

IPC HIGH RELIABILITY FORUM

Making sense out of the “Objective Evidence” language in J-STD-001 Section 8

Presenter:

Joe Rousseau
Materials and Process Scientist
Precision Analytical Laboratory, Inc.

Introduction: Why am I talking about Section 8?

- There seems to be a lot of confusion about how to implement Section 8 requirements
 - Significant numbers of questions about how best to approach qualifying that a process produces “clean” products are being asked regularly.
 - IPC has been receiving a questions
 - PAL also receives a lot of questions
- Goals:
 - To hopefully provide some clarity to understanding what constitutes “Objective Evidence” when we discuss “cleanliness”
 - To point to inconsistencies within Section 8 where confusion may be arising
 - Disclaimer: My views may not entirely line up with the J-STD-001 Task Group

Current “Objective Evidence” Definition:

1.8.9 Objective Evidence Documentation in the form of hard copy, computer data, video, or other media that demonstrates the requirements in the standard have been met (for examples, see Appendix C). Such documentation may include, but is not limited to:

- a. Work instructions.
- b. Procedures and records required by the quality management system.
- c. Chemical and physical test data.
- d. Reliability calculations based on recognized industry reliability standards.
- e. Manufacturer data sheets/reports, known acceptable record of performance by selected suppliers.
- f. External and/or internal audit reports.
- g. Test/Inspection reports including actual measured values.
- h. Training records.
- i. Soldering temperature versus time profiles.
- j. Technical basis for changes in materials and/or processes (as an example, see Appendix C).
- k. Historical data.
- l. Competency matrix (skills checklist).

Current “Objective Evidence” Definition: Thoughts

- Current definition is general to the overall standard...
 - It’s not precise enough related to Printed Board Assembly (PBA) “cleanliness”.
- Many of the listed examples don’t provide any evidence towards “cleanliness”
 - i.e. Work Instructions, Training records, Competency matrices, etc. provide zero evidence that a PBA is “clean”.
- Current definition and examples are better suited towards the types of items necessary for an ISO certification audit.
 - It does not clearly define how to determine if a PBA is “clean” or how best to qualify a process...
- Perhaps J-STD-001 Task Group would be open to a suggestion to improve the “Objective Evidence” definition...

Suggestions for a definition upgrade...

- Goal of a definition ought strive to be clear and concise...
- Suggested “Objective Evidence” definition:
 - Evidence based on provable facts, obtained by measurement, analysis and/or observation.
 - Examples may include:
 - Historical Performance Data for a product / material set / process – provided no significant changes
 - Test Data from a PBA evaluation / analysis / failure analysis that exonerates the failure being caused by “contamination”
 - Example: Ion chromatography (IC) test data results
 - Qualification test data of materials or processes for evaluating “cleanliness”
 - Example: Surface Insulation Resistance (SIR) tests or IC tests

More definitions to consider:

- Need to make a distinction before discussing section 8...
- **Functional Testing**
 - Testing to determine if a device or system under test functions as expected according to its specifications.
 - Examples: ICT, Flying Probe Testing, Environmental/Bias Testing of actual hardware
- **Cleanliness Testing**
 - Testing that seeks to identify, quantify and assess the affects of different material and process contaminates to ascertain how they may impact the functionality of a device or system.
 - Examples: Fourier Transform Infrared (FTIR) Spectroscopy, Ion Chromatography (IC), Surface Insulation Resistance (SIR)
- Both types of testing provide different aspects of “Objective Evidence” related to “cleanliness” and are essential for determining ECM risk and how to mitigate that risk.

Section 8.0: Cleaning and Residue Requirements

- Section 8.1 states:
 - Unless otherwise specified by the User, the Manufacturer **shall [N1D2D3]** qualify soldering and/or cleaning processes that result in acceptable levels of flux and other residues.
 - The use of extraction testing, i.e., ROSE, IC, etc., with no supporting objective evidence **shall not [N1D2D3]** be used to qualify a manufacturing process, see IPC-WP-019.
 - Questions often asked:
 - What are acceptable levels of flux and other residues?
 - Does the industry have criteria defined for acceptable levels for guidance?
 - How do we define acceptable levels of flux and other residues?
 - What are the best tools to make those determinations?
 - Will discuss shortly...
 - What is the best approach to check cleanliness and qualify a process?



Section 8.1 - Continued

Supporting objective evidence **shall [N1D2D3]** be test data and/or other documentation demonstrating that the performance of the actual hardware is not adversely affected under conditions anticipated in the service environment, see Appendix C.

- This may include:
 - 1. Surface insulation resistance (SIR), possibly in combination with ion chromatography testing, to demonstrate acceptable levels of residue. See IPC-9202 and IPC-9203.
 - 2. Historical evidence, including field returns, warranty service records and failure analysis, demonstrating that ionic and other residues on delivered products have not caused failures in service.
 - 3. Electrical testing results, with power on, during extremes of temperature and humidity, which simulate the end use environment. Electrical failures should be subjected to failure analysis to determine whether ionic or other residues have caused the failure. This testing may occur during product qualification or outgoing acceptance testing.
- Rework processes **shall [N1D2D3]** be included in the process qualification.



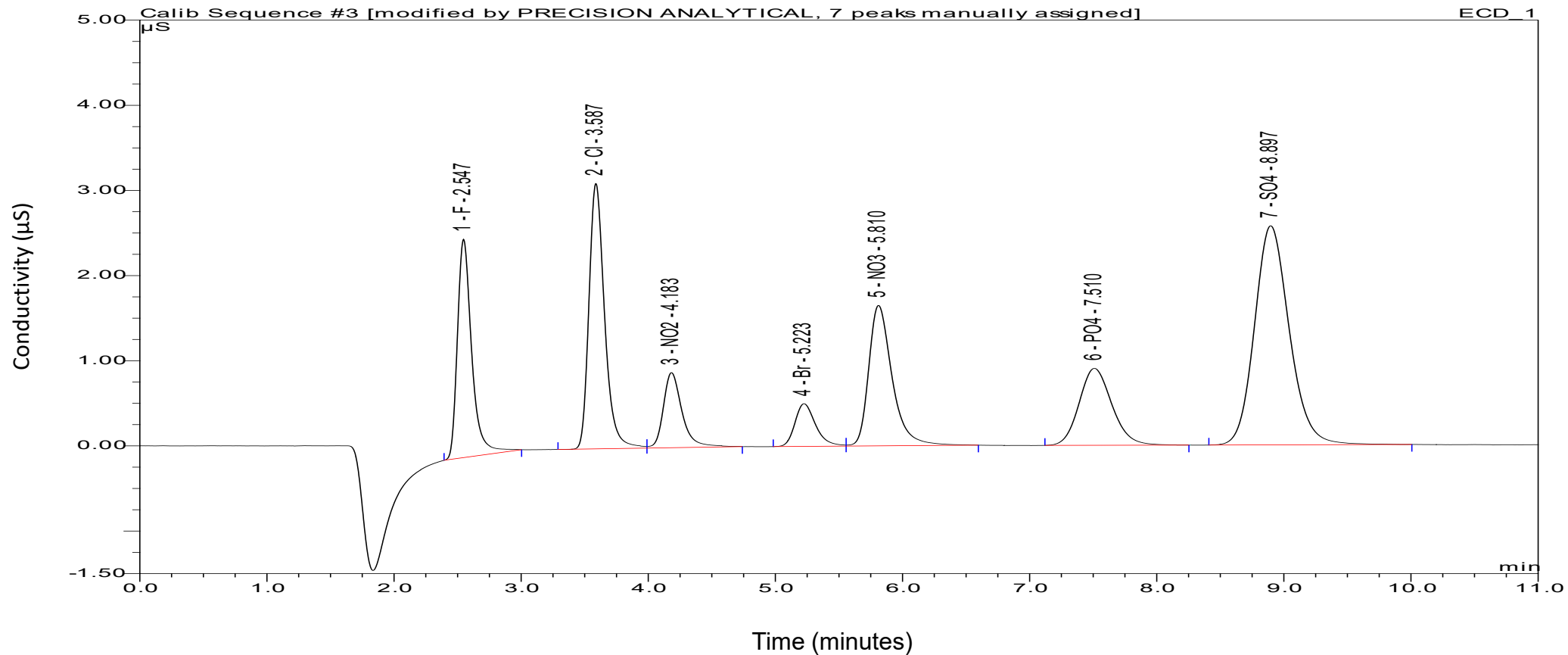
What tools are available for evaluating acceptable levels of flux and other residue?

- **Ion Chromatography (IC):** This tool is used in our industry to identify and quantify ionic residues from various chemistries used in the making of the final assembly, including residues from flux and fabrication residues (i.e. board and components), etc.
 - Highly accurate / highly selective / highly sensitive
 - Expensive, Need Trained Personnel, No industry defined Pass/Fail criteria



Photo courtesy of PAL Library

Sample Chromatograph: Common Anions



Current Tools - Continued

- **Surface Insulation Resistance (SIR):** This tool is used to assess if a residue left from a material or process has the ability to initiate and sustain an electrochemical event (i.e. current leakage, corrosion, dendritic growth).
 - It is a “rubber meets the road” test for assessing the impact of residues on electrical performance.
 - Residue characterization
 - It cannot be used for evaluating “actual hardware”, at least not easily.
 - The test vehicle that is typically used for this testing is the IPC-B-52, which the chief complaint is that it doesn’t represent modern products.

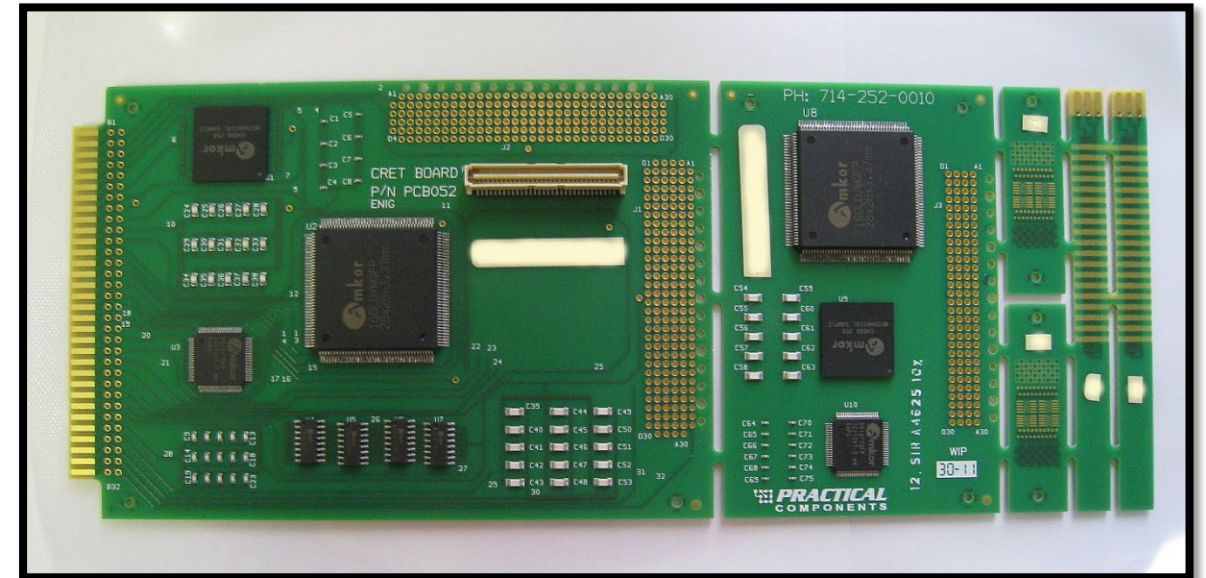
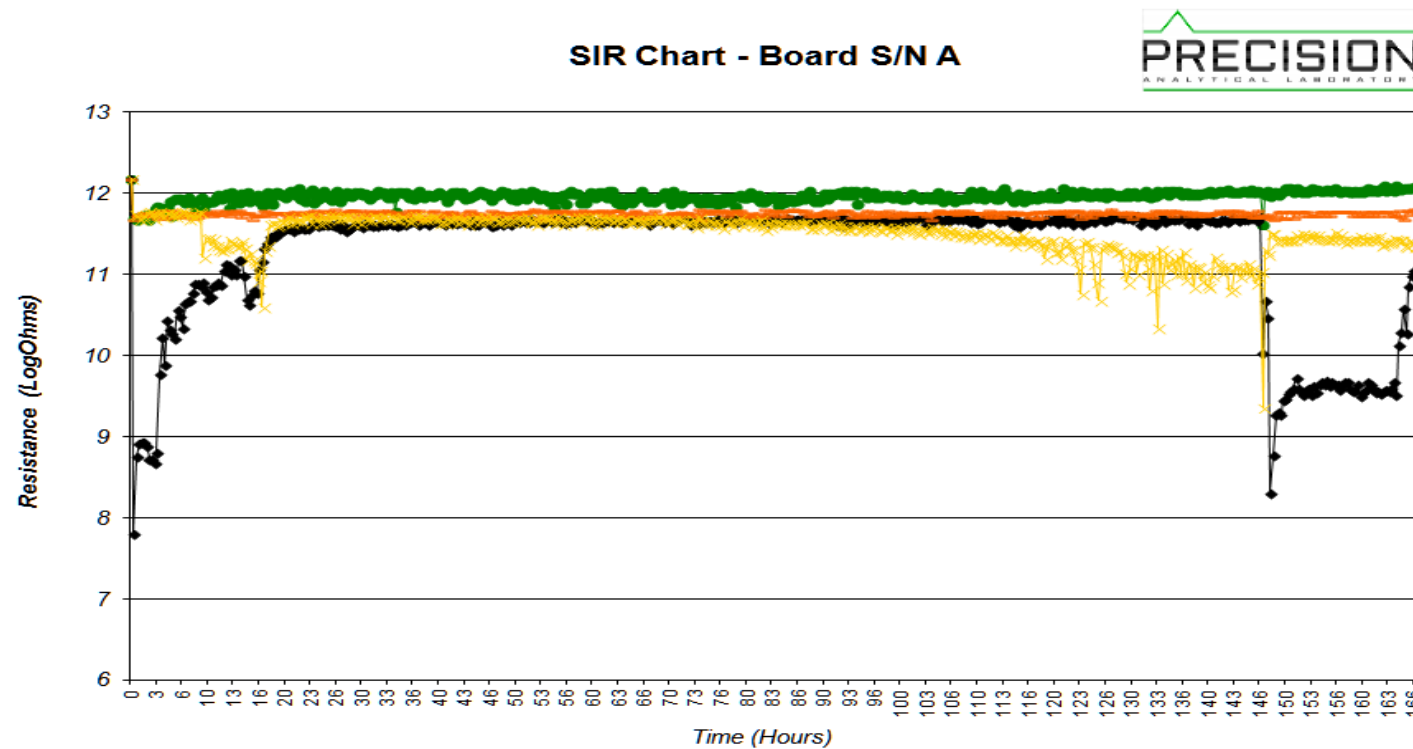


Photo courtesy of PAL Library

IPC-B-52 Coupon

Current Tools: SIR Sample Graph



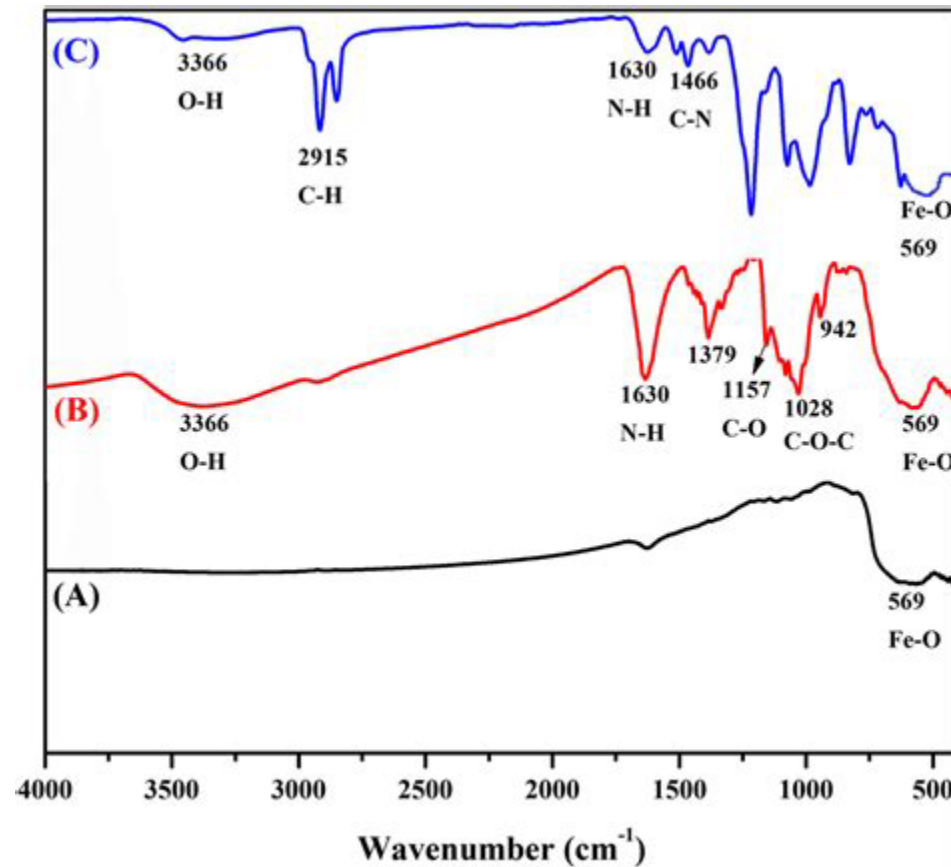
Current Tools: Continued



Stock photo taken from the Web

- **Fourier Transform Infrared Spectroscopy (FTIR):** This tool is used to identify organic and inorganic materials.
- It is good for qualitative work...
- Not the best for quantitative analysis...

Current Tools: FTIR Sample Spectra



Stock photo taken from the Web

Why can't we use Resistivity of Solvent Extract (ROSE)?

- Lack's selectivity
 - No residue identification
- Lack's sensitivity
 - Dilution problem
- Current solvent not effective for extracting all flux types
- Result is meaningless
- Industry no longer supports old pass/fail limit
 - $1.56 \mu\text{g}$ of NaCl eq. / cm^2
 - $10.06 \mu\text{g}$ of NaCl eq. / in^2
- Not adequate as a "cleanliness tool or as a process control tool"



Photo courtesy of PAL Library

Section 8.1.1: Cleaning Designator

- The cleaning designator is a 2-digit (minimum) code that describes the cleaning and process control testing required for assemblies under this standard. The code begins with the letter “C” and then a dash followed by two or more digits. The first digit represents the cleaning option, see Table 8-1.

Table 8-1 Designation of Surfaces to be Cleaned

0	No surfaces to be cleaned
1	One side (solder source side) of assembly to be cleaned
2	Both sides of assembly to be cleaned

- The second and any subsequent digits define the requirements for process control of residues, see Table 8-2.

Table 8-2 Residue Testing for Process Control

0	No test required
1	Test for rosin residues required (see 8.6 Non-Ionic Residues)
2	Test for ionic residues required (see 8.2 Ionic Process Monitoring)
3	Test for surface insulation resistance (Note 1)
4	Test for surface organic contaminants (Note 1)
5	Other testing (Note 1)

- Note 1. As established between Manufacturer and User if required.

- In the absence of a specified cleaning designator, the designator C-22 **shall [N1D2D3]** apply. A cleaning designator of C-00 specifies a “no-clean” process with no testing for residues. A cleaning designator of C-223 specifies an assembly requiring cleaning on both sides, in addition to ionic residue and SIR testing.

Section 8.1.1: Cleaning Designator - Continued

- So, if I don't clean because I am using a "no clean" classified flux, then according to the C-00 designation I don't need to do any "cleanliness" testing of my assembly, is that a correct understanding?
 - Seems to be implied, but it is not prudent... Why?
 - No clean assemblies still fail as a result of cleanliness
 - Incoming boards – Can be dirty
 - IPC-5704 could be used as a starting point
 - Flux residues – Some materials absorb moisture over time (based on SIR evaluations)
 - Components – Can also be dirty (GEIA-STD-0006 uses ROSE to evaluate component cleanliness)
 - No Clean Assemblies: Dirt in = Dirt out
 - No clean assemblies should be checked for cleanliness
 - Incoming boards should be checked regularly
 - Components may also need to be checked, at very least benchmarked
 - J-STD-001, section 8 needs to clarify this area.
 - If they agree that "no clean" assemblies don't need to be cleanliness tested, then are absolutely wrong.
- The same requirements should still apply to "no clean" environments for providing "Objective Evidence"

Section 8.2: Ionic Process Monitoring

- When a manufacturing process has been defined and qualified per 8.1 Qualified Manufacturing Process, and when ionic residue testing is required, ionic residue testing shall [N1P2D3] be controlled as follows.
 - 8.2.1 Sampling Plan The Manufacturer shall [N1P2D3] determine an objective sampling plan (see IPC-9194 for guidance) for determining the total extractable ionic content from the printed board by using ROSE testing per IPC-TM-650, Test Method 2.3.25.
 - Other methods, e.g., surface insulation resistance or ion chromatography, either on actual product or representative samples, may be used with User approval. The sampling plan shall [N1N2D3] define the test frequency.
 - ROSE Testing will not provide “Objective Evidence” that the boards in a given process are free of “ionic residue”.
 - SIR cannot be used on actual product.
 - The best choice for process checks - Ion Chromatography.

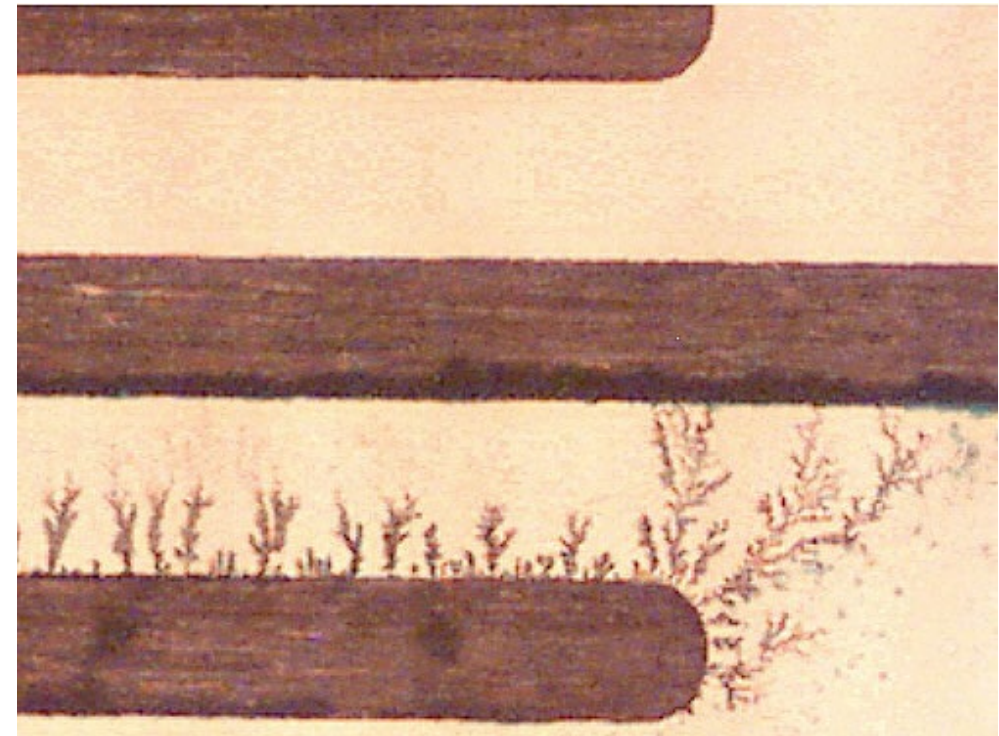


Photo courtesy of PAL Library

Section 8.2: Continued

- **8.2.2 Control Limits** The Manufacturer **shall [N1D2D3]** determine an upper control limit (UCL) for ionic residue process testing based on the results of 8.1 Qualified Manufacturing Process, and have objective evidence available for review.

Question that is often asked:

1. How are UCL's for residues to be established without measuring what the residues are and how much of each are present?
2. Can we use extraction-based testing to help establish UCL?
 - Yes, use extraction-based testing as one tool to help establish UCL
 - Functional Tests under humid conditions should also be used to help establish UCL
 - SIR is not the best tool for UCL's because:
 - How to equate test board results to live product?
 - Industry test vehicles don't closely mimic modern circuit designs
 - SIR best applied to screen materials and process changes ahead of making full commitment to those changes (i.e Material & Process Characterization)

Section 8.6: Non-ionic Residues

- States: All other residue testing requirements, when specified, **shall [N1P2D3]** be as established between Manufacturer and User. Such agreements should include the test method, the test parameters, and the pass/fail criteria. When rosin flux residue testing is required, assemblies **shall [N1P2D3]** be tested and **shall [D1D2D3]** comply with the following requirements for the maximum allowable level of flux residues.
 - When SIR is required, it **shall [N1P2D3]** be performed using a documented method that includes pass/fail criteria and is available for review, see IPC-9201.
 - When surface organic contamination testing is required, assemblies **shall [N1P2D3]** be tested in accordance with IPC-TM-650 Test Method 2.3.39 and **shall not [N1P2D3]** exceed the maximum acceptance level as established between Manufacturer and User.

■ **Table 8-3 Maximum Acceptable Rosin, Note 1**

Class 1	200 µg/cm ²
Class 2	100 µg/cm ²
Class 3	40 µg/cm ²

- Rosin values in this table are not typical of modern assemblies. Values are at least 25 years old!
 - Same rosin requirements are found in HDBK-001 rev B (JSTD-001 rev B) section 8.3.5 from 1998.
 - Method 2.3.29 is on IPC's cancelled method list
 - No longer an active method
- FTIR may be a good tool for evaluating non-ionic residues

Conclusion:

Objective Evidence is going to be a multi-tool endeavor to meet all of the “Objective Evidence” requirements in Section 8.

- I. Using historical evidence serves as a basis to show that product and processes are not creating significant field returns.
 - a. However, even if you’re not having field failures baselining the “cleanliness” of your products is still a good risk mitigation plan
 - i. Using IC to evaluate incoming board residues, flux residues, component residues and assembly residues provides a good basis to understand the types and amounts of ionic residues on your final boards.
- II. SIR is good to have done whenever there is a change to a material or process.
 - i. This allows an opportunity to determine if there are any hidden ECM land mines.
 - ii. Not good for testing live product.
 - iii. Functional tests under humid conditions where practicable are absolutely valuable for assessing if product are going to have ECM related faults or failures.
- III. ROSE testing should no longer be used for evaluating final assembly “cleanliness”, nor should it be used to monitor the cleanliness of product coming from the manufacturing line (i.e. process control). It simply doesn’t make the grade today and there are better tests available.
- IV. This should go without saying, but always consult your customer to see if they have specific requirements for cleanliness.
- V. Lastly, IPC-J-STD-001 task group may wish to consider improving clarity of the document by improving definitions and re-evaluating the test recommendations that are currently available to assess “ionic” cleanliness.

Questions:





IPC HIGH RELIABILITY FORUM

THANK YOU!

For Questions Contact:

Joe Rousseau

Email: Joe.Rousseau@precisionanalysts.com

Phone: (765) 252-3970