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JOINT INDUSTRY STANDARD

Requirements for Soldering Fluxes

participants from
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IPC-J-STD-004C-WAM1

Requirements for Soldering Fluxes

A standard developed by the Flux Specifications Task Group (5-24a) of the Assembly and Joining Processes Committee (5-20) of IPC

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Users of this publication are encouraged to participate in the development of future revisions.

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1 SCOPE

This standard prescribes general requirements for the classification and characterization of fluxes for high quality solder interconnections. This standard may be used for quality control and procurement purposes.

1.1 Purpose The purpose of this standard is to classify and characterize Sn-Pb and Pb-free soldering flux materials for use in electronic metallurgical interconnections for printed circuit board assembly. Soldering flux materials include the following: liquid flux, paste flux, solder paste, solder cream as well as flux-coated and flux-cored solder wires and preforms. It is not the intent of this standard to exclude any acceptable flux or soldering material; however, these materials must produce the desired electrical and metallurgical interconnection.

1.2 Classification

CLASS 1 General Electronic Products

Includes products suitable for applications where the major requirement is function of the completed assembly.

CLASS 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end-use environment would not cause failures.

CLASS 3 High Performance/Harsh Environment Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

1.3 Measurement Units All dimensions and tolerances in this specification are expressed in hard SI (metric) units and bracketed soft imperial [inch] units. Users of this specification are expected to use metric dimensions. All dimensions ≥ 1 mm [0.0394 in] will be expressed in millimeters and inches. All dimensions < 1 mm [0.0394 in] will be expressed in micrometers and microinches.

1.4 Definition of Requirements The words **shall** or **shall not** are used in the text of this document wherever there is a requirement for materials, preparation, process control or acceptance.

The word “should” reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

Line drawings and illustrations are depicted herein to assist in the interpretation of the written requirements of this Standard. The text takes precedence over the figures.

1.5 Process Control Requirements The primary goal of process control is to continually reduce variation in the processes, products, or services to provide products or processes meeting or exceeding User requirements. Process control tools such as IPC-9191, JESD557 or other User-approved system may be used as guidelines for implementing process control.

Manufacturers of Class 3 products **shall** develop and implement a documented process control system.

A documented process control system, if established, **shall** define process control and corrective action limits.

This may or may not be a statistical process control system. The use of “statistical process control” (SPC) is optional and should be based on factors such as design stability, lot size, production quantities, and the needs of the Manufacturer, see 4.6.

Process control methodologies **shall** be used in the planning, implementation and evaluation of the manufacturing processes used to produce soldered electrical and electronic assemblies. The philosophy, implementation strategies, tools and techniques may be applied in different sequences depending on the specific company, operation, or variable under consideration to relate process control and capability to end product requirements.

When a decision or requirement is to use a documented process control system, failure to implement process corrective action and/or the use of continually ineffective corrective actions would be grounds for disapproval of the process and associated documentation.

1.6 Order of Precedence The contract takes precedence over this Standard, referenced standards and drawings.

In the event of conflict, the following order of precedence applies:

1) Procurement as agreed and documented between customer and supplier.
2) Master drawing reflecting the customer's detailed requirements.
3) When invoked by the customer or per contractual agreement, this standard..

When documents other than this standard are cited, the order of precedence would be defined in the procurement documents.

The User has the opportunity to specify alternate acceptance criteria.

1.6.1 Conflict In the event of conflict between the requirements of this standard and the applicable drawing(s) and documentation, the applicable user-approved drawing(s) and documentation govern.

Some examples of documentation include the contract, purchase order, technical data package, engineering specification or performance specification. In the event of a conflict between the text of this standard and the applicable documents cited herein, the text of this standard takes precedence. In the event of conflict between the requirements of this standard and drawing(s) and documentation that has not been user approved, this standard governs.

1.6.2 Clause References When a clause in this document is referenced its subordinate clauses apply, unless the requirement references specific subordinate clauses.

1.6.3 Appendices Appendices to this standard are not binding requirements unless separately and specifically required by this standard, the applicable contracts, assembly drawing(s), documentation or purchase orders. Appendices provide further information or refer to other sources of information to help explain the document.

1.6.3.1 Appendix A Example Qualification Test Report
1.6.3.2 Appendix B Notes
1.6.3.3 Appendix C Abbreviations and Acronyms

1.7 Use of "Lead" For readability and translation, this document uses the noun lead only to describe leads of a component. The metallic element lead is always written as Pb.

1.8 Abbreviations and Acronyms Periodic table elements are abbreviated in the standard. See Appendix C for full spellings of abbreviations (including elements) and acronyms used in this standard.

1.8.1 ECM The acronym ECM stands for Electrochemical Migration. ECM is defined as the growth of conductive metal filaments under the influence of a DC voltage bias where growth is by electro-deposition from a solution containing metal ions that are dissolved from the anode, transported by the electric field and redeposited at the cathode and specifically excludes phenomena such as field induced metal transport in semiconductors and diffusion of the products arising from metallic corrosion.

1.8.2 SIR The acronym SIR stands for Surface Insulation Resistance. SIR is defined as the electrical resistance of an insulating material between a pair of contacts, conductors or grounding devices and that is determined under specified environmental and electrical conditions.

1.9 Terms and Definitions Other than those terms listed below, the definitions of terms used in this standard are in accordance with IPC-T-50.

1.9.1 Halide Halogen ions are known as halides. Specifically, chlorine ion is known as chloride or (Cl-), bromine ion is known as bromide or (Br-), fluorine ion is known as fluoride or (F-), iodine ion is known as iodide or (I-) and halogen compounds that have ionic character are termed halide compounds.

1.9.2 Halogen Halogen is the term for all chlorine (Cl) and/or bromine (Br) in compounds. These two types of compounds are referenced based upon the EN 14582 test method (see 3.4.4).

1.9.3 Low Halogen Flux (Cl and Br) Low halogen materials contain ≤1000 ppm (0.1%) Br, and ≤1000 ppm (0.1%) Cl. Sample preparation should be AABUS.

1.9.4 Resin Flux Primarily composed of synthetic resins and/or natural resins other than rosin types.

1.9.5 Rosin Flux Primarily composed of natural rosin, extracted from the oleoresin of pine trees and refined. The rosins used **shall** have a minimum acid value of 130 as determined per ASTM D-465. A synonym for rosin is colophony.

1.9.6 Supplier The term "supplier" is equivalent to the "manufacturer" of the flux product. Only the manufacturer (not other intermediate providers, such as wholesalers, distributors, representative firms, etc.) is responsible to qualify the flux product. Therefore, throughout this document, the term "supplier" is used.

2 APPLICABLE DOCUMENTS

The following documents of the issue currently in effect form a part of this specification to the extent specified herein. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 IPC[1]

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-9191 General Guidelines for the Implementation of Statistical Process Control

IPC-TM-650 Test Methods Manual[2]

2.3.13 Determination of Acid Value of Liquid Solder Flux - Potentiometric and Visual Titration Methods

2.3.28.1 Halide Content of Soldering Fluxes and Pastes

2.3.32 Flux Induced Corrosion (Copper Mirror Method)

2.3.33 Presence of Halides in Flux, Silver Chromate Method

2.3.34 Solids Content, Flux

2.3.35.1 Fluorides by Spot Test, Fluxes - Qualitative

2.4.14.2 Liquid Flux Activity, Wetting Balance Method

2.4.34.4 Paste Flux Viscosity - T-Bar Spindle Method

2.4.46 Spread Test, Liquid or Extracted Solder Flux, Solder Paste and Extracted Cored Wires or Preforms

2.6.1 Fungus Resistance Printed Wiring Materials

2.6.3.3 Surface Insulation Resistance (SIR), Fluxes

2.6.3.7 Surface Insulation Resistance

2.6.14.1 Electrochemical Migration Resistance Test

2.6.15 Corrosion, Flux

2.2 Joint Industry Standards[3]

2.2.1 J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

2.2.2 J-STD-003 Solderability Tests for Printed Boards

2.2.3 J-STD-005 Requirements for Soldering Pastes

2.3 American Society for Testing and Materials (ASTM)[4]

2.3.1 ASTM D-465-15 Standard Test Methods for Acid Number for Pine Chemical Products including Tall Oil and Other Related Products

2.4 British Standards[5]

2.4.1 EN 14582 Characterization of Waste. Halogen and sulfur content. Oxygen combustion in closed systems and determination methods.

2.5 International Organization for Standards[6]

2.5.1 ISO 9001-2000 Quality Systems—Model for Quality Assurance in Production and Installation

2.6 National Conference of Standards Laboratories (NCSL)[7]

2.6.1 ANSI-NCSL-Z540-1 American National Standards for Calibration - Calibration Laboratories and Measuring Test Equipment - General Requirements

1 www.ipc.org
2 Current and revised IPC Test Methods are available on the IPC Web site (www.ipc.org)
3 www.ipc.org
4 www.astm.org
5 www.bsi-global.com
6 www.iso.org
7 www.ncsli.org

3 GENERAL REQUIREMENTS

Unless otherwise specified on the design or assembly drawings or instructed by the user, the fluxes covered by this document **shall** conform to the following paragraphs.

Although the requirements of J-STD-004 have changed with each revision, fluxes that were classified to earlier revisions of IPC-J-STD-004 do not require reclassification. Anywhere the J-STD-004 classification is documented for a particular product, the revision level of J-STD-004 to which the product was classified **shall** be included.

The requirements for fluxes are defined in general terms for standard classification. Appendix B has additional information that will help users understand some of the requirements of this standard. In practice, where more stringent requirements are necessary or other manufacturing processes are used, the user **shall** define these as additional requirements.

3.1 Designation For ordering purposes and designation by other specifications, the following flux identification system **shall** be used (see Table 3-1).

3.2 Flux Qualification A flux **shall** be considered qualified per this document if it has been classified and characterized via the testing outlined below and has met all of the minimum requirements. Preparation of each form of flux for qualification testing is shown in Table 3-2. The chosen flux form **shall** align with the form material to be used in the application.

Table 3-1 Flux Identification System

Flux Composition	Flux/Flux Residue Activity Levels	% Halide[1] (by weight)	Flux Type[2]	Flux Designator
Rosin (RO)	Low	<0.05%	L0	ROL0
		≥0.05 and <0.5%	L1	ROL1
	Moderate	<0.05%	M0	ROM0
		≥0.5 and <2.0%	M1	ROM1
	High	<0.05%	H0	ROH0
		≥2.0%	H1	ROH1
Resin (RE)	Low	<0.05%	L0	REL0
		≥0.05 and <0.5%	L1	REL1
	Moderate	<0.05%	M0	REM0
		≥0.5 and <2.0%	M1	REM1
	High	<0.05%	H0	REH0
		≥2.0%	H1	REH1
Organic (OR)	Low	<0.05%	L0	ORL0
		≥0.05 and <0.5%	L1	ORL1
	Moderate	<0.05%	M0	ORM0
		≥0.5 and <2.0%	M1	ORM1
	High	<0.05%	H0	ORH0
		≥2.0%	H1	ORH1
Inorganic (IN)	Low	<0.05%	L0	INL0
		≥0.05 and <0.5%	L1	INL1
	Moderate	<0.05%	M0	INM0
		≥0.5 and <2.0%	M1	INM1
	High	<0.05%	H0	INH0
		≥2.0%	H1	INH1

1 Halide measuring <0.05% by weight in flux solids may be known as halide-free. This method determines the amount of halide present (see Appendix B-10).
2 The 0 and 1 indicate the absence or presence of halides, respectively. See paragraph 3.2.1.2.2 for flux type nomenclature.

3.2.1 Classification As part of the qualification process, fluxes **shall** be classified according to the composition, flux type, and physical form. Flux designators identify both composition and type of fluxes (see Table 3-1). It is the responsibility of the material suppliers to classify their flux in accordance with this standard.

3.2.1.1 Flux Composition The flux **shall** be classified as either rosin, resin, organic or inorganic (see Table 3-1), based on the largest weight percent constituent of its nonvolatile portion.

3.2.1.2 Flux Type Based on Flux Activity and Halide Content, fluxes **shall** also be classified according to the corrosive or conductive properties of the flux or flux residue. In order to be classified as a specific type, a flux must meet all the requirements as shown in Table 3-3.

3.2.1.2.1 Flux Activity The Flux Type **shall** be identified (see Table 3-2) based on the ionic and corrosive activity of the flux and its residue. Fluxes **shall** be qualified as one of the following three types:

L, 0 or 1 = Low or no flux/flux residue activity
M, 0 or 1 = Moderate flux/flux residue activity
H, 0 or 1 = High flux/flux residue activity

Table 3-2 Preparation of Flux Forms for Testing

	Liquid Flux	Paste Flux	Solder Paste or Solder Cream	Preforms	Cored Wire
Copper Mirror	As Received[1]	As Received	As Received	Extracted	Extracted
Corrosion	Reflowed	Reflowed	Reflowed	Reflowed	Reflowed
Halides	Diluted	Extracted & Diluted	Extracted & Diluted	Extracted & Diluted	Extracted & Diluted
SIR[2]	Reflowed	Reflowed	Reflowed	Extracted & Reflowed	Soldered with Soldering Iron
ECM[2]	Reflowed	Reflowed	Reflowed	Extracted & Reflowed	Soldered with Soldering Iron
Solids Content	As Received	As Received	Test the Paste Flux or As Received	Extracted	Extracted
Acid Value	As Received	Diluted	Extracted & Diluted	Extracted & Diluted	Extracted & Diluted
Specific Gravity	As Received	N/A	N/A	N/A	N/A
Viscosity	N/A	As Received	As Received	N/A	N/A
Visual	As Received	As Received	Extracted	Extracted	Extracted
Halogen Content	Flux residue after reflow	Flux residue after reflow	Flux residue after reflow; metal removed	Flux residue after reflow; metal removed	Flux residue after reflow; metal removed

1. Testing an as-received flux containing >50% water may give a failing result due to the presence of water, so it may be oven dried at 80° ± 2°C for 1 hour +15 minutes/-0 minutes and reconstituted (dissolved in the appropriate solvent) per IPC-TM-650, Method 2.3.32 for use in this test. If the sample is tested in the reconstituted state, results from both the as-received and reconstituted samples **shall** be reported.
2. Product must be tested using a Sn-Pb or Pb-free profile based on product end-use.

Table 3-3 Test Requirements for Flux Classification

Flux Type	Copper Mirror	Corrosion	Quantitative Halide[1] (Cl-,Br-,F-,I-) (by weight)	Conditions for Passing 100 MΩ SIR Requirements[2]	Conditions for Passing ECM Requirements[2]
L0	No evidence of mirror breakthrough	No evidence of corrosion	<0.05%[3]	No-clean state[5]	No-clean state[5]
L1			≥0.05 and <0.5%		
M0	Breakthrough in less than 50% of test area	Minor corrosion acceptable	<0.05%[3]	Cleaned[6] or No-clean state[5]	Cleaned[6] or No-clean state[5]
M1			≥0.5 and <2.0%[4]		
H0	Breakthrough in more than or equal to 50% of test area	Major corrosion acceptable	<0.05%[3]	Cleaned	Cleaned
H1			≥2.0%[4]		

1. This method determines the amount of halide present (see Appendix B-10).
2. If a printed circuit board is assembled using a no-clean flux and it is subsequently cleaned, the user should verify the SIR and ECM values after cleaning. J-STD-001 may be used for process characterization.
3. Fluxes with halide measuring <0.05% by weight in flux solids may be known as halide-free.
4. Even if the flux shows no corrosion, it is considered an M1 if the halide content is ≥0.5% and <2.0%, and H1 if the halide content is ≥2.0%.
5. Fluxes that are not meant to be removed require testing only in the no-clean state.
6. If the M0 or M1 flux passes SIR and ECM when cleaned, but fails when not cleaned, this flux **shall** always be cleaned.

It is possible that certain corrosive fluxes could meet one or more tests for the L-type flux. However, failure to meet all test requirements will cause the given flux to be classified as either type M or H.

3.2.1.2.2 Halide Content Flux Type **shall** be identified using 0 or 1 to indicate the absence or presence of halide in the flux, where <0.05% halide is defined as halide free. The absence or presence of halide **shall** be determined per the test method outlined in Table 3-3 and the corresponding paragraphs. The quantitative halide method determines the amount of halide present (see Appendix B-10). Testing for halide content does not include evaluation for halogen content. A material with a ‘‘0’’ indicator may contain non-ionic halogen.

3.2.2 Characterization As part of the qualification process, fluxes **shall** be characterized by performing the following determinations: flux solids content, acid value, specific gravity, viscosity (paste flux) and visual examination.

3.3 Qualification Testing For qualification testing, the flux supplier **shall** perform or have performed testing in accordance with test requirements listed in 3.3 and complete a qualification test report (see Appendix A for an example) which **shall** be available to customers upon request. Testing requirements in 3.3.1 classify the flux as listed in Table 3-1. Testing requirements in 3.3.2 characterize the flux. Test methods to be used are summarized in the appropriate column in Table 4-1.

3.3.1 Classification Testing

3.3.1.1 Copper Mirror Test The corrosive properties of the flux **shall** be determined in accordance with IPC-TM-650, Test Method 2.3.32, (one of two methods utilized to determine corrosivity). The flux **shall** be classified as type L only if there is no complete removal of the copper film. If there is any complete removal of the copper film, as evidenced by the background showing through the glass, then the flux **shall not** be classified as type L. If there is complete removal of the copper only around the perimeter of the drop (less than 50% breakthrough), then the flux **shall** be classified as type M. If the copper film is completely removed (greater than or equal to 50% breakthrough), then the flux **shall** be classified as type H. Figure 3-1 shows examples of qualitative results for flux activity classification.

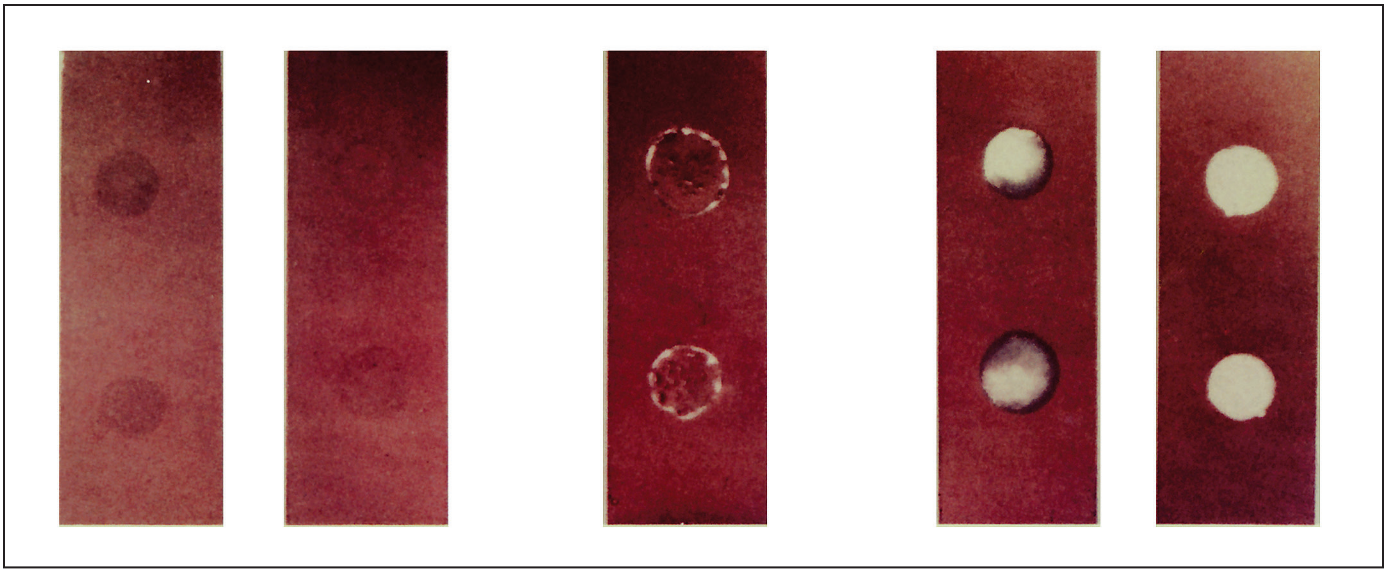

Figure 3-1 Flux Corrosivity by Copper Mirror Test

L **No Breakthrough** **M** **Less Than 50% Breakthrough** **H** **Greater Than 50% Breakthrough**

3.3.1.2 Corrosion Test The corrosive properties of flux residue **shall** also be determined in accordance with IPC-TM-650, Test Method 2.6.15. For purposes of this test method, the following definition of corrosion **shall** apply: "A chemical reaction between the copper, the solder, and the flux residues that occurs after soldering and during exposure to the above environmental conditions." Corrosion is qualitatively assessed as follows:

No Corrosion No evidence of corrosion is observed. Any initial change of color, which may develop when the test panel is heated during soldering, is disregarded as seen in Figure 3-2.

Minor Corrosion Discrete white or colored spots in the flux residues or a color change to green-blue ***without*** pitting of the copper is regarded as *minor* corrosion. See Figure 3-3.

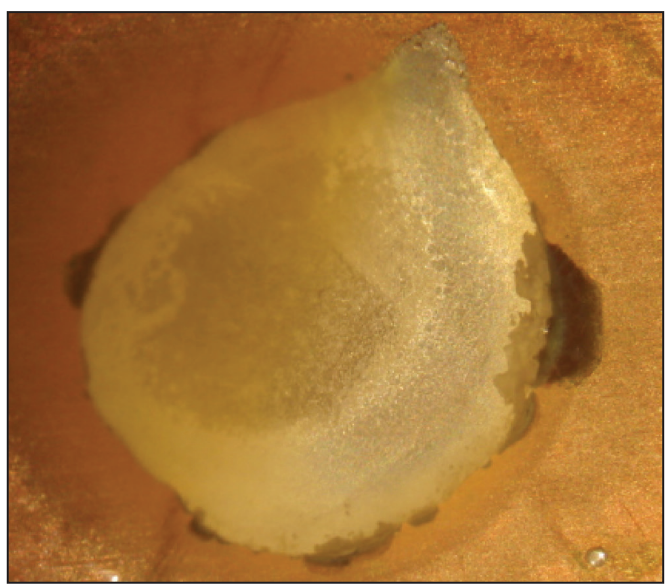

Figure 3-2 Example of No Corrosion

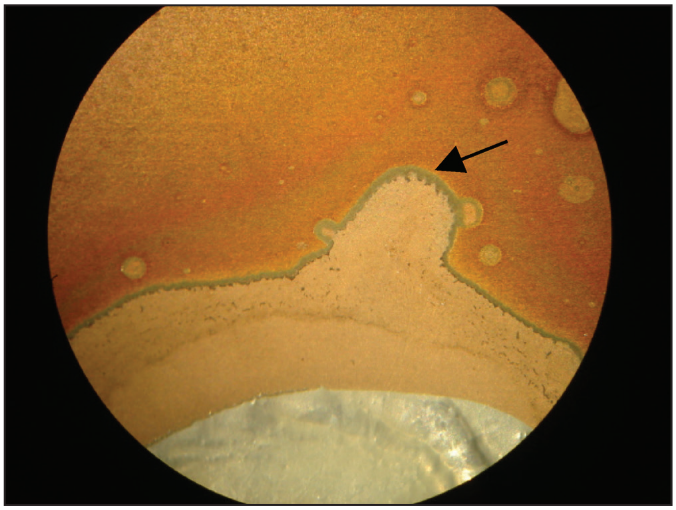

Figure 3-3 Example of Minor Corrosion

Figure 3-4 Example of Major Corrosion

Major Corrosion Development of green-blue discoloration/corrosion with observation of pitting of the copper panel is regarded as major corrosion. This is shown in Figure 3-4.

3.3.1.3 Quantitative Halide Content Tests Quantitative halide tests **shall** be used to determine the concentration of chloride (Cl-), bromide (Br-), fluoride (F-) and iodide (I-) in liquid fluxes or extracted flux solutions. The total halide content of the flux is obtained by adding together the Cl-, Br-, F-, and I- contents. The halide content is reported as the weight percentage of halide of the solid (nonvolatile) portion of the flux. The combined concentration of chlorides, bromides, fluorides, and iodides **shall** be determined in accordance with IPC-TM-650, Test Method 2.3.28.1. The solids content is determined in accordance with 3.3.2.1.

3.3.1.4 SIR Test The SIR requirements for fluxes **shall** be determined in accordance with IPC-TM-650, Test Method 2.6.3.7, except that the test duration **shall** be 168 hours. SIR patterns **shall** be prepared per using the product-specific reflow or wave soldering profile (see Table 3-2).

3.3.1.4.1 Reporting SIR Test Results When specifying the SIR test results, the supplier **shall** clearly indicate if cleaning is required and the type of cleaning procedure to be used prior to SIR testing (see Appendix A Qualification Test Report). The supplier:

- **Shall** clearly indicate if cleaning is required.
- **Shall** document the cleaning procedure used in preparing the SIR coupons.
- **Shall** disclose thermal profile or solder pot temperature and preheat temperature.
- **Shall** disclose type per IPC-4101 or glass transition temperature (Tg) of board laminate material.

3.3.1.4.2 SIR Test Criteria The requirements for passing the SIR test are:

- All SIR measurements on all test patterns **shall** exceed the 100 MOhm requirement after 24 hours of exposure.
- Control coupons **shall** exceed the 1000 MOhm requirement.
- There **shall not** be evidence of electrochemical migration (filament growth) that reduces the conductor spacing by more than 20%.
- There **shall not** be corrosion* of the conductors.

***Note:** Minor discoloration of one pole of the comb pattern conductors is acceptable.

3.3.1.5 Resistance to ECM Testing The resistance to ECM testing **shall** be assessed in accordance with IPC-TM-650, Test Method 2.6.14.1, using the 65 °C ± 2 °C, 88.5% ± 3.5% RH condition. ECM patterns **shall** be prepared per IPC-TM-650, Method 2.6.3.3, using the product-specific reflow or wave soldering profile.

3.3.1.5.1 Reporting ECM Test Results When specifying the ECM test results, the supplier **shall** clearly indicate if cleaning is required and the type of cleaning procedure to be used prior to ECM testing (see Appendix A Qualification Test Report).

The $IR_{initial}$, or initial insulation resistance, is the data measurement taken after a 96 hour stabilization period. The IR_{daily}, the daily IR measurements and the final insulation resistance (IR_{final}) measurement values **shall** be reported according to the test method. The criteria for passing the ECM test are:

- The $IR_{final} \geq IR_{initial}/10$. That is, the IR **shall not** degrade by more than or equal to one decade, as a result of the applied bias.
- There **shall not** be evidence of electrochemical migration (filament growth) that reduces the conductor spacing by more than 20%.
- There **shall not** be corrosion* of the conductors.

***Note:** Minor discoloration of one pole of the comb pattern conductors is acceptable.

3.3.2 Characterization Testing This testing is required for initial qualification of a product and **shall** be provided on the product datasheet.

3.3.2.1 Flux Solids (Nonvolatile) Determination The determination of the amount of residual solids content of liquid fluxes **shall** be made in accordance with IPC-TM-650, Test Method 2.3.34, or as agreed between user and supplier (AABUS). For fluxes with solids content less than 10%, the solids content **shall not** differ by more than 10% of the supplier's formulated value. For all other fluxes, flux solids content **shall not** differ by more than 5% of the supplier's nominal value.

3.3.2.2 Acid Value Determination The acid value of liquid flux **shall** be evaluated in accordance with IPC-TM-650, Test Method 2.3.13.

3.3.2.3 Specific Gravity Determination Specific Gravity of liquid flux **shall** be evaluated in accordance with ASTM D-1298 (static method).

3.3.2.4 Viscosity of Paste (Tacky) Flux The viscosity of the paste flux **shall** be evaluated in accordance with IPC-TM-650, Test Method 2.4.34.4.

3.3.2.5 Visual The flux material **shall** be examined for clarity and the absence of precipitation.

3.4 Optional Testing Optional testing may be required AABUS or may be used as a quality conformance check.

3.4.1 Optional Qualitative Halide Tests The following tests are performed most often by the user to determine the presence of halides, specifically chlorides (Cl-), bromides (Br-), fluorides (F-) and iodides (I-), in liquid fluxes or extracted flux solutions.

3.4.1.1 Optional Chlorides and Bromides by Silver Chromate Method The presence of chlorides and bromides may be determined in accordance with IPC-TM-650, Test Method 2.3.33.

3.4.1.2 Optional Fluorides By Spot Test The presence of fluorides may be determined in accordance with IPC-TM-650, Test Method 2.3.35.1.

3.4.2 Optional SIR Tests SIR may be measured by using one or more of the following test methods, when required in the procurement documentation and AABUS:

- Bellcore GR-78-CORE, Section 13.1.3
- ISO 9455-17
- TM-650 method 2.6.3.7 except the test duration would be 168 hours and the chamber condition **shall** be 85°C ± 2°C and 85% + 2% R.H.

3.4.2.1 Reporting Values for Optional SIR Test Methods When specifying the test results, the supplier **shall** clearly indicate if cleaning is required and the type of cleaning procedure to be used prior to the optional SIR testing (see Appendix A Qualification Test Report).

3.4.3 Optional Fungus Resistance Test When specified in the procurement document, fungus resistance **shall** be evaluated in accordance with IPC-TM-650, Test Method 2.6.1.

3.4.4 Optional Halogen Content Test When reporting of halogen content is requested, the concentration of Cl and Br **shall** be determined using the EN 14582 oxygen bomb method followed by ion chromatography per IPC-TM-650, Method 2.3.28.1. Alternate test methods may be used AABUS. Halogen levels measured are impacted by the sample preparation method selected; therefore, specific sample preparation details **shall** be included in the test report (see Appendix A). Flux materials that do not contain metal **shall** be tested in the final reflowed residue form. Samples that contain metal **shall** be reflowed or extracted to obtain the flux residue portion of the material. The metal must be discarded and weight of the metal should not be considered in the calculation for halogen content. Alternate sample types (e.g., testing of raw flux) may give varying results and **shall** be AABUS. A flux residue is considered low halogen if the maximum halogen values are in accordance with Table 3-4.

Table 3-4 Halogen Content in Low Halogen Materials

Maximum Quantitative Halogen
≤1000 ppm (0.1%) Br, and ≤1000 ppm (0.1%) Cl

3.5 Quality Conformance Testing The following tests **shall** be performed to evaluate product consistency per the flux supplier's technical data sheets.

3.5.1 Acid Value Determination The acid value of liquid flux **shall** be evaluated in accordance with IPC-TM-650, Test Method 2.3.13.

3.5.2 Specific Gravity Determination Specific Gravity of liquid flux **shall** be evaluated in accordance with ASTM D-1298 (static method).

3.5.3 Viscosity of Paste (Tacky) Flux The viscosity of the paste flux **shall** be evaluated in accordance with IPC-TM-650, Test Method 2.4.34.4.

3.5.4 Visual The flux material **shall** be examined for clarity and the absence of precipitation.

3.6 Performance Testing The following tests may be used to determine the flux's performance AABUS.

3.6.1 Wetting Balance Test When specified, wetting may be evaluated in accordance with IPC-TM-650, Test Method 2.4.14.2. See Appendix B for evaluation guidance.

3.6.2 Spread Test - Liquid Flux The solder spread may be determined by means of a flux wetting/ spreading test (static method) per IPC-TM-650, Test Method 2.4.46. See Appendix B for evaluation guidance.

4 QUALIFICATION AND QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection The flux supplier is responsible for all inspections specified herein except the performance inspections which are the responsibility of the user. The flux supplier may use in-house or outside facilities suitable for the inspections specified herein, unless disapproved by the user. The user reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure that supplies and services conform to prescribed requirements.

4.1.1 Responsibility for Compliance Materials covered by this specification **shall** meet all requirements of Section 3. The inspection(s), excluding the performance inspections defined in this specification, **shall** become a part of the supplier's overall inspection system or quality program. The supplier has responsibility of ensuring that all products or supplies submitted to the user for acceptance comply with all requirements of the purchase order or contract.

4.1.1.1 Quality Assurance Program When required by the user, a supplier's quality assurance program for material furnished under this specification **shall** be established and maintained in accordance with ISO 9001, ISO/TS 16949 (IATF 0043973), or AABUS.

4.1.2 Test Equipment and Inspection Facilities Test / measuring equipment and inspection facilities, of sufficient accuracy, quality, and quantity to permit performance of the required inspection(s), **shall** be established and maintained or designated by the supplier. Establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment **shall** be in accordance with ISO 10012-1 and/or ANSI-NCSL-Z540-1.

4.1.3 Inspection Conditions Unless otherwise specified herein, all inspections **shall** be performed in accordance with the test conditions specified in Section 3.

4.2 Types of Inspections

The inspections specified herein are classified as follows:

1) Qualification Inspection (3.3)
2) Quality Conformance Inspection (3.5)
3) Performance Inspection (3.6)

Table 4-1 Qualification, Quality Conformance and Performance Testing for Flux

Test Method					
Name	IPC-TM-650 or Other Method	Reference Paragraph	Qualification	Quality Conformance	Performance
Copper Mirror	2.3.32	3.3.1.1	R		
Corrosion	2.6.15	3.3.1.2	R		
Quantitative Halides	2.3.28.1	3.3.1.3	R		
Surface Insulation Resistance	2.6.3.7	3.3.1.4	R		
		3.4.2	O		
	Bellcore-GR-78-CORE, Section 13.1		O		
	ISO 9455-17		O		
Electrochemical Migration	2.6.14.1	3.3.1.5	R		
Flux Solids, Nonvolatile Determination	2.3.34	3.3.2.1	R		
Acid Value Determination	2.3.13	3.3.2.2	R	R	
Flux Specific Gravity Determination	ASTM D-1298	3.3.2.3	R	R	
Viscosity—Paste Flux	2.4.34.4	3.3.2.4	R	R	
Visual		3.3.2.5	R	R	
Qualitative Halides, Silver Chromate	2.3.33	3.4.1.1	O	O	
Qualitative Halides, Fluoride Spot	2.3.35.1	3.4.1.2	O	O	
Fungus	2.6.1	3.4.3	O		
Halogen Content	EN 14582	3.4.4	O		
Wetting Balance[1]	2.4.14.2	3.6.1	O		O
Spread Test, Liquid Flux[1]	2.4.46	3.6.2	O		O

R = Required
O = Optional
1. For these tests to be used to gauge performance, testing to be performed initially and when a reassessment of performance is necessary. Initial and retest results should be compared.

4.3 Qualification Inspection Qualification inspection **shall** be performed at a laboratory acceptable to the user on samples produced with equipment and procedures normally used in production.

4.3.1 Sample Size Sample sizes **shall** be appropriate to the flux form being inspected and the inspection being performed.

4.3.2 Inspection Routine The sample **shall** be subjected to the required inspections specified in Table 4-1.

4.3.3 Requalification The supplier **shall** be responsible for the requalification of the product for any material change from the original formulation used for the initial qualification samples. This also includes formulation changes, where applicable in accordance with 4.3.3.1.

4.3.3.1 Formula Variations Constituting Material Change Any formulation, process, or manufacturing site change that results in a change in the performance of the flux, including but not limited to the following, **shall** be considered to be a material change:

- Elimination, addition, or substitution of any ingredient, volatile or nonvolatile, to the flux formulation.
- Change in specification of the recommended reflow or wave soldering profile (Ex. Use with Pb changed to Pb-free).
- Any change to halide content or corrosive ingredient.
- Changes in the formula weight of any ingredient from its original formula weight.

4.3.3.2 Manufacturing Site Change A change in the manufacturing site of the flux **shall** require requalification.

4.4 Quality Conformance Inspection The material supplier **shall** perform those inspections necessary to issue a certificate of compliance to ensure that the process is in control and the product is within the specification limit.

4.4.1 Sampling Plan Statistical sampling and inspection **shall** conform to 4.1.1.1.

4.4.2 Rejected Lots Products that do not conform to specified requirements or are suspected of not conforming are identified, segregated, and controlled to prevent unintended use or delivery.

4.5 Performance Inspection Performance inspections are nonmandatory inspections and are AABUS.

4.6 Statistical Process Control (SPC) SPC utilizes systematic statistical techniques to analyze a process or its outputs. The purpose of these analyses is to take appropriate actions to achieve and maintain a state of statistical control, and to assess and improve process capability. The primary goal of SPC is to continually reduce variation in processes, products or services in order to provide product meeting or exceeding real or important customer requirements.

Implementation of SPC **shall** be in accordance with IPC-9191.

Depending on the progress made in implementing SPC on a particular product, an individual supplier may demonstrate compliance to specification with any of the following:

- Quality Conformance Evaluations
- End-Product Control
- In-Process Product Control
- Process Parameter Control

An individual supplier may choose to use a combination of the four assurance techniques listed to prove compliance. For example, a product with 15 characteristics may meet specifications by quality conformance evaluations on two characteristics, in-process evaluations on five characteristics, and process control parameter control for five characteristics. The remaining three characteristics meet specifications by a combination of in-process quality control and quality conformance evaluations. Evidence of compliance to the specification at a level of SPC implementation claimed is auditable by the customer or appointed third party.

Requirements are dynamic in nature and are based on what is accepted in the worldwide market. Requirements may be stated as a reduction of variation around a target value, as opposed to just meeting the specification or drawing.

Appendix A

Example Qualification Test Report (Page 1 of 2)

ID Number:	
Flux Designator:	**Date of Flux Manufacture:**
Flux Supplier's Identification:	**Flux Supplier's Batch Number:**
Use by Date:	**Reflow Profile Used:**
Date Qualification Tests Completed:	**Cleaning Procedure Used**
Tested By:	
Witnessed By:	

Classification Tests	Paragraph Requirement	IPC-TM-650 Method	Test Requirement		Result				Classification
Copper Mirror	3.3.1.1	2.3.32	No breakthrough	L					L
			<50% breakthrough	M					M
			Greater than or equal to 50% breakthrough	H					H
Quantitative Halide	3.3.1.3	2.3.28.1	<0.5%	L					L
			≥0.5 to <2.0%	M	Cl- =	Br- =	F- =	I- =	M
			≥2.0%	H					H
					Total Halide =				
Corrosion	3.3.1.2	2.6.15	No Corrosion	L					L
			Minor Corrosion	M					M
			Major Corrosion	H					H
SIR[1]	3.3.1.4	2.6.3.7	No-clean state ≥100 MΩ	L					L
			Cleaned or no-clean state ≥100 MΩ	M					M
			Cleaned ≥100 MΩ	H					H
ECM[1]	3.3.1.5	2.6.14.1	No-clean ≤1 decade drop	L					L
			Cleaned or no-clean ≤1 decade drop	M					M
			Cleaned ≤1 decade drop	H					H
What is the highest classification rating listed above?					L M H				
What is the halide rating based on the percent halide as measured above?			<0.05%	0	0				
			≥0.05%	1	1				
Final Flux Classification:									

Characterization Tests	Reference Paragraph	IPC-TM-650 Method	Result	
Acid Value	3.3.2.2	2.3.13		
Specific Gravity	3.3.2.3	–		
Viscosity (Paste Flux Only)	3.3.2.4	2.4.34.4		
Visual	3.3.2.5	–		
Solids Content (Nonvolatile Determination)	3.3.2.1	2.3.34		
Other Qualification/Conformance/ Performance Tests	**Reference Paragraph**	**IPC-TM-650 Method**	**Result**	
Qualitative Halide (Optional) Silver Chromate	3.4.1.1	2.3.33		
Qualitative Halide (Optional) Fluoride Spot	3.4.1.2	2.3.35.1		
SIR (Optional) Telcordia - Bellcore GR-78-CORE, Section 13.1	3.4.2	–	Cleaned	
			No-clean	
SIR (Optional) ISO 9455-17	3.4.2	–	Cleaned	
			No-clean	
Fungus (Optional)	3.4.3	2.6.1		
Halogen2 (Optional)	3.4.4	EN 14582		
Wetting Balance (Optional)	3.6.1	2.4.14.2		
Spread Test (Optional)	3.6.2	2.4.46		

Note 1: _________________

Required Information for Cleaned Product	
Cleaning Procedure for SIR/ECM Testing:	
Cleaning Material:	
Cleaning Equipment:	
Cleaning Process Parameters:	

Note 2: _______________-

Required Information for Halogen Determination	
Procedure used to extract metal, if applicable	
Reflow Profile	
Substrate used to collect reflowed sample residue	
Reflow Atmosphere	
Halogen Determination via Ion Chromatography	Weight of ion (g) in sample = [*Conc. of Ion in Extract* (μg */mL*)]x[*Dilution Factor*]x[*Dilution Volume* (*mL*)]x10^{-6} Percent of ion in residue = $\frac{\textit{Wt of ion (g) in Sample}}{\textit{Wt (g) of Flux Residue}} \times 100$

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Appendix B
Notes

B-1 Intended Use This document is intended to be applicable to all types of flux as used for soldering in general and to soldering in electronics particularly. The fluxes involved relate to all aspects of application, such as for wave soldering, PWB fabrication, lead tinning, and reflow, and include those in solder pastes, flux-cored wire, and flux-coated preforms. Fluxes covered by this standard are intended for use in various consumer, industrial and commercial electronics soldering applications of industry and, when adopted by government, in applications on that government's electronic hardware.

B-2 Flux Composition No-clean fluxes may have rosin compositions (symbol RO), resin compositions (symbol RE), or they may be substantially free of rosins and resins, in which case they are classified as organic type (symbol OR). They typically have type L or M activity levels. Water-soluble fluxes for electronic soldering applications and synthetic activated fluxes generally have organic compositions (symbol OR). They typically have type H activity levels.

B-3 Cleaning and Test Methods The type of flux used impacts cleaning requirements of the assembly, so any changes in flux type or cleanliness requirements may require changes in cleaning method and test methods.

B-4 Ordering Data Purchasers should select the preferred options permitted herein and include the following information in procurement documents:

a. Title, number, revision, and date of this specification.
b. Part number of product.
c. Flux designator (see Table 3-1).
d. Specify use in Sn-Pb or Pb-Free Process.
e. Flux form.
f. Viscosity and tolerance, if applicable.
g. Detailed requirements for nonstandard flux and/or flux characteristics, when specified.
h. RoHS, REACH or other compliance information, if required.

B-5 Formic Acid Formic acid is not considered a flux for the purposes of this document.

B-6 Wetting Balance Test Guidance Using the coupon as specified in IPC-TM-650, Test Method 2.4.14.2, the acceptance to satisfactory solderability is defined as those fluxes which exhibit the following:

1) A wetting time (Tw) for the wetting curve to cross the corrected zero axis after the start of the test of less than 2.0 seconds (see Figure B-1).

2) A maximum wetting force, Fmax, taken after correction for buoyancy (see J-STD-003) greater than the minimum acceptance force of 150 micronewton/millimeter (mN/mm).

4) If the ‘‘dip and look’’ requirement is specified, the sample from the above procedure can be used, and a minimum of 95% of the surface area immersed should exhibit good wetting.

Additionally, ensure that the time of the coupon's immersion in the solder bath is at least five seconds.

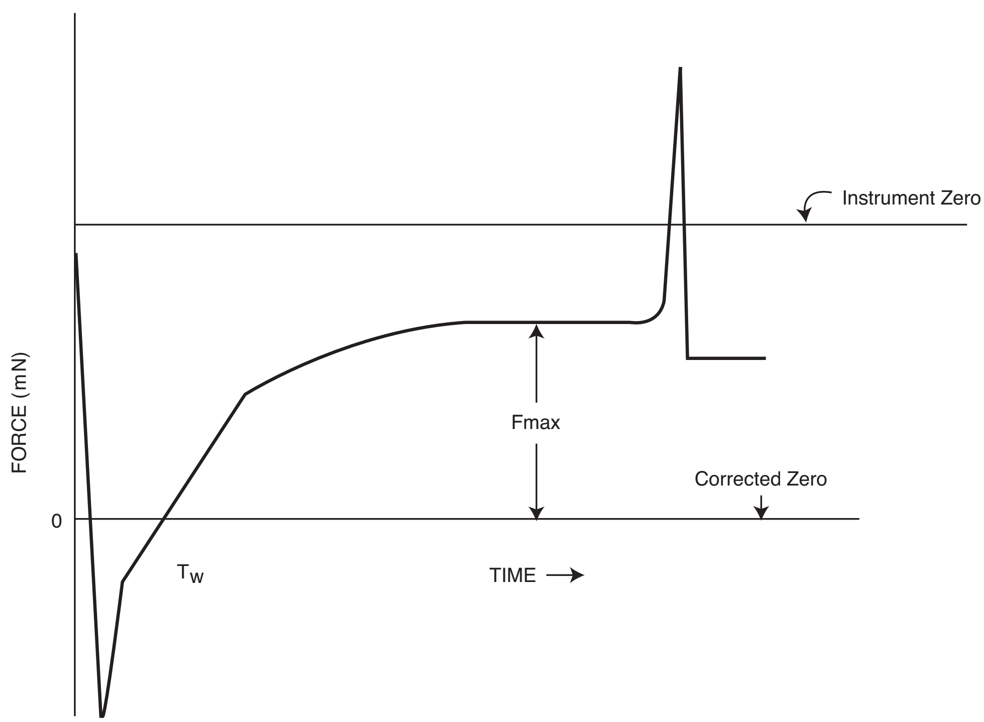

Figure B-1 Typical Wetting Balance Curve

B-7 Spread Test Guidance Table B-1 lists the typical minimum spread for each flux activity type when tested with Sn-Pb alloys per IPC-TM-650, Test Method 2.4.46.

Table B-1 Spread Area Requirements

Minimum Spread	
Diameter (mm)	**Area (mm²)**
10.0	78.5
10.7	90.0[1]
11.3	100.0[2]

1. Suggested Minimum for L1
2. Suggested Minimum for M1

B-8 Extension of Shelf Life for Liquid Flux If the stated shelf life of a product is expired, but the product meets the values recorded on the product's datasheet for the characterization tests (Acid Value and Specific Gravity), the shelf life may be extended by the user at the user's risk. Additionally, the material should be validated in the user's process. Certain performance tests may also assist the user in assessing the risk in extending shelf life, but please note that for these tests to be useful, they must have been requested and performed prior to expiration of the product.

B-9 REACH (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals. REACH is a European Union chemicals regulation that entered into force on 1 June 2007, with phased deadlines to 2018. It aims to improve the protection of human health and the environment, and enhance the competitiveness of the EU chemicals industry. It replaces several existing EU chemical legislation with a single system for all chemical substances, both ''existing'' or phase-in substances and ''new'' substances.

B-10 Halide versus Halogen Content IPC-TM-650, Method 2.3.28.1, is intended for the detection of ionic halides. Ionic halide content is not to be confused with halogen content. Halogen content should be tested per EN 14582 or AABUS. An Oxygen Bomb is utilized to dissociate the covalently bound halide and this product is dissolved and analyzed via ion chromatography. For additional information see *A Review of Test Methods* and *Classifications for Halogen-Free Soldering Materials* by Jasbir Bath, Gordon Clark, Tim Jensen, Renee Michalkiewicz and Brian Toleno published in the 2011 IPC APEX conference proceedings.

B-11 Restriction of Hazardous Substances (RoHS) The RoHS Directive stands for ''the restriction of the use of certain hazardous substances in electrical and electronic equipment.'' This Directive bans the placing on the European Union (EU) market of new electrical and electronic equipment containing more than agreed levels of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl (PBB) and polybrominated diphenyl ether (PBDE) flame retardants. Although RoHS started in the EU, additional countries are following with their own RoHS requirements. For a complete list of banned substances go to ec.europa.eu/environment/topics/waste-and-recyling/rohs-directive_en

B-12 SIR Testing: Chamber conditions' effect on SIR results For certain fluxes, such as rosin and resin-based solder pastes and core fluxes, it has been shown that it is more relevant to conduct SIR testing at 85°C/85% R.H. conditions. Due to updates to other factors in the SIR test, if it is desired to test fluxes at this higher temperature condition, use the optional test TM-650 Method 2.6.3.7, except that the test **shall** be 168 hours and the chamber condition **shall** be 85°C ± 2°C and 85% ± 2% R.H.

APPENDIX C

Abbreviations and Acronyms

AABUS	As Agreed Between User and Supplier
ASTM	American Society for Testing and Materials
Br	Bromide or Bromine
Cl	Chloride or Chlorine
cm	Centimeter
DC	Direct Current
ECM	Electrochemical Migration
Fl	Fluoride or Fluorine
I	Iodide or Iodine
ImAg	Immersion silver
IPA	Isopropyl Alcohol
MFG	Mixed flowing gas
MSDS	Material Safety Data Sheets
μN/mm	Micronewton per mm
nm	Nanometer
OSP	Organic Solderability Preservative
Pb	Lead
PBDE	polybrominated diphenyl ether
PBB	Polybrominated biphenyl
ppm	Parts per million
RoHS	Restriction of Hazardous Substances
SIR	Surface Insulation Resistance
SI Units	Metric Units
SMD	Surface Mount Device
SnPb	Tin-lead
SPC	Statistical Process Control
Tg	Glass transition temperature
Tw	Wetting time

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