Cleaning and Cleanliness
In IPC Specifications

Doug Pauls and Dave Hillman
Principal Materials and Process Engineers
Rockwell Collins

Keynotes: Marketing Vs. Reality

What Was Pitched

The Grim Reality
The Goal of Today’s Presentation/Discussion: Educate - Entertain - Engage!

Agenda

- IPC-A-610E
  - Visual Cleanliness / Crud / “Schmutz”
- J-STD-001E
  - Systematic Cleanliness / Cleanliness Verification
- IPC-5704
  - Bare Board Cleanliness
- IPC-9202/9203
  - Process Qualification / Materials Compatibility
IPC-A-610
Visual Cleanliness

Magnification and Cleanliness

- If you look close enough at ANY printed wiring board, you WILL find something wrong, or something that looks like it might be wrong.
Is This Clean?

Flux Residues?
### How Close Do You Look?

<table>
<thead>
<tr>
<th>Magnification Aid Applications – Other</th>
<th>Cleanliness (with or without cleaning processes)</th>
<th>Magnification not required; see Note 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleanliness (no-clean processes)</td>
<td>Note 1</td>
<td></td>
</tr>
<tr>
<td>Conformal Coating / Encapsulation</td>
<td>Notes 1, 2</td>
<td></td>
</tr>
<tr>
<td>Marking</td>
<td>Note 2</td>
<td></td>
</tr>
<tr>
<td>Other (Component and wire damage, etc.)</td>
<td>Note 1</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** Visual inspection may require the use of magnification, e.g. when fine pitch or high density assemblies are present, magnification may be needed to determine if contamination affects form, fit or function.

**Note 2:** If magnification is used, it is limited to 4X maximum.
610 Sections 3.3.X - Handling

- Cleanliness of the work area and work surfaces
- Food, drink, tobacco - bad in the workplace
  - Popcorn day is a stupid idea
- Minimize handling - finger salts and oils
  - Especially if no-clean
- Gloves and finger cots
  - False sense of security

SMART Conference 2010

610 Sections 3.3.X - Handling

- Don’t use hand creams and lotions containing silicones
  - Or anything else
- Foreign Objects and Debris (FOD)
  - From the environment or improper assembly practice

SMART Conference 2010
The Law of Unintended Consequences: PWB Packaging

The Law of Unintended Consequences: Use of Pearl Pink Erasers
Appearance of Solder Joints

Bright & Shiny or Dull & Matte?

Appearance of Solder Joints

Just How Many Times Can I Wash An Assembly?
Visual Assessment of No-Clean

- Wow, look at all of that flux residue (solder paste)!

A-610 Section 10.6 – Cleanliness

- Contaminant is not only to be judged on cosmetic or functional attributes, but as a warning that something in the cleaning system is not working properly.
- Every production facility should have a standard based on how much of each type of contaminant can be tolerated. Testing with ionic extract devices based on J-STD-001, insulation resistance tests under environmental conditions and other electrical parameter tests as described in IPC-TM-650 are recommended for setting a facility standard.
10.6.1 Flux Residues

Flux Material Characteristics Have An Impact

Darker residue 2nd pass

SAC 2nd. pass light residues

Photos Courtesy of P. Biocca, Kester
10.6.2 Particulates

Particulate debris on an assembly is never a good thing

How Much Particulate Is Too Much?
10.6.3 Chlorides, Carbonates, and White Residues

Cleaning Solution is rarely the issue – the materials dissolved in the cleaning solution are the enemy.

The assembly materials and interaction with the product use environment need to be understood.
10.6.3 Chlorides, Carbonates, and White Residues

Beware product use environment and product design interactions

Courtesy of Terry Munson, Foresite Inc.

10.6.5 Surface Appearance

Material Compatibility Issue Clearly Evident
A-610 Takeaways

- Pretty Simple:
  - Understand your materials
  - Understand how your materials should be processed
  - Understand your process
  - MEASURE your process
  - Don’t assume that everyone is going to play together well in the sandbox! Process and material interactions can result in problems
Areas of Primary Impact

- 3.1 on Materials
- 3.3 on Fluxes
- 4.2 on Facilities
- 4.8 on Presoldering Cleanliness Requirements
- 4.19 on heat shrink devices
- **8.0 on Cleanliness Requirements**
- 9.2 on Marking requirements
- 11.2.2 on Visual Inspection
- 12.3 on Post Rework / Repair Cleaning
- Appendix A, section A-4

Section 8 - Cleanliness

- Primarily aimed at “post solder cleanliness”
  - Should be immediately before conformal coating
- Do I HAVE to clean to be J-STD-001 compliant?
  - It depends
- An item that is **required to be cleaned** shall [N1N2D3] be cleaned per a documented process to allow removal of all contaminants (especially flux residue). The items cleaned shall [D1D2D3] be capable of meeting the cleanliness requirement as specified herein (see 8.3).
- A no-clean assembly is not required to be cleaned
- The fine point is – required by whom?
  - Darn customers
Section 8

- Cleanliness Designator is chosen by the manufacturer
  - The default is C-22 (clean both sides, test by ROSE)
  - First number is how many board sides are cleaned, second
    and following numbers are what process control tests you use
  - C-15 would be cleaning one side, alternate cleanliness test
    used (e.g IC) (IC can be used in place of ROSE)
  - C-02 would be a no-clean process, ROSE testing as a monitor

- So you have to clean only if your cleanliness designator says so.
- If you are doing no-clean, then a materials compatibility data package will be key to convincing customers

Materials and Process Qualification

- The old Appendix C was never required to be J-STD-001 compliant
  - Customers may have demanded it, but the spec did not
  - This was only ONE way, out of several possible, to demonstrate materials and process compatibility

- J-STD-001E has no Appendix “C”
  - IPC staff has been directing users to the old Appendix C until the new protocol is released
  - IPC-9202 (stay tuned)

- Yes, such testing can cost a few quid
  - the cost of ignorance is far far worse
Materials and Process Qualification

- Product design, materials and processes

Localized Residues

- J-STD-001 focuses on cleanliness of the entire assembly
  - Often times, automated assembly is assumed
  - Localized residues can often cause failures that a global evaluation of an assembly will miss
    - The small signal gets diluted out
    - True for ROSE
    - Can also be true for IC or any other form of global extraction methods
- IPC Ionic Cleanliness Task Group is pursuing localized extraction and evaluation methods
  - White paper draft from IPC Midwest
Other Points of Interest

- 8.3.6.1: The residual rosin numbers are far too high for today’s fluxes - based on old RMA numbers
  - It’s meaningless, don’t use it.
- 8.3.6.2/3: ROSE sucks
  - Its only valid use is for process control
  - Mod ROSE (TM650, method 2.3.25.2) works better
  - But still heavily used for product acceptance
    - We’ve always done it this way
    - The contracts say we have to do it
    - It keeps the customers happy
    - Product C this year is very similar to Product B from last year so we use the same boilerplate in new contracts

J-STD-001 Take Aways

- Cleaning is required only if customers demand it, but the J-STD does not
- Having a materials and process qualification data package will help those who wish to do no-clean and what REAL process control metrics to use and what REAL product acceptance numbers to use
- ROSE sucks
IPC-5704
Cleanliness Requirements for Unpopulated Printed Boards

IPC-5704

- IPC hosted a Webinar (recorded) on 5704 in June 2010 if interested - Presenter was somewhat odd
  - Doug has both with him (large files)
- IPC-57XX series
  - IPC-5701: Guidance to Purchasing - Published
  - IPC-5702: Guidance to OEMs - Published
  - IPC-5703: Cleanliness for Fabricators - in process
  - IPC-5704: Cleanliness Requirements for Printed Boards
  - IPC-5705: A Users Guide for IPC-5704 - just starting
- IPC-5704 is a cleanliness standard based on ion chromatography, a much more precise method of measuring ionic cleanliness
IPC-5704 Test Method

- Method 2.3.28.2 – Ion Chromatography for Bare Boards
  - Uses standard 10% isopropanol/90% deionized water
  - Generally gentler to electronics than 75%/25% solution
  - WILL give you different numbers than extracting in 75/25
  - Use approximately 0.5 mL per every square centimeter of board surface
  - Method is ion specific
- Extraction: 60 minutes at 80°C
- Extraction performed in non-contaminating bags
  - Recommend Bee Packaging 4-6 mil wall cleanroom bags
  - www.beepackaging.com
  - 3M Scotchpak Kapak bags also work, but may contribute sulfate

IPC-5704 Requirements

<table>
<thead>
<tr>
<th>4 CLEANLINESS REQUIREMENTS</th>
</tr>
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<tbody>
<tr>
<td>4.1 Ion Chromatography Test</td>
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</table>

A qualified laboratory shall be used to perform the IC testing. It is recommended that the qualification be to ISO/IEC 17025, QSI 1000, or equivalent.

All as-received single or double-sided and multilayer printed boards shall conform to the stated ionic cleanliness requirement listed for the respective surface finish in Table 4-1, when tested in accordance with IPC/TM-650, Method 2.3.28.2.

**Table 4-1 Bare Printed Board Ionic Contamination Maximum Limits (μg/cm²)**

<table>
<thead>
<tr>
<th>Ions</th>
<th>Non-OSP</th>
<th>OSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride (Cl⁻)</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Bromide (Br⁻)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Sodium (Na⁺) – Potassium (K⁺)</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Total Inorganics</td>
<td>3.9</td>
<td>5.9</td>
</tr>
</tbody>
</table>

The units in Table 4-1 are in micrograms (μg) per square centimeter (cm²) based on the extraction volume and the calculated sample surface area.

- It is important to remember to match the criteria to the test method (2.3.28.2) generating the numbers
- Non-OSP boards include immersion tin, immersion silver, ENIG, etc.
- OSP boards are different because of the different cations that you get from those preservatives
- Note the units: they are **NOT** the same as for ROSE values
Impact of 5704

- These levels are largely in line with what the test labs recommend as bare board cleanliness levels
- While these levels may not be iron clad for all products for all applications for all end item environments, they are a vast improvement over cleanliness by ROSE
- OEMs that have used these levels have reported successes and a reduction of failures attributed to bare board cleanliness
- An ion chromatograph is worth its weight in gold
  - IPC-WP-008 is a paper on what is involved with setting up an ion chromatography lab

IPC-9202 and 9203
Process Investigation / Qualification
IPC-9202 and 9203

- **IPC-9202**: Material and Process Characterization / Qualification Test Protocol For Cleanliness
  - Intended as an international protocol accepted for both IPC-J-STD-001 and IEC-61189
  - Uses the IPC-B-52 Test Assembly
  - Intended for use with the assemblers chosen material set and chosen suppliers
- **IPC-9203**: IPC-B-52 Users Guide
  - An overall guide on what goes into an intelligent process investigation and qualification effort
  - Doug and Graham wrote most of it, so beware
- Working to harmonize 9202 and IEC-61189

**IPC-B-52 Test Assembly**

- SIR Section
- IC Coupon
- Optional Coupons
9202 Requirements

- Can use test kits for process investigations
  - Sample size of 5
- Use actual material sets for process qualifications
  - Sample size of 10
- SIR Testing per IPC-TM-650, method 2.6.3.7
  - Frequent monitoring, 40C/90% RH, 5 VDC, 4 days minimum
  - Uncoated condition
  - 100 megohm minimum for all patterns
- Ion Chromatography required per method 2.3.28
  - No pass fail requirements, but sets historical baseline
- Post Test Visuals
  - Document dendrites - more than 25% is a fail
  - Cannot throw out more than 2 data points (from 10)

IPC-9203

- Largely Doug Pauls In A Can
- Explains the test vehicle
  - What you can and can’t do
  - Components
- How to setup a process investigation using the B-52
- How to evaluate a B-52 for SIR and Ionic Assay
- Still in revision
- Can be found on the IPC 5-32b Committee Home Page
Closing Thoughts

Become Better Educated

- IPC Cleaning Handbooks (in revision)
- Cleaning Newsletters, BFK Solutions
- College text on chemistry
- Ewing’s Analytical Instrumentation Handbook, 3rd Edition
- Brian Ellis’ Cleaning and Contamination of Electronics Components and Assemblies
- Dale Carnegie Speaking Courses
- IPC Technet Listserv
- Dr. Ken Galeo’s Mysteries of Science
- Failure Analysis case studies
Contact Information

Douglas Pauls  
Principal Materials and Process Engineer  
Rockwell Collins  
400 Collins Road NE  
MS 108-101  
Cedar Rapids, IA 52498  
319.295.2109  
dopauls@rockwellcollins.com

David Hillman  
Principal Materials and Process Engineer  
Rockwell Collins  
400 Collins Road NE  
MS 108-101  
Cedar Rapids, IA 52498  
319.295.1615  
dbillma@rockwellcollins.com

Now The Fun Part - Discussion