

Ionic Cleanliness in IPC and Military Bare Board Standards

During one of the recent meetings of the IPC Bare Board Cleanliness Assessment Task Group, one of the group members asked what resources IPC has available to help a professional in his position. This person had been tasked with qualifying all bare board suppliers but had no background or training on how to do so in a rational manner. When asked how they qualified bare board vendors now, he indicated, "Well, as near as I can figure, the vendor rep comes in, takes us out to lunch, and when we get back from lunch, the vendor is qualified."

Don't laugh, it is amazing how many fluxes, solder masks, adhesives, etc., are chosen using this same principle.

Having had a reasonably long history as an IPC task group chairman, I knew some of the standards and guideline documents available to help the novice, but I knew my knowledge was far from complete. I asked our IPC staff liaison, **Jane Koh**, to compile a list of IPC documents where cleanliness was a keyword. Every task group should be so blessed to have Jane to work with. She got me the results in about a week. I also did some research on other standards and specifications that might give additional insight on cleanliness requirements. Obviously, there are many other factors to consider than bare board cleanliness. Because I work for a company that concentrates on cleanliness issues, this is where we tend to focus.

First, look at some of the requirements for the raw materials that go into circuit boards.

Materials

IPC-CF-148A, *Resin Coated Metal Foil for Printed Boards*

- Cleanliness not specified

IPC-MF-150, *Metal Foil for Printed Wiring Applications*

- The metal foil shall be free from dirt, oil, corrosion, salts, smut, grease, fingerprints, foreign matter, and other defects that may affect the life, serviceability, or appearance of the metal foil.
- Cleanability to be tested per TM 2.3.1.1, (a visual test with water break). Cleanable to a uniform matte finish. Deionized or distilled water poured on the metal surface does not bead or form puddles.

IPC-CF-152, *Composite Metallic Material Specification for Printed Wiring Boards*

- The composite metal shall be free from dirt, oil, corrosion, salts, smut, grease, fingerprints, foreign matter, and other defects that may affect the life, serviceability, or appearance of the composite metal.
- Cleanability to be tested per TM 2.4.1.5 (a tape pull test)

IPC-FC-231, *Flexible Base Dielectrics for Use in Flexible Printed Wiring*

- Cleanliness not specified

IPC-FC-232, *Adhesive Coated Dielectric Films for Use as Cover Sheets for Flexible Printed Wiring and Flexible Bonding Films*

- Referee cleaning procedures for bright copper

IPC-FC-241, *Flexible Metal-Clad Dielectrics for Use in Fabrication of Flexible Printed Wiring*

- Cleanliness not specified

As you can see, for most materials, cleanliness is not a consideration, unless it may affect the properties later on. Even then, the cleanliness tests are often qualitative in nature. An example is the MF-150 document. Oils and greases can affect adhesion to the laminate, so cleanliness testing is a consideration, but the cleanliness measure is a water break test with just a visual assessment.



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Bare Boards

IPC-A-600, *Acceptability of Printed Boards*

- Only guidelines on how to keep clean, but no pass-fail limits

IPC-6012, *Qualification and Performance Specification for Rigid Printed Boards*

- Post-oxide treatment, pre-lamination inner layers, procurement document
- Pre-permanent solder resist boards, TM 2.3.25, 1.56 mg/cm² max ionic contamination (ROSE) test
- Pre-permanent solder resist boards, when specified, TM 2.3.38, any visual contamination from this qualitative test (FT-IR Test)
- Post-permanent solder resist boards, procurement document

IPC-6013, *Qualification & Performance Specification for Flexible Printed Boards*

- Pre-permanent solder resist Type 4 and 5 boards, TM 2.3.25, 1.56 mg/cm² max ionic contamination
- Pre-permanent solder resist other types, when specified, TM 2.3.25, 1.56 mg/cm² max ionic contamination
- When specified, TM 2.3.38, any visual contamination from this qualitative test

IPC-6015, *Qualification & Performance Specification for Organic Multichip Module (MCM-L) Mounting & Interconnecting Structures*

- Pre-permanent solder resist MCM-L structures, TM 2.3.25, 1.56 mg/cm² max ionic contamination
- Pre-permanent solder resist MCM-L structures, TM 2.3.38, any visual contamination from this qualitative test
- Post-permanent solder resist MCM-L structures, if exposed to fusing fluids or fluxes after coating, within the allowable limits of ionic and other contaminants (open to interpretation).

IPC-6016, *Qualification & Performance Specification for High Density Interconnect (HDI) Layers or Boards*

- Cleanliness as specified in IPC-6012, IPC-6013, etc.

IPC-6018, *Microwave End Product Board Inspection & Test*

- Pre-permanent solder resist boards, TM 2.3.25, 2 x 10⁶ ohm-cm max ionic contamination – in all practicality, this measure equates to the 1.56 ug/cm² ionic contamination limit listed above

IPC-MC-324, *Performance Specification for Metal Core Boards*

- Pre-permanent solder resist boards, TM 2.3.25, 2 x 10⁶ ohm-cm max ionic contamination
- Pre-permanent solder resist boards, when specified, TM 2.3.38, any visual contamination from this qualitative test

J-STD-003, *Solderability Tests for Printed Boards*

- Cleanliness can affect solderability

All of these documents recognize several fundamental cleanliness considerations:

- Cleanliness of bare boards is important, even if we cannot all agree on how it should be measured or what pass-fail levels are needed. Failure to pay attention to cleanliness considerations will have a negative impact.
- You need to have your surface clean before you put down your solder resist or before you laminate layers. If it is not clean before these steps, you will have no opportunity to go back and remedy the problem later.
- You need to have the boards clean when you deliver them to the assembler. Process fluids encountered after solder resist application, such as fluxes and fusing fluids, need to be adequately removed/reduced. Because different end-item applications will have differing bare board cleanliness needs, it is left to the assembler/user to state in their procurement document how clean the bare boards need to be and by what measure cleanliness is determined.

In the IPC specifications for bare boards, you will find two IPC-TM-650 test methods listed:

- Method 2.3.25 – *Resistivity of Solvent Extract (ROSE.)* This test is used to generate a bulk measure of the ionic residues extracted into an isopropanol/water solution. Anyone who has an Omegameter, Zero Ion, Contaminometer, etc., has done this test. It is also sometimes called a solvent extract conductivity (SEC) test.
- Method 2.3.38 – *Fourier Transform Infrared Spectroscopy.* This test is generally used to look for organic (non-ionic) residues in extract solution. A skilled FTIR chemist can use this test to determine the presence of polyglycol residues, if he/she knows what to look for.

As with any single test method, each has its advantages and disadvantages. We refer the reader to IPC-HNBK-001, *Handbook and Guide to the Requirements of Soldered Electronic Assemblies to Supplement ANSI/J-STD-001B*, Section 8, for a good overview of the various residue assessment methods.

The values of 1.56 ug/cm² and 2x10⁶ ohm-cm are essentially synonymous and originate from 1970-era military specifications as process control limits for finished assemblies processed with high solids rosin fluxes. While many technical papers have noted that it is inappropriate to use these figures as measures of bare board cleanliness, they remain in the specifications until something else comes along.

Speaking of old outdated specifications, let's take a look at how the military specifications view bare board cleanliness. Old veterans of the board business might recognize MIL-C-28809, MIL-P-55110, MIL-P-50884, MIL-P-55640, or MIL-P-82585. All of these specifications, which did discuss cleanliness of bare boards are now either cancelled or inactive for new designs. Those that are inactive have a pointer to the currently active specification MIL-PRF-31032.

MIL-PRF-31032 - Performance Specification: Printed Circuit Board/ Printed Wiring Board, General Specification for:

6.4.24 Process monitor. Process monitors are the physical verification of an

operational parameter of a process output (i.e., plating thickness, ionic contamination, solder coat coverage, etc.).

6.5.2 Quality and reliability. Printed boards compliant to MIL-PRF-31032 associated specifications are required to meet or exceed the quality and reliability of Department of Defense specifications, such as MIL-P-55110, MIL-P-50884, MIL-P-55640, or MIL-P-82585. Printed boards compliant to MIL-PRF-31032 associated specifications are processed through the conversion of customer requirements (see 6.4.8 and A.4.4) system of this document to meet or exceed every individual performance requirements or acceptance criteria specified by the customer.

From MIL-PRF-31032/1A - Printed Wiring Board, Rigid, Multilayered, Thermosetting Resin Base Material, With Or Without Blind And Buried Plated Through Holes, For Soldered Part Mounting

3.7.3 Chemical requirements.

3.7.3.1 Cleanliness. When printed wiring board test specimens are tested in accordance with 4.6.3.1, the levels of cleanliness shall be in accordance with the requirements of 3.7.3.1.1 or 3.7.3.1.2, as applicable.

3.7.3.1.1 Prior to the application of solder resist. Unless otherwise specified, prior to the application of solder resist, the level of ionic contamination shall not exceed 1.56 micrograms/square centimeter (10.06 micrograms/square inch).

3.7.3.1.2 Completed printed wiring boards (when specified, see 3.1 and 6.2.1a). The levels of cleanliness for completed printed wiring boards shall be as specified.

4.6.3.1 Cleanliness. The sodium chloride (NaCl) salt equivalent ionic contamination tests of 4.6.3.1.1 or 4.6.3.1.2 all be used to test for ionic cleanliness.

4.6.3.1.1 Manual method. The test for cleanliness shall be performed in accordance with IPC-TM-650, method 2.3.25.

* 4.6.3.1.2 Automatic methods. The test for cleanliness shall be performed in accordance with IPC-TM-650, method 2.3.25.

This same wording was found in the cancelled or inactive specs and has not appreciably changed in the last 15 years. Once you get around the oddities of MIL-spec wording, you see that the same approach is taken as for the IPC specifications: ROSE as the measurement tool, 1.56 ug/cm² as the pass-fail limit, and you must have a "clean" board prior to and after solder mask application. Be aware that this 1.56 value is also the allowable ionic contamination for finished assemblies as well.

It is a matter of opinion as to whether these approaches adequately allow you to separate "clean" from "unclean" boards, or if the pass-fail limits should even apply for such a test.

In the next issue, we will examine how some companies are charting new territory in the areas of measuring and specifying ionic cleanliness on bare boards.

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