44/home/interpretation.html.

Soft soldering fluxes — Test methods —

Part 17: Surface insulation resistance comb test and electrochemical migration test of flux residues

1 Scope

This document specifies a method of testing for deleterious effects that can arise from flux residues after soldering or tinning test coupons. The test is applicable to type 1 and type 2 fluxes, as specified in ISO 9454-1, in solid or liquid form, or in the form of flux-cored solder wire, solder preforms or solder paste constituted with eutectic or near-eutectic tin/lead (Sn/Pb) or Sn95,5Ag3Cu0,5 or other lead-free solders as agreed between user and supplier (see ISO 9453).

This test method is also applicable to fluxes for use with lead-containing and lead-free solders. However, the soldering temperatures can be adjusted with agreement between tester and customer.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 9454-1, *Soft soldering fluxes — Classification and requirements — Part 1: Classification, labelling and packaging*

IEC 61189-5-501, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies — Part 5-501: General test methods for materials and assemblies — Surface insulation resistance (SIR) testing of solder fluxes*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Principle

The objective of this test method is to characterize fluxes by determining the degradation of electrical resistance and the electrochemical migration of rigid printed wiring coupon specimens after exposure to the specified flux. This test is carried out at high humidity and heat conditions under bias voltage. For fluxes which can leave undesirable residues and hence require cleaning, the results obtained from the test will depend on the characteristics of the flux residue, substrate and metallization, and also on the effectiveness of the cleaning operation.

The measurement of surface insulation resistance (SIR) makes use of a printed wiring coupon substrate having one or more conductive interleaved test patterns. Prior to being subjected to conditioning, the interleaved test patterns are fluxed, soldered or tinned, and cleaned (when required). The patterns are then exposed to a controlled environment for a specified time with an applied voltage. The surface insulation resistance is measured using insulation test apparatus at a suitable test voltage while the test coupons are in the controlled environment. Annex A provides further information on SIR testing.

5 Reagents

Use only reagents of recognized analytical grade or higher and only distilled or deionized water with a conductivity of less than 0,05 µS/cm (resistivity ≥ 20 MΩ).

5.1 Propan-2-ol, $(CH_3)_2CHOH$ or other suitable solvent.

5.2 Cleaning solvent (if required), recommended by the flux manufacturer as suitable for the removal of post-soldering flux residues or propan-2-ol.

6 Apparatus

Equipment shall be capable of demonstrating repeatability in accordance with the gauge r and R methodology specified in ISO 5725-2. The usual laboratory apparatus and, in particular, the following shall be used.

6.1 Low profile container, for example a Petri dish or a watch glass.

6.2 Drying oven, suitable for use at up to 120 °C ± 3 °C.

6.3 Insulated wire or cable, 1 000 V general-purpose wire, temperature rated to 150 °C; primary insulation of radiation-crosslinked; configuration suitable for equipment in use.

For consistent and repeatable results, it is important that all cabling carrying test signals be encased in an electromagnetic shield. Most often, this is a metallic foil or braid material. Since SIR measurement often deals with picoamperes of current or less, electromagnetic coupling (EMC) and other stray electrical fields can unduly affect the test signals. Encasing the signal lines with a grounded metal dramatically reduces currents due to EMC and other electrical noise. It is not necessary to individually shield each line, such as in coaxial cabling, but separating voltage supply lines and current-return lines is recommended. A single EMC shield can be used to encase all current-return lines.

6.4 Connector, 64-position, glass filled polyester body with the following properties:

— 1,27 mm × 10,67 mm (0,05 in × 0,42 in) on 2,54 mm (0,10 in) centres;

— 32 tabs, gold-plated over nickel plate over copper;

— 0,762 µm (0,000 03 in) gold plated post/pin mating end;

— bifurcated beam contacts;

— for coupon thickness of 1,40 mm to 1,78 mm (0,055 in to 0,070 in);

— capable of resisting temperatures up to 105 °C.

The IR (insulation resistance) of pin to pin at the connector shall have a resistance under climate and temperature conditions, with a minimum of 1 012 Ω under test conditions. The connector shall be suitable for use under different test conditions.

6.5 Test coupon. The test pattern IPC B53 according to IEC 61189-5-501, as shown in Figure 1, shall be used for the test specimen. Of the six comb patterns, A and B patterns have 0,4 mm line width and 0,2 mm

spacing, comprising 5 207 squares (IEC 61189-5-501); C and D patterns have 0,4 mm line width and 0,5 mm spacing, comprising 1 038 squares (IPC B24); and E and F patterns have 0,318 mm line width and 0,318 mm spacing, comprising 1 981 squares (Bellcore).

NOTE The Bellcore/Telcordia standard assumes a serial model for electronic parts and it addresses failure rates at the infant mortality stage and at the steady-state stage with Methods I, II and III.[2,3] Method I is similar to the MIL-HDBK-217F parts count and part stress methods. [6]

The specimen is approximately 150 mm × 95 mm in size. The conductive patterns shall be either unpreserved bare copper or finished with electroless nickel gold (ENIG).

— 32 tabs, gold-plated over nickel plate over copper;

— 1,27 mm × 10,67 mm (0,05 in × 0,42 in) on 2,54 mm (0,10 in) centres.

The test pattern shall comply with Table 1 and the test coupon shall comply with Figure 1:

Table 1 — Test pattern

Type of SIR test patterns	A and B	C and D	E and F
Width of conductor	0,4 mm	0,4 mm	0,318 mm
Spacing of conductor	0,2 mm	0,5 mm	0,318 mm
Overlap length	25,4 mm	15,25 mm	15,75 mm
Overlapping spaces	41	34	40
Squares (nominal)	5 207	1 038	1 981

NOTE Spaces are determined by counting the number of overlapping areas per pattern. Squares are determined by:

$$\frac{l_o \times n_s}{w_s} = q$$

where

l_o length of overlap

n_s number of spaces

q squares

w_s spacing width

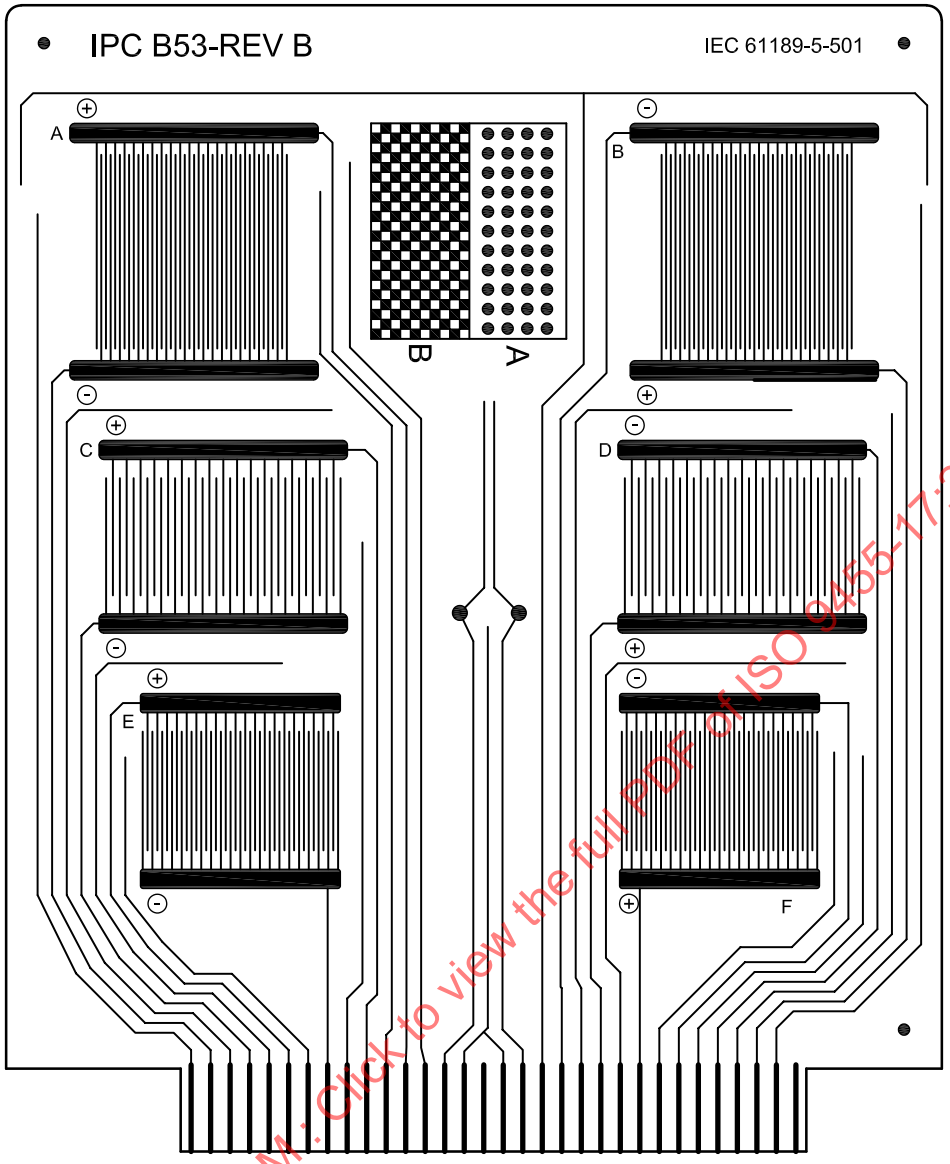

Figure 1 — IPC B53-Rev B test coupon[1)]

6.6 Soldering equipment.

6.6.1 Flux-cored solder wire. If cabling is connected by soldering, non-activated flux of ISO 9454-1, classification 1111, shall be used, tin/lead or lead-free solder shall be agreed between user and supplier conforming to eutectic or near-eutectic tin/lead (S Sn60Pb40E or S Sn63Pb37) or lead-free solder (Sn95,5Ag3Cu0,5 or other lead-free solders as agreed between user and supplier, see ISO 9453).

NOTE This wire consists of 60/40 or 63/37 tin/lead solder wire or Sn96,5Ag3Cu0,5 or other lead-free solder wire agreed between user and supplier with a core of non-activated rosin (colophony) flux (ISO 9454-1, classification 1111).

6.6.2 Wave solder system, comprising a wave-soldering machine with the solder in a bath. Tin/lead or lead-free solder shall be agreed between user and supplier and conform to eutectic tin/lead (Sn63Pb37) or lead-free solder (Sn95,5Ag3Cu0,5 or other lead-free solders as agreed between user and supplier, see ISO 9453). The set point temperature shall be maintained to ±5 °C.

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6.6.3 Static bath, containing solder to a depth of not less than 40 mm. Tin/lead or lead-free solder shall be agreed between user and supplier and conform to grade Sn63Pb37E or Sn96,5Ag3Cu0,5 or other lead-free solder agreed between user and supplier. The set point temperature shall be maintained to ±5 °C.

6.6.4 Reflow oven, with controllable temperature profiling.

6.6.5 Soldering iron.

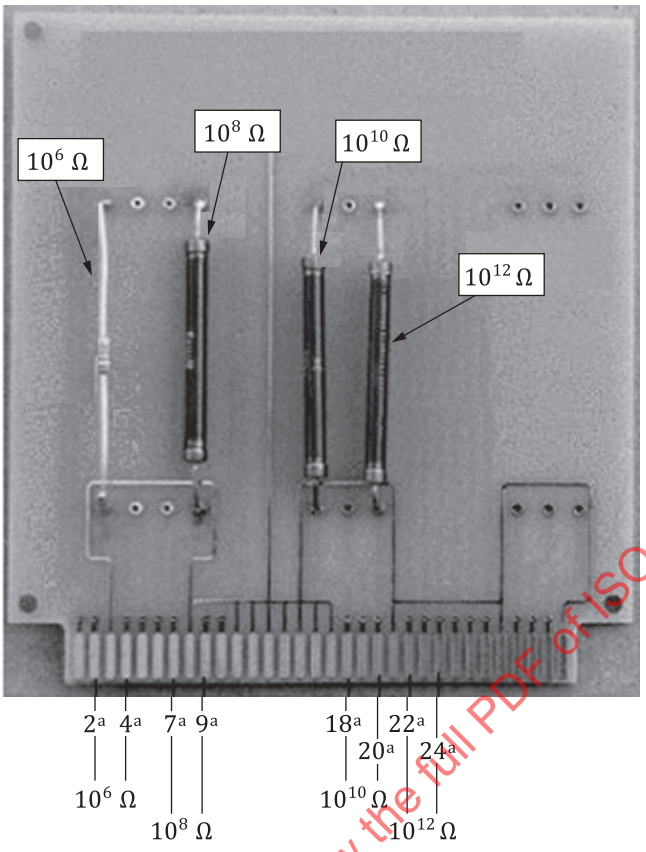
6.7 Humidity chamber, capable of maintaining environments up to 90 °C with temperature control of ±2 °C and relative humidity (RH) up to 95 % with control of ±3 % at a specific RH set point when loaded with test coupons. The chamber shall be constructed with stainless steel inner surfaces and be well insulated. Some solid-state sensors cannot tolerate high temperature and humidity. The temperature and humidity levels of the test chamber shall be recorded throughout the test, preferably with independent control sensors.

If used, independent temperature and humidity sensors should be located in close proximity to the test coupons. Conformance with these conditions will ensure that uniform test conditions can be maintained while the chamber is under test load.

6.8 High-resistance measurement system, capable of measuring surface insulation resistance (SIR) in the range of at least 10^6 Ω to 10^{12} Ω and with a test and bias voltage supply capable of providing a variable voltage from 5 V to 100 V direct current (d.c.) (±2 %) with a 1 MΩ load. The sample selection system shall be capable of individually selecting each test pattern under measurement. The system shall incorporate a 1 MΩ current limiting resistor in each current pathway. The tolerance of the total measurement system shall be ±5 % up to 10^{10} Ω, ±10 % between 10^{10} Ω to 10^{11} Ω, and ±20 % above 10^{11} Ω.

6.9 Resistor verification coupon, with the same dimensions as the test coupon, with four resistors with the values 10^6 Ω, 10^8 Ω, 10^{10} Ω and 10^{12} Ω in specific current pathways as shown on Figure 2. It shall have a

protective metal (stainless steel) cover attached with stainless hardware to the grounded mounting holes on the coupon to protect the resistors from contamination or damage during handling (see Figure 3).



[a] Test coupon tab connectors.

Figure 2 — Resistor verification coupon

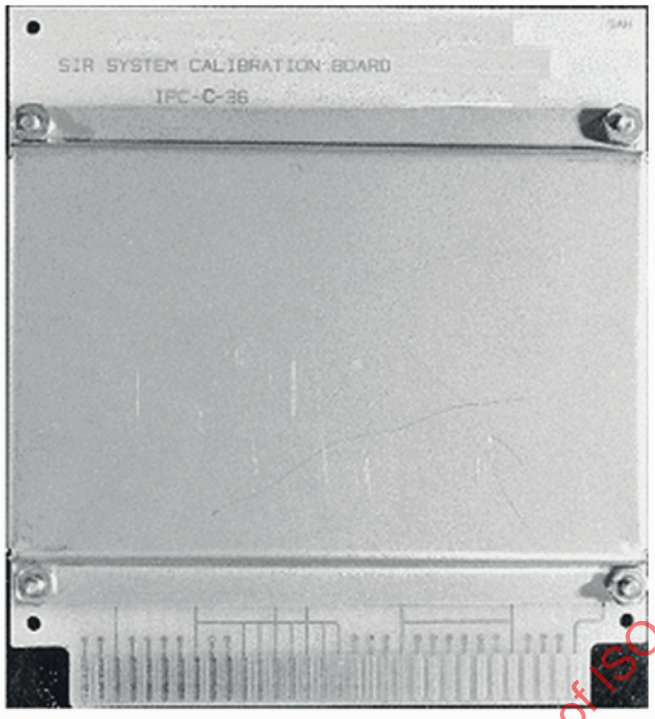


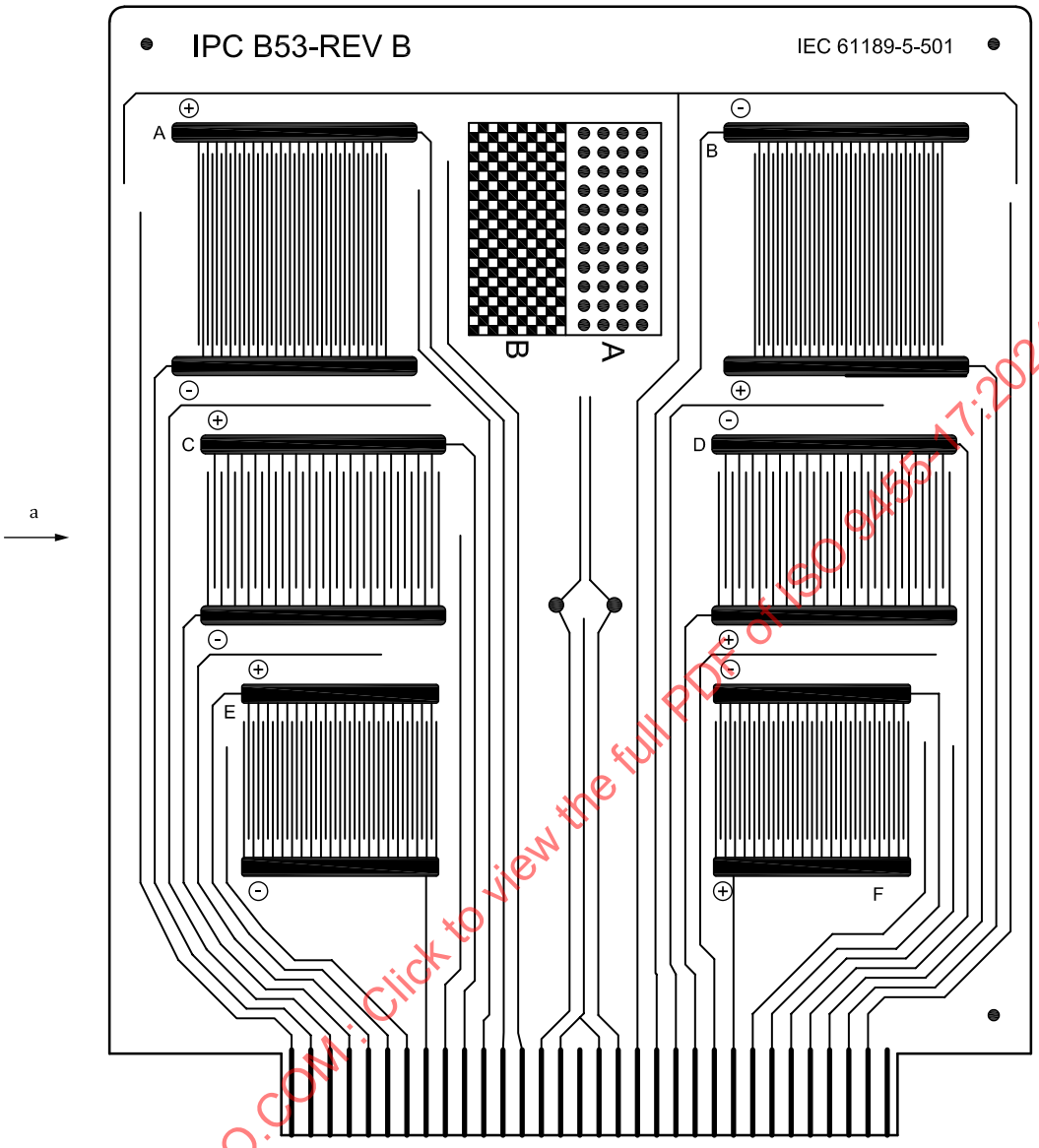
Figure 3 — Resistor verification board with protective cover

6.10 Soft bristle brush.

6.11 Scalpel, doctor blade or equivalent, cutting tool for solder wire.

6.12 Analytical balance, capable of measuring to an accuracy of 0,000 1 g, for solvent extract method.

6.13 Test coupon fixing device, capable of uniformly spacing coupons (minimum of 15 mm), parallel to air flow with the connector (if present), in accordance with Figure 4.



a Air flow.

Figure 4 — IPC B53-Rev B test coupon location with respect to chamber air flow

6.14 Soxhlet extraction apparatus.

7 Inspection of test coupons

7.1 Surface plating

7.1.1 Slivering (thin metal overhang on etch runs)

Copper tracks on test coupons shall be free of slivering since the slivers are prone to breaking off with the associated possibility of creating electrical short circuits during SIR testing.

NOTE Slivering is sometimes associated with surface plating or etching.

7.1.2 Plating nodules

Plating nodules on the edges of etch runs shall be kept to a minimum and in no case shall nodules violate minimum conductor design electrical spacing requirements. Nodules, if present, shall not be loose nor flake on to the laminate substrate.

7.1.3 Plating pits

All conductors and plated-through lands shall be free of plating pits.

Gold-plated card edge connector pads shall be free of plating pits that expose copper or nickel.

7.2 Surface laminate

Measles or crazing of the bare printed coupon, if present, shall not exceed 1 % of the coupon area. There shall be no more than 25 % reduction in space between electrically uncommon conductors due to measling or crazing. A separate determination shall be made for each side of the coupon.

The area of measling or crazing is determined by combining the area of each measle or craze and dividing by the total area of the printed coupon.

The referee test (destructive) to determine propagation of measling or crazing is to pre-condition the test coupon and then solder-float the specimen on a solder bath at a temperature of (260 ± 5) °C for a period of 5 s.

Total measling or crazing of the assembled test coupon shall not exceed 2 % of the test coupon area. There shall be no more than a 50 % reduction in the space between electrically uncommon conductors.

The area of measling or crazing is determined by combining the area of each measle or craze and dividing by the total area of the printed coupon. A separate determination is made for each side of the coupon.

Conductor edges, if not smooth and even, shall be within design tolerances.

8 Sample preparation

8.1 Preparation of the flux test solution

8.1.1 Liquid flux samples

Use liquid flux samples, as received (i.e. unmodified), as the flux test solution.

8.1.2 Solid flux samples

Prepare a solution with mass fraction of 25 % of the solid flux sample in propan-2-ol, ethanol or other solvent recommended by the flux manufacturer's instructions.

8.1.3 Flux-cored solder wire or preform samples

If a sample of the solid flux used in the cored solder wire or preform is not available from the flux manufacturer, then use the following method to prepare samples.

Cut a length of the flux-cored solder wire or preform weighing approximately 150 g and seal the ends by crimping. Wipe the surface clean with a cloth moistened with propan-2-ol (5.1). Place the sample in a beaker, add sufficient water to cover the sample and boil for 5 min to 6 min. Remove the sample, rinse with propan-2-ol and allow to dry.

Protecting the solder surface from contamination, cut the sample into 3 mm to 5 mm lengths using a scalpel (6.11) and avoid crimping the cut ends. Weigh and place the cut segments into the extraction tube of a clean Soxhlet extraction apparatus (6.14) and extract the flux with propan-2-ol, or other suitable solvent (5.2),

until the return condensate is clear. Calculate the approximate non-volatile matter content of the extract from the loss in mass of the segments and the volume of the extract.

To produce the flux test solution, adjust the non-volatile matter content of the extract to a mass fraction of 25 %, by evaporation or by dilution with the solvent used during the extraction stage.

8.1.4 Solder paste samples

Use solder paste samples, as received (i.e. unmodified), as the solder paste test material.

8.1.5 Paste flux samples

Use paste flux samples, as received (i.e. unmodified), as the paste flux test material.

8.2 Preparation of the test coupons

8.2.1 Sample identification

Following inspection, in accordance with Clause 6, mark test coupons using a positive, permanent and non-contaminating method, for example with an engraving tool, so that they can be identified.

8.2.2 Test coupons

The preparation and number of test coupons shall be in accordance with Table 2 and is dependent on the sample group. Include a minimum of two control coupons for each test run in each test chamber.

Each test coupon shall comprise six test patterns as described in 6.5.

For Group A, prepare a minimum of three test coupons for each liquid flux, paste flux, solid flux, flux-cored solder wire and flux-cored preform to be tested in the cleaned state. If more than three test coupons are used, report all results.

When testing fluxes which are intended to remain in the uncleaned state use six test coupons. Wave solder three uncleaned test coupons pattern side down (group B of Table 2) and three test coupons pattern side up (group C of Table 2).

Reflow solder paste coupons pattern side up and either clean (group D of Table 1) or not (group E of Table 1), depending on the intended usage of the flux.

Pre-clean group F coupons (see 8.2.3) but neither flux, solder nor post-solder clean.

Preconditioning of SIR test coupons (see 9.1.2) may be used to determine initial coupon cleanliness levels.

Table 2 — Minimum number of patterns for SIR test

Sample group	Flux/solder	Clean	Number of test patterns
A	Yes	Yes	3
B	Yes	No	3
C	Yes	No	3
D	Yes	Yes	3
E	Yes	No	3
F	No	No	2

A = pattern down/clean
B = pattern down/no clean
C = pattern up/no clean
D = solder paste/reflow/clean
E = solder paste/reflow/no clean
F = control (pre-cleaned, unprocessed)

8.2.3 Test coupon pre-cleaning

Pre-clean the test coupons using one of the following methods:

a) Gently brush under deionized water using a soft brush (6.10) for 30 s. Rinse the coupons in the deionized water and then in propan-2-ol (5.1) and air dry.

b) Place the test coupons in an ionic contamination tester containing one of the following test solutions:

   1) a volume fraction of 75 % propan-2-ol, 25 % deionized water solution;

   2) a volume fraction of 50 % propan-2-ol, 50 % deionized water solution.

Process until ionic residue is less than 0,1 µg/cm^2 NaCl equivalent.

9 Procedure

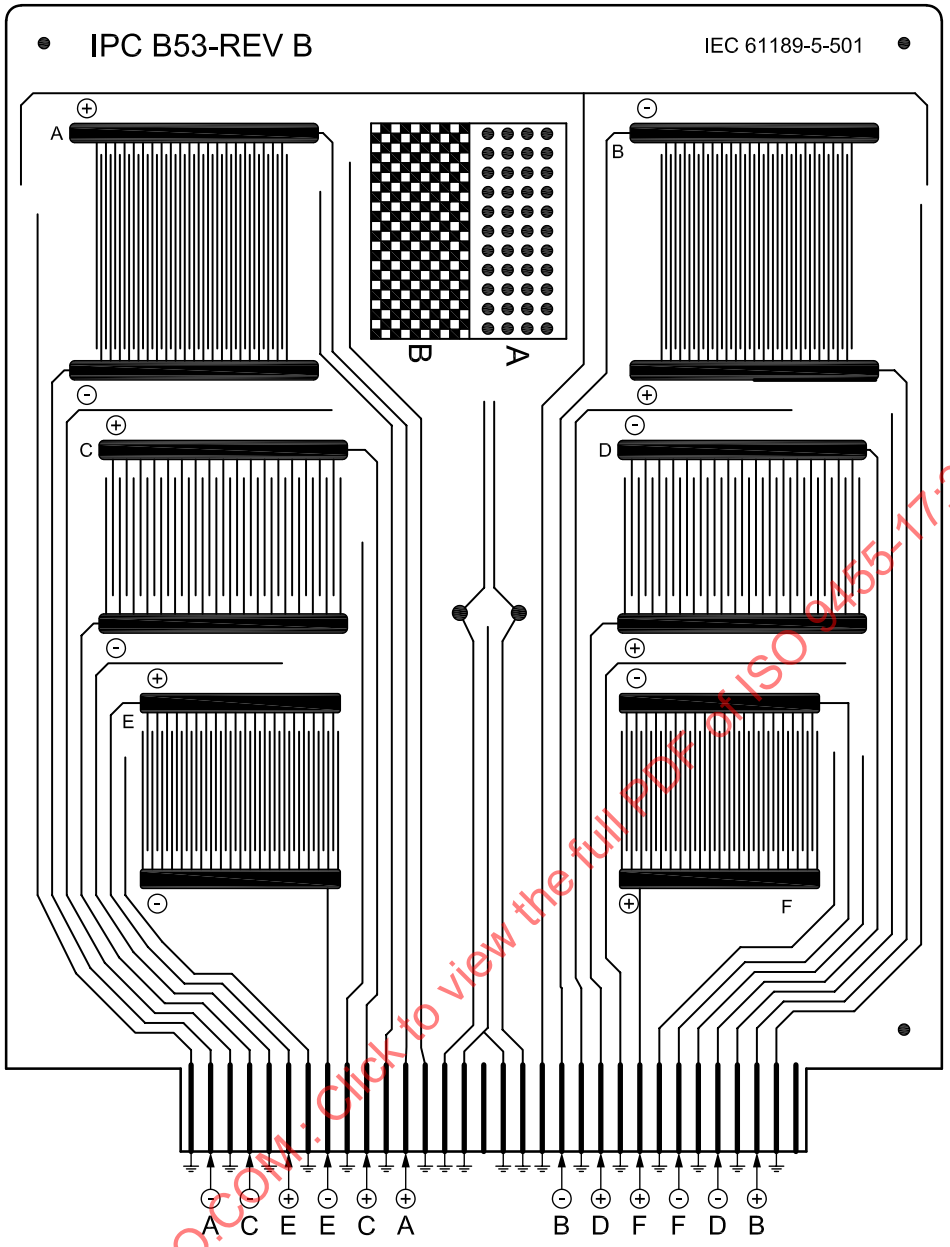
9.1 Methods for connecting test coupons

9.1.1 Board circuitry layout

9.1.1.1 Methods of connection

Connect the test coupons as shown on Figure 5 and by either hardwiring in accordance with 9.1.1.2 or connector interfacing in accordance with 9.1.1.3.

NOTE See A.7 for guidance on the advantages and disadvantages of using connectors as part of the measurement system.



Key

⏚ earth

Figure 5 — IPC B53-Rev B test coupon connections according to IPC-TM-650

9.1.1.2 Hard wiring

For each test coupon (6.5), first cover the patterns to be tested with aluminium foil to protect them from contamination during interconnect attachment soldering.

The aluminium foil should be configured to tent the patterns but not to touch them.

Solder a suitably insulated wire (6.3) to the appropriate coupon tab (see Figure 4) using a soldering iron (6.6.5) and flux-cored solder wire (6.6.1). Use a minimum amount of solder to make each joint and do not allow solder or flux to contaminate the test pattern. Tag each wire so that it can be identified outside the humidity chamber.

9.1.1.3 Connector interfacing

When connectors are used, slide coupon edge pads into the connector, mating the gold coupon tabs to the corresponding gold finish connector tabs.

Some users will use fixtures with gold plated pins to interconnect with the gold coupon tabs. In such cases the same requirements apply.

9.1.2 Preconditioning of SIR test coupons prior to processing (optional)

This option is intended for users who wish to verify the cleanliness (in terms of SIR) of the test coupons prior to fluxing and soldering.

Connect the coupons (see 9.1.1.1).

Precondition coupons for a period of 8 h to 16 h in the humidity chamber (6.7), programmed for the appropriate test condition, as follows:

a) 40 °C ± 2 °C with a relative humidity 90 % ± 3 %;

b) 85 °C ± 2 °C with a relative humidity 85 % ± 3 %.

As an alternative to 40 °C ± 2 °C / 90 % ± 3 % RH, it is acceptable to use 40 °C ± 2 °C / 93 % ± 3 % RH. This shall be agreed between users and supplier prior to use. Using 93 % RH can lead to different results when compared to using 90 % RH. See A.1 for guidance on which test condition should be used. See A.2 and A.3 for information on specimen integrity during testing.

Take SIR measurements (see 9.4) at the end of the preconditioning period at the test conditions.

NOTE See A.4 for information about frequency of monitoring during SIR testing.

9.2 Fluxing and soldering test patterns

9.2.1 Liquid and solid flux samples and flux-cored solder wire samples

Protect edge connector tabs from flux and solder contamination on all coupons. Solder test patterns, listed in Table 1, circuit-side down in accordance with 9.2.2 or 9.2.3.

Do not flux or solder the control test patterns.

If the flux residues are not designed to be cleaned during production (see 8.2.2), process a second set of test patterns circuit-side up.

After soldering, examine the test patterns to ensure there are no short circuits. Discard data from any test patterns exhibiting short circuits. Add additional coupons to maintain the number of required test patterns specified in Table 1.

9.2.2 Soldering using wave solder system

Liberally apply the flux test solution obtained in 8.1.1, 8.1.2 or 8.1.3, as appropriate, to the pattern side of the test coupons (6.5), ensuring that the test patterns are coated. Wave solder using a solder schedule which achieves topside preheat temperature as recommended by the flux manufacturer and a dwell time in the solder pot of 3 s ± 1 s at a solder temperature between 245 °C and 260 °C for Sn63Pb37E or Sn96,5Ag3Cu0,5 or liquidus point +30 °C ± 5 °C of the solder for other lead-free solder agreed between user and supplier.

9.2.3 Soldering using static solder pot

Liberally apply the flux test solution obtained in 8.1.1, 8.1.2 or 8.1.3, as appropriate, to the pattern side of the test coupons (6.5), ensuring that all the patterns are coated. Allow the excess flux to drain off by standing the coupons vertically on absorbent paper for 10 s. Dry the coupons for 5 min in the drying oven (6.2), maintained at (100 ± 3) °C.

Solder by floating the test coupon on a static solder pot maintained between 245 °C and 260 °C for Sn63Pb37E or Sn96,5Ag3Cu0,5 or liquidus point +30 °C ± 5 °C of the solder for other lead-free solder agreed between user and supplier with a dwell time in the solder pot of 4 s ± 1 s.

9.2.4 Solder paste samples

Referring to 8.2.2, select the appropriate sample size using a nominal 150 µm-thick stencil, with the solder paste sample such that 100 % of the track is covered with solder. The aperture shall be at least 80 % of the line width of the test pattern.

NOTE The control coupon is not printed with the solder paste.

For pastes with powder particles less than 38 µm, a 100 µm thick stencil should be used.

Solder the test coupons using a reflow solder oven (6.6.4) using the temperature profile recommended by the flux manufacturer.

After soldering, examine the test patterns to ensure there are no short circuits. Discard data from any test patterns exhibiting short circuits. Add additional coupons to maintain the number of test patterns specified in Table 2.

9.2.5 Paste flux samples

9.2.5.1 Referring to 8.2.2, select the appropriate sample size. Using a clean scalpel (6.11) apply a layer of paste flux over the entire area of each test pattern used 70 µm ± 20 µm thick. Solder in accordance with 9.2.5.2 or 9.2.5.3.

A layer of flux of the desired thickness can be doctor-bladed (see 6.11) on to the coupon by placing two-strips of plastic sheet of the correct thickness on either side of the pattern areas and, using a long, flat metal edge or squeegee, printing the flux on to the test patterns.

9.2.5.2 Wave solder (see 6.6.2) using a solder schedule which achieves topside preheat temperature as recommended by the flux manufacturer and a dwell time in the solder pot of between 2 s and 4 s at a solder temperature between 245 °C and 260 °C for Sn63Pb37E or Sn96,5Ag3Cu0,5 or liquidus point +30 °C ± 5 °C of the solder for other lead-free solder agreed between user and supplier.

9.2.5.3 Float the test coupon on a static solder bath maintained between 245 °C and 260 °C for Sn63Pb37E or Sn96,5Ag3Cu0,5 or liquidus point +30 °C ± 5 °C of the solder for other lead-free solder agreed between user and supplier with a dwell time in the solder pot of between 3 s and 5 s.

9.3 Cleaning

After exposure to flux and solder, specimens to be tested in the cleaned state shall be cleaned using one of the following procedures. The cleaning parameters shall be reported in the qualification test report.

The specimens to be cleaned shall be cleaned with an appropriate environmentally safe solvent or aqueous cleaning medium. The use of a commercial batch or in-line cleaner is preferred. If this is not available, the following laboratory cleaning process shall be followed: three specimens shall be cleaned within a maximum of 30 min of soldering.

For solvent or aqueous detergent cleaning, three 2 000 ml beakers each containing 1 000 ml of solvent shall be used so that one beaker serves as the primary cleaning stage and the other two are used for rinsing purposes. Each test specimen shall be agitated in each beaker for 1 minute. In the case of aqueous detergent, one beaker shall contain the cleaning agent and the remaining beakers shall contain deionised water for rinsing purposes.

After the cleaning procedure is complete, specimens are dried for 2 h at 50 °C. Following cleaning, the specimens shall be tested as outlined in 9.4.

Do not subject control coupons to this cleaning process.

Do not clean the coupons when testing fluxes intended for use on applications where the flux residues will not be cleaned after soldering.

9.4 SIR measurement

9.4.1 High-resistance measurement system verification

Prior to connecting test coupons to the measurement system, connect each cable assembly to the resistor verification coupon (6.9) inside the humidity chamber at ambient conditions and take a measurement. Rework and replace any cable that does not read within the tolerance value of the total measurement system (±5 % up to 10^{10} Ω, ±10 % between 10^{10} Ω and 10^{11} Ω, and ±20 % above 10^{11} Ω).

NOTE See A.5 for information about electromagnetic shielding of cables and A.6 for further information about connecting the verification coupon.

9.4.2 Test coupon measurements

After connecting coupons in accordance with 9.1.1.1 select environmental conditions a) or b), as appropriate.

a) 40 °C ± 2 °C with a relative humidity 90 % ± 3 %;

b) 85 °C ± 2 °C with a relative humidity 85 % ± 3 %.

As an alternative to 40 °C ± 2 °C / 90 % ± 3 % RH, it is acceptable to use 40 °C ± 2 °C / 93 % ± 3 % RH. This shall be agreed between users and supplier prior to use. Using 93 % RH can lead to different results when compared to using 90 % RH. See A.1 for guidance on which environmental conditions should be used and A.2 and A.3 for information on specimen integrity during testing.

Insert test coupons into the humidity chamber (6.7). Without bias applied, stabilize the chamber at 25 °C ± 2 °C and 50 % ± 3 % RH for 1 h and take an initial SIR measurement. Ramp the chamber up to test conditions by first increasing the temperature while maintaining the humidity at 50 % ± 3 % RH and stay at this temperature for 15 min. After this period, gradually increase the relative humidity over 0,5 hour to 85 % ± 3 % or 90 % ± 3 %. Do not allow the temperature of the samples to drop below the dew point.

This ramp-up should not exceed 3 h.

The duration of testing shall be a minimum of 168 h at test conditions. Apply bias 1 h after chamber stabilization at test conditions. With the test coupons still in the humidity chamber, apply 5 V d.c. bias potential to each specimen. After bias application, take SIR measurements at least every 30 min at the same voltage and polarity.

Other requirements for bias voltages, measurements and other test conditions have to be agreed between user and supplier.

NOTE See A.4 for further information on the frequency of monitoring.

At the end of the test exposure, remove electrical bias from all test patterns prior to temperature-humidity ramp-down initiation. After ramp-down, stabilize the chamber at 25 °C and 50 % RH for 2 h.

9.5 Electrochemical migration test

Extend SIR measurement (9.4) for 1 000 h.

10 Assessment

After conditioning, remove the specimens from the chamber and examine at ×30 to ×40 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 dendrites covering more than 20 % spacing.

c) Presence of discoloration between conductors: yes/no; if yes, capture and record the image.

d) Presence of water spots: yes/no; if yes, capture and record the image.

e) Presence of subsurface metal migration: yes/no; if yes, capture and record the image.

The insulation resistance values of each comb pattern shall be greater than 10^8 Ω. If the control coupon readings are less than 10^9 Ω, a new set of test specimens shall be obtained and the entire test repeated. Any reason for deleting values (e.g. scratches, condensation, bridged conductors, outlying points) shall be noted.

11 Precision

An intralaboratory test equipment assessment shall be performed on all SIR test coupons prior to the execution of the SIR testing to verify that the repeatability of the test coupon is within the acceptable limits. The analysis shall measure the repeatability using the gauge *r* and *R* methodology specified in ISO 5725-2.

The repeatability assessment shall consist of a minimum of five repeated measurements on a minimum of 12 test patterns.

The results shall report the standard deviation, repeatability, *r*, and the repeatability percentage of the specification for each of the test values being captured. The repeatability percentage shall be not greater than 10 % of the specification range.

12 Test report

The test report shall include, at least, the following information:

a) identification and preparation of the flux sample (see 8.1);

b) reference to this document (i.e. ISO 9455-17:—);

c) details of any post-soldering cleaning procedures used before coupon conditioning and measurement (see 9.3);

d) details of the solvent used for the solid flux sample, if appropriate (see 8.1.2);

e) qualification test report, which should be in accordance with Annex B;

f) individual charts or graphs showing the measured resistance (log ohms vs. time) for each coupon and test pattern, or box plots for the data set;

g) SIR results obtained for each pattern:

   1) after optional preconditioning, if applicable (see 9.1.2);

   2) at ambient conditions (see 9.4.2);

   3) all measurement values (see 9.4.2);

h) any unusual features noted during the test;

i) details of any operation not included in this document or regarded as optional;

j) the environmental conditions used for the test, i.e. condition a) or b) in 9.4.2;

k) the date of the test.

Annex A
(informative)

SIR testing guidance

A.1 Test conditions

Fluxes that contain more than a mass fraction of 1 % organic acid activators, such as adipic acid, that volatilize significantly at 85 °C and less than a mass fraction of 5 % rosin or modified-rosin resin should be tested at 40 °C and 90 % RH. Fluxes that contain more than a mass fraction of 0,1 % ionic halide should be tested at 85 °C and 85 % RH.

CAUTION — Some weak organic acid-containing fluxes have volatile residues which can be driven off at higher test temperatures than those experienced in environmental conditions.

A.2 Risk of condensation

If condensation occurs on the test coupons in the environmental chamber while the coupons are under voltage, dendritic growth or filament formation can occur. Dendritic growth or filament formation can be caused by a lack of sufficient control of the humidification of the oven. Water spotting can also be observed in some ovens where the air flow 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 micro-droplets which deposit on the test coupon surfaces and cause dendritic growth if the spots bridge the distance between electrified conductors. Both of these conditions shall be eliminated for proper testing.

A.3 Precautions

It is recommended that a drip shield be placed over and/or around the test samples to prevent water droplets from dropping from the chamber ceiling or from the chamber doors on to the energized test samples. However, the drip shield should also not interfere with good air flow around the test samples, which can require innovative shielding approaches.

A.4 Frequency of monitoring

During SIR testing resistance values can change rapidly over a period of minutes. These are often transitory in nature with SIR values often recovering by the end of the test. Such a drop in SIR can constitute failure in real product. Modern frequent sampling instruments can monitor up to 128 SIR patterns in less than 20 min and so capture this type of short-lived event. It is recommended that measurement readings be taken as frequently as possible to detect rapid changes in SIR.

A.5 Electromagnetic shielding

For consistent and repeatable results, it is important that all cabling carrying test signals be encased in an electromagnetic shield. Most often, this is a metallic foil or braid material. Since SIR measurement often deals with picoamperes of current or less, EMC and other stray electrical fields can unduly affect the test signals. Encasing the signal lines with an earthed metal dramatically reduces currents due to EMC and other electrical noise. It is not necessary to individually shield each line, such as in coaxial cabling, but separating voltage supply lines and current-return lines is recommended. A single EMC shield can be used to encase all current-return lines.