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IPC-5702

Guidelines for OEMs in Determining Acceptable Levels of Cleanliness of Unpopulated Printed Boards

IPC-5702

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A standard developed by IPC

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Guidelines for OEMs in Determining Acceptable Levels of Cleanliness of Unpopulated Printed Boards

Developed by the Bare Board Cleanliness Assessment Task Group
(5-32c) of the Cleaning and Coating Committee (5-30) of IPC

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

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Acknowledgment

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Table of Contents

1	SCOPE	1	6	SUGGESTED APPROACH	6
2	APPLICABLE DOCUMENTS	1	7	SUMMARY	9
2.1	IPC	1	Appendix A	ROSE TESTING	10
2.2	Joint Industry Standards	1			
2.3	Telcordia	1			
2.4	Radio Technical Commission for Aeronautics	1			
3	THE PROBLEM WITH UNDERSTANDING CLEANLINESS DATA	2			
3.1	Where to Start	2			
4	LAB TESTS	3			
5	ENVIRONMENTAL STRESS SCREENING (ESS) TESTING	5			

Figures

Figure 3-1	Dendritic Growth	3
Figure 3-2	Electrochemical Venn Diagram	3
Figure 4-1	IPC-B-24 Test Board	4
Figure 6-1	SMTA Saber Board	7
Figure 6-2	IPC-B-52 Cleanliness Assessment Test Board	8

Guidelines for OEMs in Determining Acceptable Levels of Cleanliness of Unpopulated Printed Boards

1 SCOPE

Every electronics manufacturer, whether an original equipment manufacturer (OEM) or contract manufacturer (CM), will be faced with determining if the unpopulated printed boards used in the finished assembly have an adequate level of cleanliness. The question of “how clean is clean enough” has been asked repeatedly in the last decade in many IPC committees. This is a very complex topic, with many critical considerations, and so a single methodology to determine acceptability does not exist. This document was developed as guidance for the individual(s) responsible for determining these criteria for their company.

IPC-5701 covers many aspects of how cleanliness is measured on printed boards, as well as many critical factors to consider when specifying board cleanliness in purchasing documents. This reference, and associated technical papers, show the many inadequacies of current test methodologies, as well as explains why there are no “golden numbers” for cleanliness. What is acceptably clean for one segment of the industry may be unacceptable for more demanding segments of the industry (e.g., medical or aerospace). The reader should be familiar with that document before reading this document. Appendix A of this document covers a history of the ROSE test, as well as many uses, abuses, and fallacies of that test.

This document will *not* provide individuals with a silver bullet, nor a golden number that guarantees reliability. The only thing that will give a consistently reliable product is process control, consistent materials, a thorough understanding of the process windows, and trained personnel.

2 APPLICABLE DOCUMENTS

2.1 IPC¹

IPC-A-52 Cleanliness and Residue Evaluation Test Board²

IPC-TR-476A Electrochemical Migration: Electrically Induced Failures in Printed Wiring Assemblies

IPC-TR-583 An In-Depth Look at Ionic Cleanliness Testing

IPC-TM-650 Test Methods Manual³

2.3.28 Ionic Analysis of Circuit Boards, Ion Chromatography Method

2.6.3.3 Surface Insulation Resistance, Fluxes

2.6.14.1 Electrochemical Migration Resistance Test

IPC-HDBK-001 Handbook and Guide to Supplement J-STD-001

IPC-HDBK-830 Guidelines for Design, Selection and Application of Conformal Coatings

IPC-HDBK-840 Solder Mask Handbook

IPC-5701 Users Guide for Cleanliness of Unpopulated Printed Boards

IPC-9201 SIR Handbook

IPC-9691 User Guide for the IPC-TM-650, Method 2.6.25, Conductive Anodic Filament (CAF) Resistance Test (Electrochemical Migration Testing)

2.2 Joint Industry Standards⁴

IPC-J-STD-004 Requirements for Soldering Fluxes

2.3 Telcordia⁵

Bellcore GR-78 CORE Generic Requirements for the Physical Design and Manufacture of Telecommunications Products and Equipment

2.4 Radio Technical Commission for Aeronautics⁶

D0-160 Environment Conditions and Test Procedures for Airborne Equipment

2.5 MIL Standards⁷

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests

MIL-STD-883 Test Method Standard Microcircuits

1. www.ipc.org

2. This is the electronic artwork package for fabricating the IPC-B-52 test board referenced in this document.

3. Current and revised IPC Test Methods are available on the IPC Web site (www.ipc.org/html/testmethods.htm)

4. www.ipc.org

5. www.telcordia.com (This document is no longer available as a stand alone document and exists as an enterprise license purchase through Telcordia.)

6. www.rtca.org

7. dsccl.dla.mil

3 THE PROBLEM WITH UNDERSTANDING CLEANLI- NESS DATA

Most people understand that having residues on a printed board, component, or printed board assembly increases the risk of premature failure or improper function, complicates manufacturing processes, and represents a decrease in quality. Unfortunately, many of those who have to deal with cleanliness related issues have no background in chemistry or chemical analytical test methods, and so do not know how to measure or define cleanliness, nor can they recognize process problems related to residues.

In the rare case where cleanliness and its determination is well understood by the process professional, the challenge still remains to correlate the residues to one or more aspects of long term reliability or determining the impact of residues on the functionality of hardware.

This document was drafted and reviewed to give the average printed board or printed board assembly professional some guidance on how to correlate cleanliness related data to electrical function and determine “acceptable” cleanliness levels. Good cleanliness data remains merely an academic curiosity until one can relate it to acceptable/unacceptable assembly function in the end use environment.

3.1 Where to Start There is no standard or universal starting point. The considerations of what data to generate, how much data to generate, the meaning or context of the data, and what to do with the data depends on the viewpoints of the tester, the company or the customers involved.

There are literally hundreds of tests, such as thermal cycling, vibration, or temperature-humidity testing, that can be used to examine various aspects of reliability on the life of the product. Many of these tests do not specifically look at the impact/risk of residues on the long term life. If the reader is unfamiliar with such testing, documents such as MIL-STD-810, MIL-STD-883, or DO-160D are good documents covering the tailoring of such tests to product requirements. The following factors need to be considered when determining what tests to run:

- The end use environment (aerospace, marine, office, space, under the hood, etc.)
- The design/service life of the product (90 days, 3 years, 20 years, 50 years, warranty life + 1 day)
- The technology involved (high frequency, high impedance, power supplies)
- The consequences of failure (e.g., cell phone vs. pacemaker), which can generally relate to IPC end product Class 1, 2, and 3.

Considering the staggering number of possible combinations involved, it is clear that each OEM must determine the answer on a case by case, or product family by family

basis. This is why no single “golden” number is possible that can be applied to all products, nor should it be pursued. Specifying a cleanliness test for ultra-critical applications would be unnecessary overkill in some segments of the electronics industry.

One area to start is with a company quality manual. What kinds of test does the company use to determine if product will perform in the end use environment for the design life of the product? Do those tests include humidity as an environmental stress? Do the tests look for infant mortality kinds of failures, or end of life wear out failures? How varied or consistent are the material sets? How varied or consistent is the supplier base?

If a company has a form of life testing that incorporates humidity, that is a good place to start. If a company does not have well defined standards in these areas, then other alternative approaches can be considered (e.g., MIL-STD for high reliability, or Society of Automotive Engineers (SAE) for automotive).

With the understanding that there are many acceptable approaches to correlating residue levels with functional life tests, there are two primary arenas for test selection. The first is standard laboratory testing, such as surface insulation resistance testing or electrochemical migration testing, performed on standard test substrates. The second are environmental stress screening (ESS) methods, often called burn-in tests, on actual hardware.

Whatever test is chosen, it is very important that humidity be present, usually in amounts greater than 70% relative humidity (RH) as an environmental stress condition. To understand why this is critical, it is important to first understand that a significant number of electronics failures are related to electrochemical failure mechanisms arising from ionic residues. These electrochemical failures include electrolytic corrosion, electrochemical migration (Figure 3-1) or electrical leakage under humid conditions.

Electrochemical failure mechanisms are comprised of three elements: (1) an ionic residue; (2) an electrical potential or voltage gradient; and (3) moisture or humidity. All three must be present at some minimum level (which varies) for electrochemical failures to occur. The Venn diagram shown in Figure 3-2 is useful in understanding the relation between these three factors. The amount of impact can be visualized by considering the diameter of the individual circles to be proportional to the forcing function. As an example, if a device is operating in a very humid environment, the diameter of the humidity circle grows larger as does the electrochemical failure region.

This illustrates why the tests chosen must have humidity present if electrochemical failures are to be detected. Rob the test of either bias or humidity, such as running thermal cycling in a nitrogen-filled oven, and the failures do not manifest, a correlation to cleanliness cannot be achieved.