Identifying Your Cleaning Quality Standards

AUSTIN AMERICAN TECHNOLOGY

IPC / SMTA Cleaning Workshop

The Science of Cleaning Green

Content

- Classification
- Quality Standards
- Test Methods

Classification

- Class 1: General Electronic Products
  - Includes products suitable for applications where the major requirement is a function of the completed assembly
- Class 2: Dedicated Service Electronic Products
  - Includes products where continued performance and service 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 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.

Source: IPC J-STD-001E-2010. (2010, April). IPC, Bannockburn, IL.

Customer Expectations Determine Cleanliness Standards

- Level 1 Disposable Electronics
  - Low Cost
  - Talking cards, calculators, toys
- Level 2 Consumer/Commercial Electronics
  - Medium Cost
  - Home Computers/Appliances
- Level 3 High Reliability/Performance Electronics
  - High Cost
  - Servers, Military, Medical, Space, Aircraft, Automotive

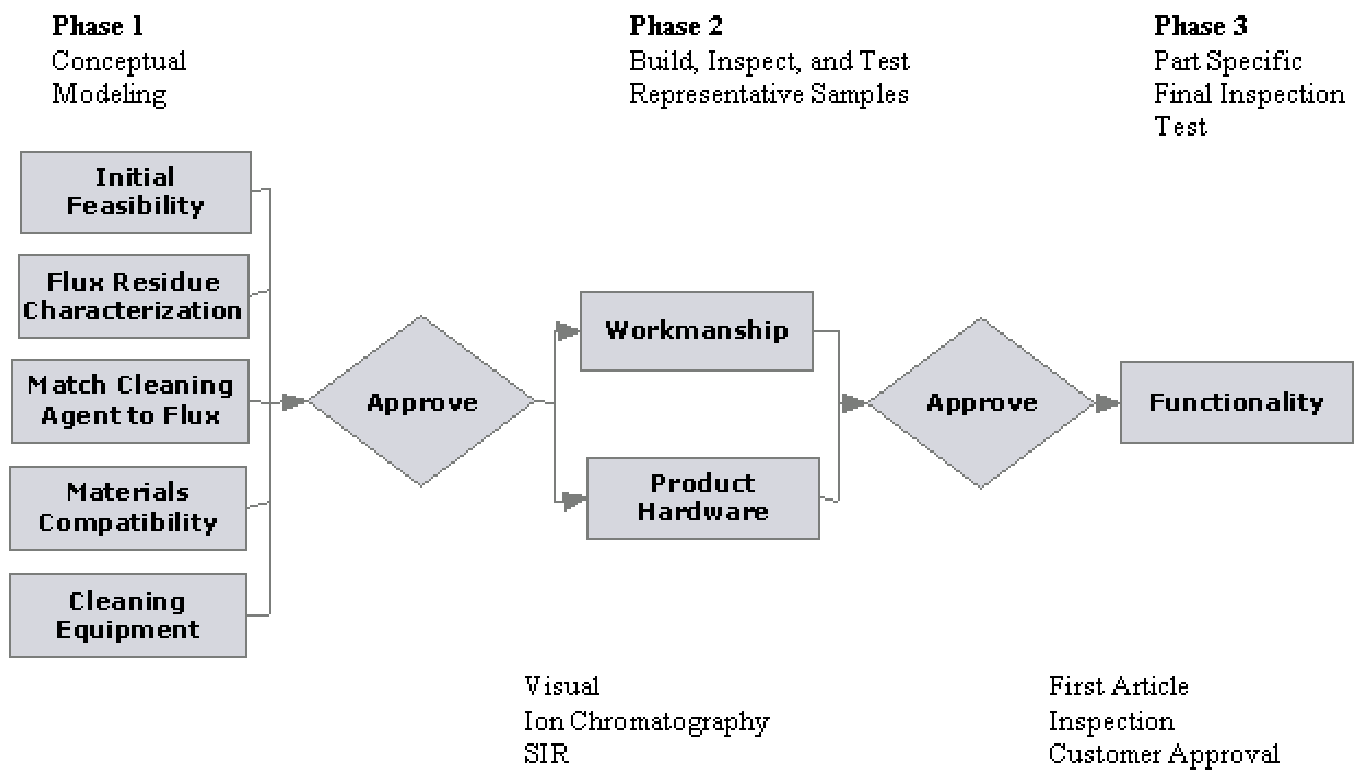
Quality Standards

Reasons to Evaluate Cleanliness

1. Baseline residues not directly related to your process
2. Understand the residues left on the assembly and how they impact product reliability
3. Proactive in capturing residue issues before they become an issue

Source: Russeau, Joe (2008). Utilizing and Understanding the Various Methodologies for Evaluating Ionic Cleanliness of Printed Wiring Assemblies. IPC / SMTA Cleaning Symposium.

Designing the Cleaning Process



Source: Honeywell Engineering Specification (2009). M4093482

Initial Feasibility

- Application standards
  - Requirements for Soldered Electrical and Electronic Assemblies ~ J-STD-001E-2010
  - Solder flux ~ J-STD-004
  - Solder paste ~ J-STD-005
  - Solder alloys ~ J-STD-006
- Material analysis
  - Material Technical Specifications
  - Manufacturers' Test Results
  - Material Safety Data Sheets
  - Material Suppliers Quality Assurance
  - Process Control Methods

Where do Your Cleaning Quality Standards Apply?

1. What are the offensive residue problems?
   - Ionic (chemical corrosion)
   - Bulk (Stencil printing, electrical test, adhesion cosmetics)
   - Ionic/Bulk Mixture (non-corrosive electrical leakage)
2. How do you assess the offensive residues?
   - Process Qualification Testing
   - Process Control Testing
   - Standards
3. What level is acceptable?
   - Process Qualification
   - Process Control

What Test Applies?

- How Clean is Clean Enough?

Operational

Visual

ROSE

IC test

SIR test

Copper Mirror

Residual Rosin

FTIR

Water Break

SEM/EDAX

Ionic (chemical corrosion)

Bulk (Stencil printing, electrical test, adhesion, cosmetics)

Ionic/Bulk Mixture (non-corrosive electrical leakage)

Apollo Disaster

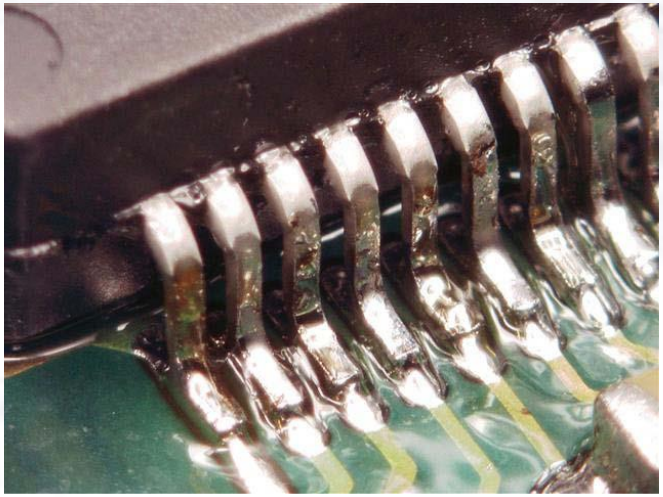
- **Cause of Fire**
  - No single ignition source of the fire was conclusively identified.
- **Determination**
  - The most probable initiator was an electrical arc in the sector between the -Y and +Z spacecraft axes

January 27, 1967

Test Methods

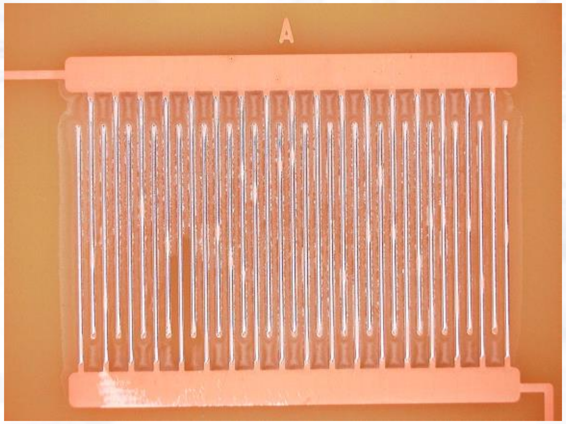
Optical

- Visual inspection under minimum magnification (10-30x)
- Inspection for
  - Residues
  - Contamination
  - Corrosion
  - Mask and substrate condition
  - Solder joint formation
  - Discoloration
  - Solder balls
  - Cleaning agent entrapment
  - Particulates



Electrical

- Surface Insulation Resistance
  - IPC-TM-650 2.6.3
- Electrochemical Migration
  - IPC-TM-650 2.6.14 & 2.6.14.1
  - Telcordia GR-78-CORE



Chemical

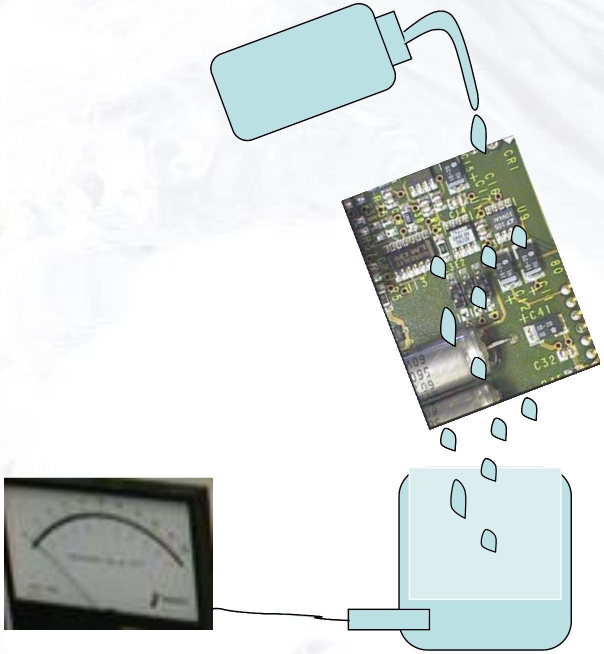
- Ionic Cleanliness Level 1 (R.O.S.E.)
  - IPC-TM-650 2.3.25
- Ionic Cleanliness Level 2 (Ion Chromatography)
  - IPC-TM-650 2.3.28
- Surface Organic Contamination
  - IPC-TM-650 2.3.38 & 2.3.39
- Conformal Adhesion Test
  - IPC-TM-650 2.4.16
- Component Compatibility Test
  - Ensure no adverse affects with the cleaning agent and process
- Residue Analysis
  - Surface Analysis
    - Scanning Electron Microscopy
    - FTIR ~ Fourier Transform Infrared Spectroscopy
    - HPLC ~ High Performance Liquid Chromatography

History of the Ionic Cleanliness Test

- In the **1960's**
  - DoD concerned about PCB failure
  - Ionic contamination cited at the root cause
- Quality assurance and process control needed
- Task Force Objectives
  - Quantitative process control method
  - Detect ionic contamination
  - Establish Pass / Fail criteria

R.O.S.E. Background

- Developed by the Navy in 1970s
  - Residue correlated to conductivity
  - MIL-P-28809
    - DoD spec for Acceptability of Military
  - Manual method



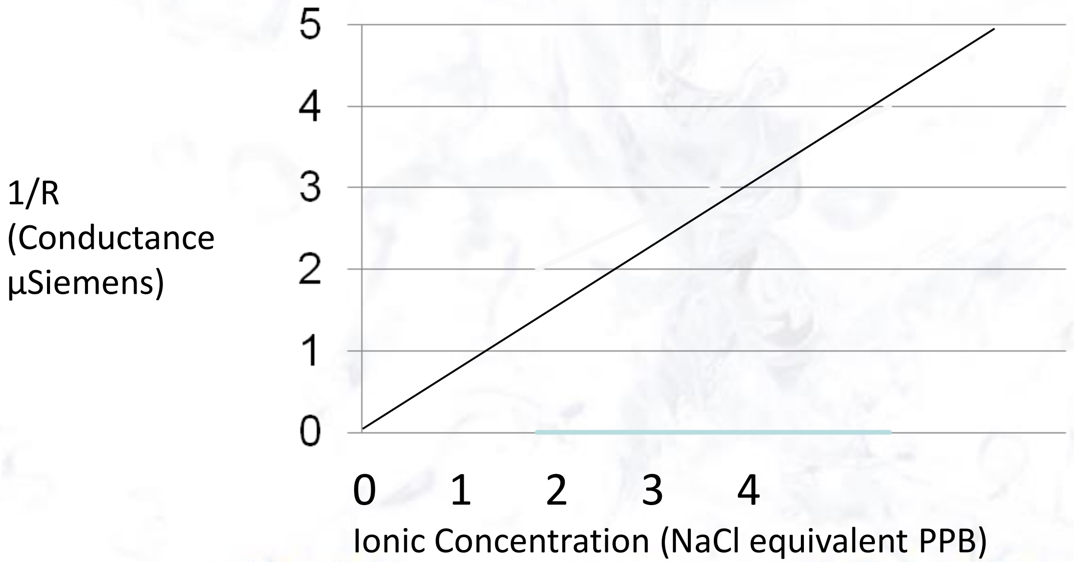
What is a “ROSE” test

“**R**esistivity **O**f **S**olvent **E**xtract”

- Industry standard test for circuit board cleanliness

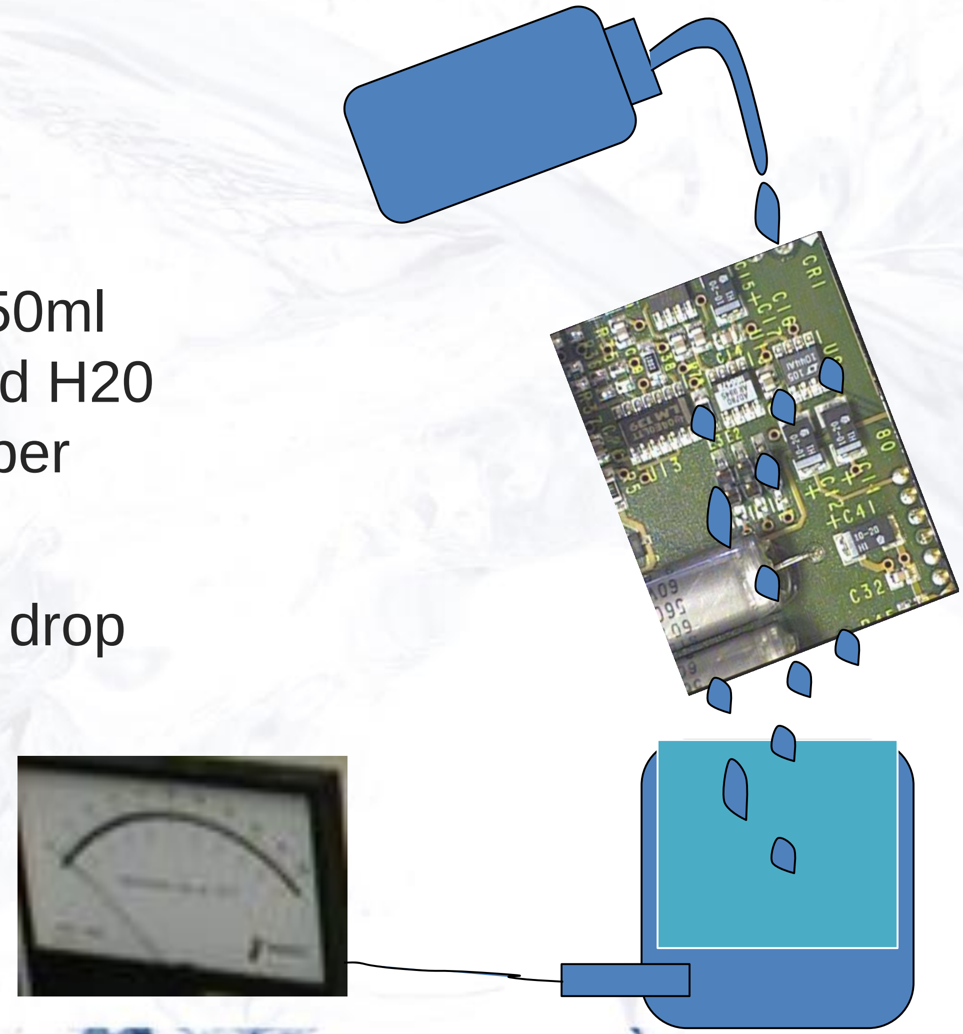
(Mil-P-28809 in 1971)

- Measures the ionizable residues remaining on a circuit board or assembly
- NaCl eq/cm2 = (Concentration X Test volume)/ circuit area



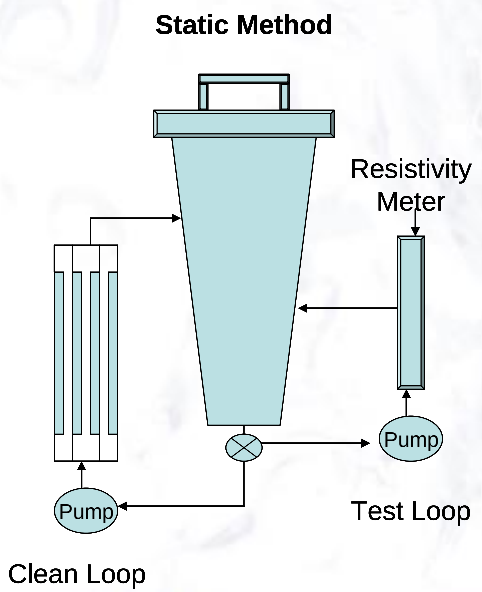
Manual ROSE Method

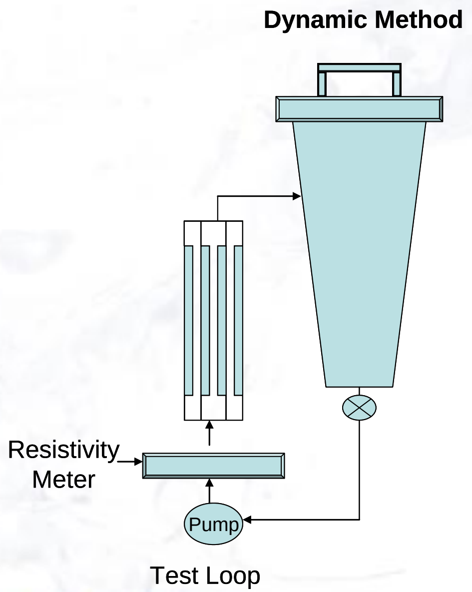
- **Procedure**
  - Rinse each board with 50ml of reagent grade IPA and H20 in a 75%/25% mixture per inch square
  - Measure the resistance drop



R.O.S.E. Automated Testing

- Most prevalent cleanliness evaluation technique
  - Low cost
  - Ease of use
- Two automated methods





R.O.S.E. Data

- J-STD-001 Limits
  - 1.56 micrograms / cm^2 NaCl equivalence
  - Historical value derived for high solids rosin-based flux
  - Extraction solvent
    - IPA 75% / H_2O

Applicability of R.O.S.E. Data

- Extraction tests are based on ….
  - Solubility of soil
  - Temperature of extraction solvent
  - Ion exchange resins
  - Time
  - Impingement energy
- Problem
  - Modern fluxes do not readily dissolve in IPA extraction solvent
  - No quantifiable indicator of the ion that is increasing conductivity

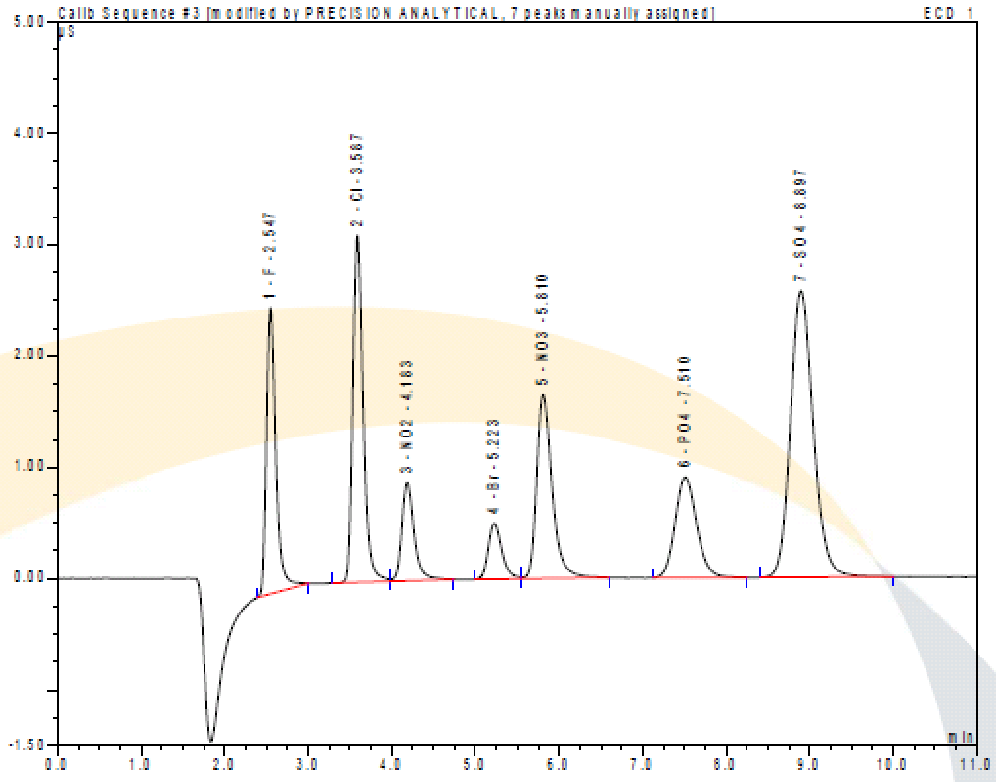
Russeau, 2008

Ion Chromatography

- Developed in the 70s by Dow Chemical Company
- IC separates ionic species by ….
  - Mobile phase = eluent (chemical for moving the ions through the column)
  - Pump
  - Solid phase = analytical column
  - Suppressor = filters background noise from eluent
  - Conductivity cell and detector

Detects Anions / Cations

Chromatogram



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How is IC Different?

- IC utilizes the same extraction solvent as does R.O.S.E.
  - IPA 75% / H_2O 25%
- More rigorous extraction methodology
- Typical ions analyzed by IC
  - Anions: fluoride, chloride, bromide, nitrate, nitrite, phosphate, and sulfate
  - Common organic anions: formate, meleate, succinate, acetate, citrate, adipate, methane sulfonate
  - Cations: lithium, sodium, magnesium, potassium, ammonium, calcium

IC Data

- IC is not as widely used as R.O.S.E.
  - More capital intensive
  - Takes longer than R.O.S.E. to run
  - Requires a skilled person to run and interpret IC
  - Higher cost on a per sample basis
- So why implement ion chromatography
  - Selectivity and sensitivity
  - Provides insights into the manufacturing process
  - Trouble shooting and process optimization

Russeau, 2008

IC – Pass / Fail Limits

- Pass / Fail Criteria
  - Assemblies ~ User Defined
  - Bare PWB's ~ Delphi Electronics Specification Adoption
- Cleanliness should be viewed as a sliding risk scale
  - Not as a go / no-go value
- Test labs recommend ion-specific levels to be used as cleanliness breakpoints until more focused product specific tests can establish better values

Russeau, 2008

Recommended Starting Points

All values in the table are in micrograms / square inch.

Condition	Chloride Cl	Bromide Br	Nitrate NO3	Phosphate PO4	Sulfate SO4	Organic Acids
Bare Board (Cold plating)	< 1.0	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	PI
Bare Board (HASL)	< 2.0	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	PI
No Clean Assembly						
Surface Mount Only	< 2.5	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	5 - 20.0
Mixed Technology	< 2.5	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	20 - 50.0
Through Hole Only	< 2.5	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	50 - 100
Post-Assembly Cleaning						
Surface Mount Only	< 4 - 5.0	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	5 - 20.0
Mixed Technology	< 4 - 5.0	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	20 - 50.0
Through Hole Only	< 4 - 5.0	< 12.0	< 3 - 5.0	PI	< 3 - 5.0	50 - 100

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Performance Testing

- Residue specific information
  - Not enough and does not always predict reliability
  - Only provides a snapshot of the residues present
- Electrical testing
  - Allows for the correlation of the amount and kind of residue
  - Estimate of field service reliability

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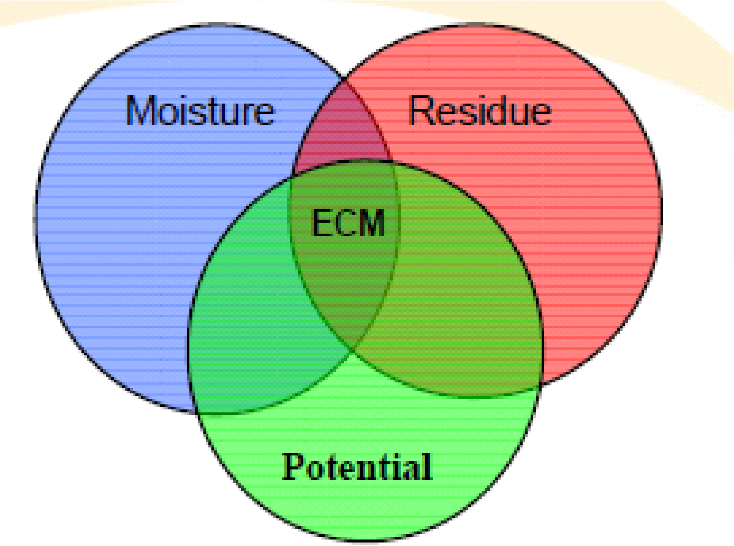
SIR and ECM Testing

- Provide insight into the soils propensity for
  - Electrochemical Migration
  - Electromigration
- Three elements must be in place to initiate and sustain such failures



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SIR and ECM Tests

- Accelerated aging
  - The goal is determine field performance data
- SIR test methodology
  - 40C / 93% RH with an applied bias of 10 VDC, 4-7 days
- Risks / Limitations
  - Humidity levels can influence test
  - User defined product environment
  - Actual conditions needed to discriminate between good and bad

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Critical Points for SIR / ECM

- Always include control samples
- Properly designed test cards
- Functional assemblies are not good candidates for this testing as live components will affect resistance readings

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Critical Points

- Always process test boards as you would a normal production test
- Check samples for solder shorts before testing

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SIR / ECM Data

- Indicates how your assembly process and materials may affect electrical performance under humid conditions
- Using more frequent monitoring
  - Tests the stability of the process
  - Better detection of dendrites and their cause
- Visual board conditions and test patterns
  - Provide clues as to the corrosivity of the residues
- SIR / ECM
  - Will not differentiate between a good and bad process
  - Will provide an indication of electrochemical risk failures

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Critical Cleaning Inspections
Clean or No-clean Assembly Process?

No-clean	Emphasis	Clean
High	Incoming parts	Low
Low	Post Solder	High
High	Handling	Medium
High	Misprints	High
Medium	Stencils	Medium
Medium	Tools/pallets	Low

Current IPC Post Solder Cleaning Documents

IPC sub-committee working on new hand book that combines all three in one

IPC-SC-60...Post Solder Solvent Cleaning handbook
IPC-SA-61...Post Solder Semiaqueous Cleaning Handbook
IPC-AC-62A...Post Solder Aqueous Cleaning Handbook
IPC-CH-65...Guidelines for Cleaning of Printed Boards and Assemblies
IPC-SM-839... Pre and Post Solder Mask Application Cleaning Guidelines
IPC-9201....Surface Insulation Resistance Handbook.

Current IPC Bare Board Cleaning Documents

- IPC-5702...Testing and Assessing Risk of Manufacturing Residues
- IPC-5704...Cleanliness Requirements for unpopulated circuit boards
- IPC-TM 650 Method 2.3.28.2....Ion Chromatography for Bare Board cleanliness

Concluding Remarks

- Many factors need to be considered when designing the cleaning process
- By first characterizing the soils
  - You have an accurate baseline for removing the soil
  - Matching the right cleaning agent to the soil
  - Determining compatibility issue early in the process
  - Selecting the right equipment
  - Running validation testing that provides functional data

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