IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Defluxing of Eutectic and Lead-Free PCBs in a Single Cleaning Application

Speaker:

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1. Lead-Free Effects on Cleaning
2. Regulation & Definitions
3. Main risks of Mixed Processes
4. Conclusion

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1. Lead-Free Effects on Cleaning

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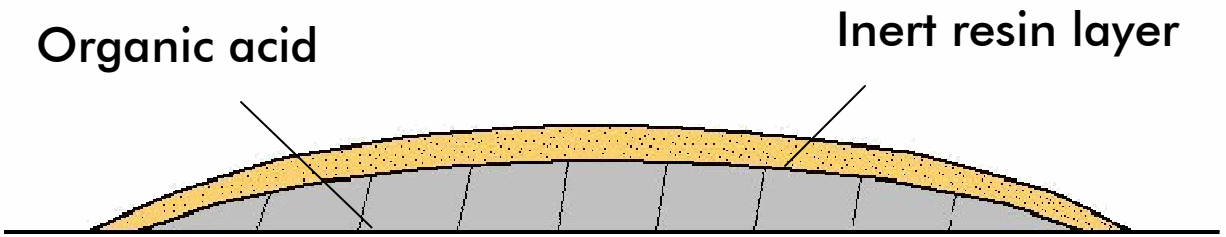
Lead-Free Effects on Cleaning

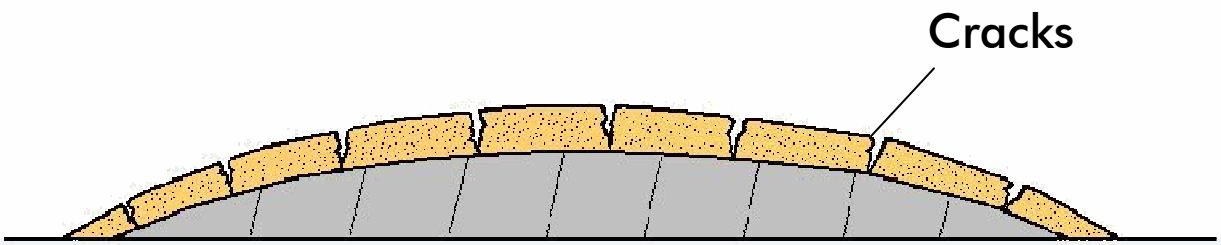
From Lead to Lead-free	Consequences
More aggressive activators	→Risk of corrosion on leads and connectors →Danger of leakage currents

Encapsulation of organic activators



After soldering

BUT: Exposed to climatic stressors



After 4 weeks
climatic changes

Lead-Free Effects on Cleaning

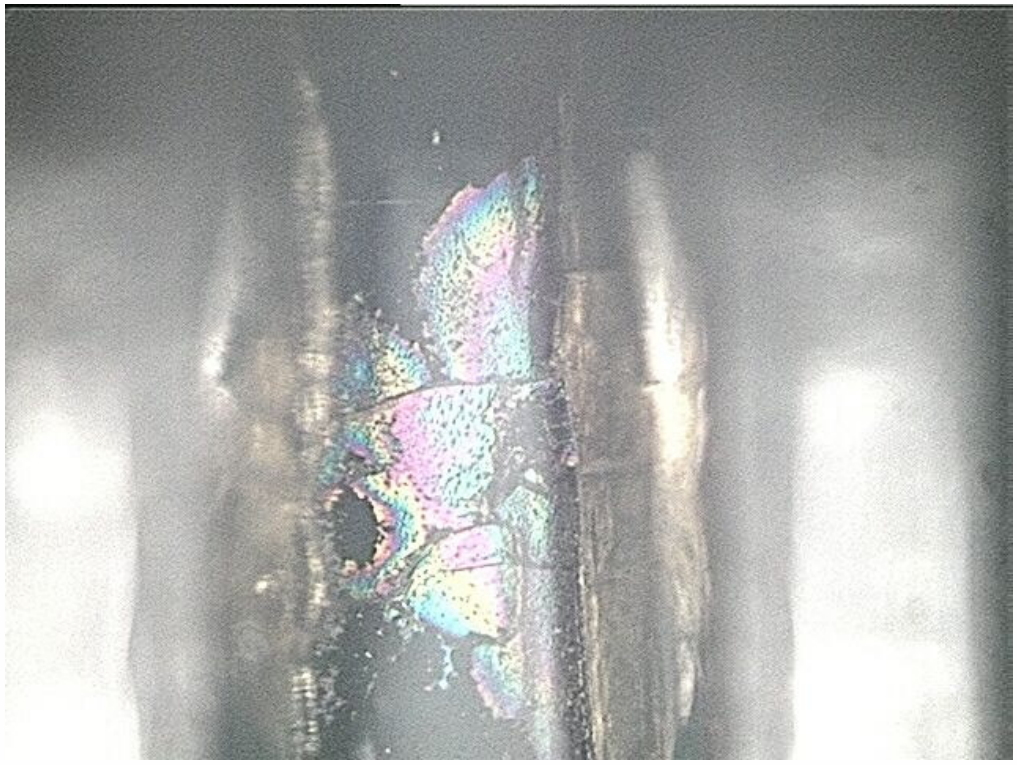
From Lead to Lead-free	Consequences
More aggressive activators	→Risk of corrosion on leads and connectors →Danger of leakage currents
Higher rosin content	→Formation of hairline cracks on coatings →Affected signal integrity with HF (RF) assemblies →Impaired testability

Damaged Coating

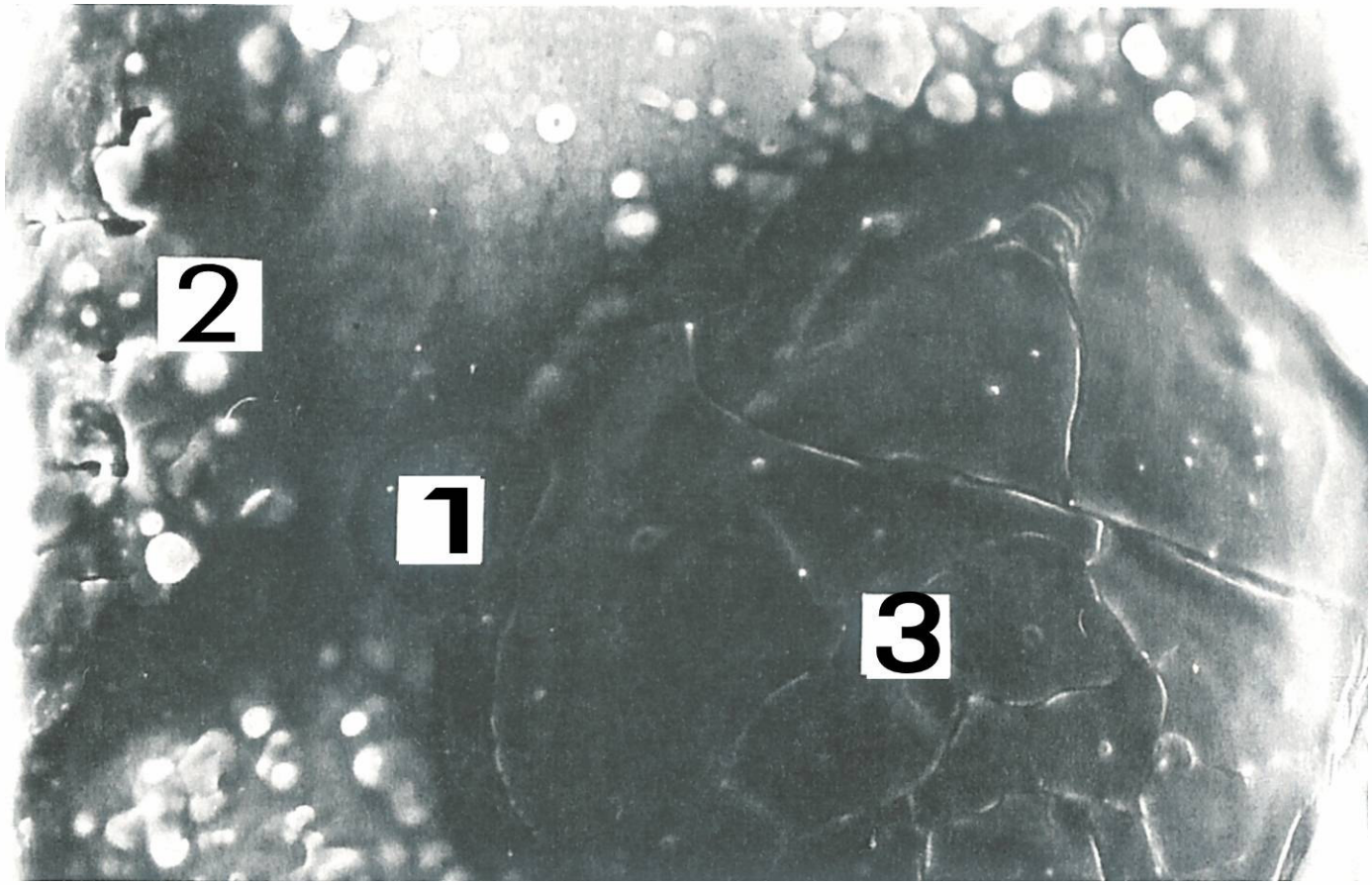
Higher rosin content

→ Worse dewetting

→ No adhesion of coating

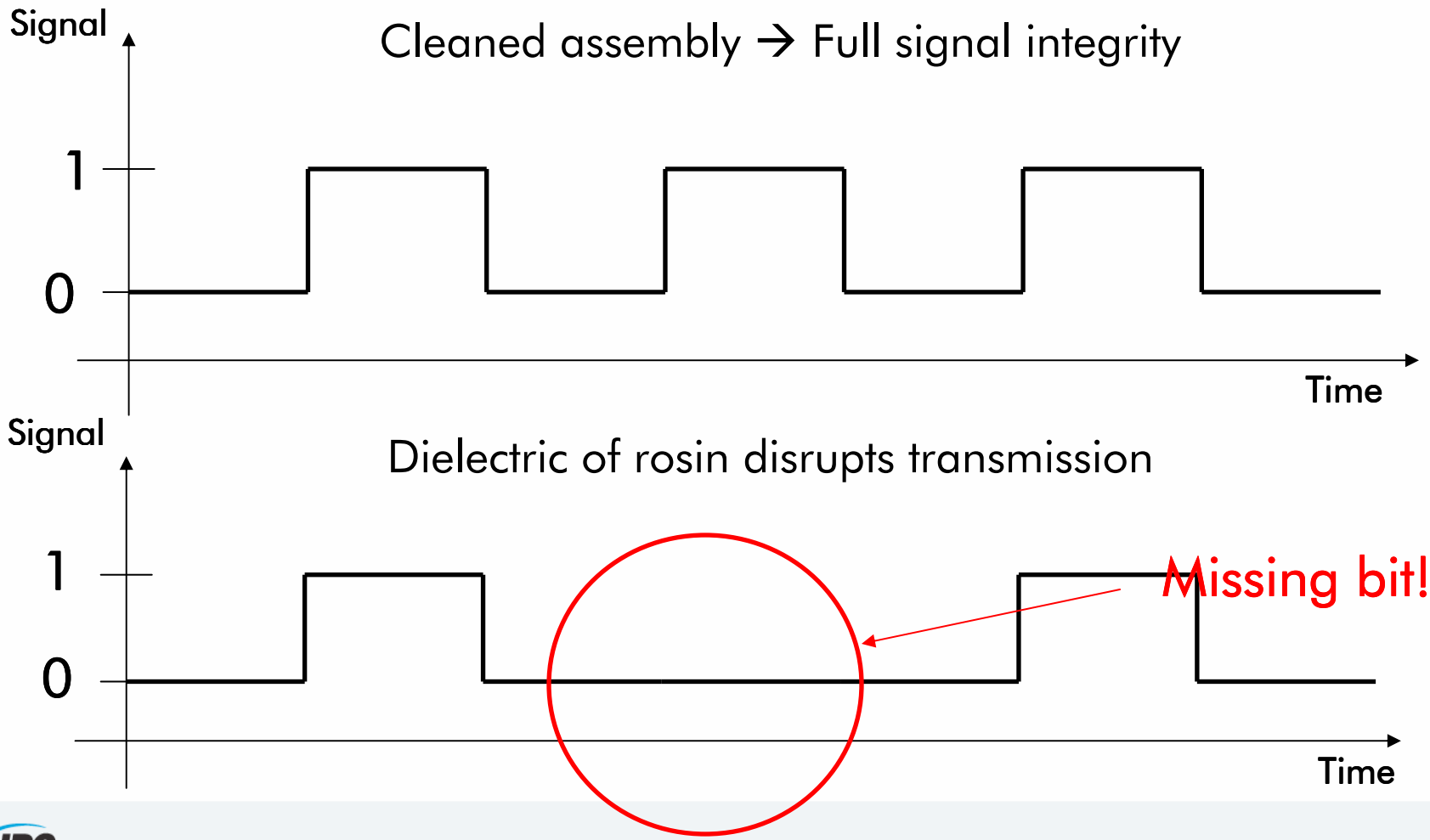


Damaged Coating

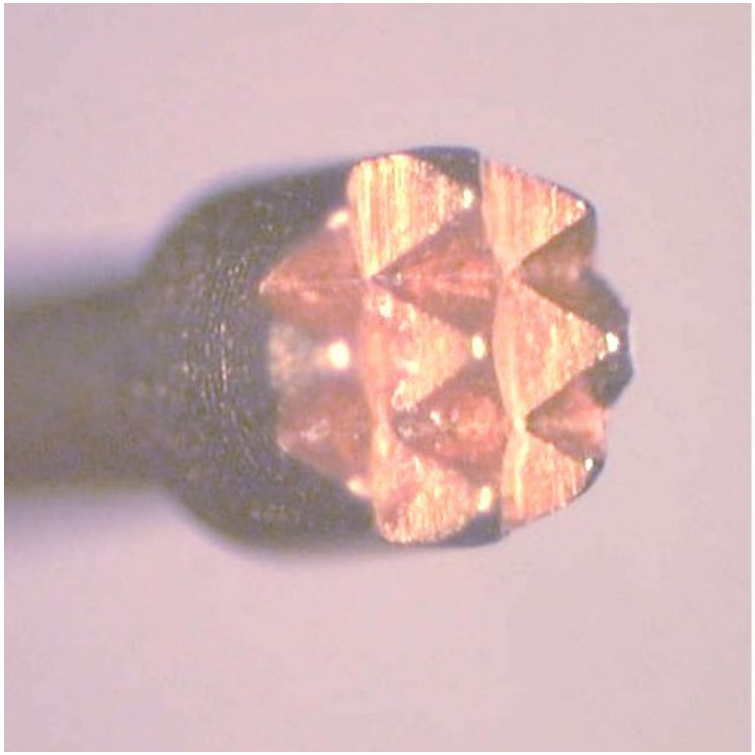


1 - Non wetting 2 - Pores 3 - Crack

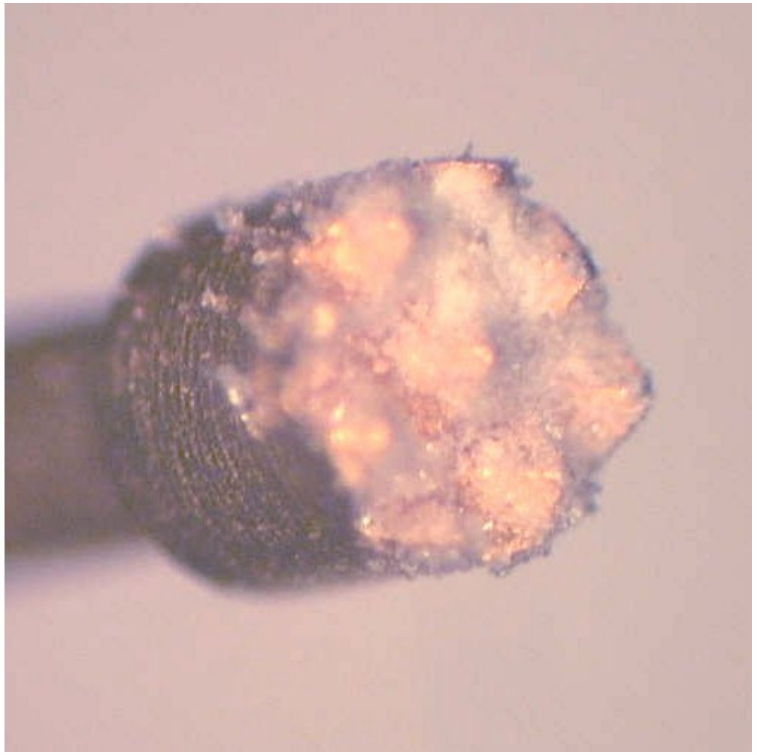
Affected Signal Integrity with HF Assemblies



Testability – Contaminated IC needle



With conventional flux residues



With lead-free flux residues

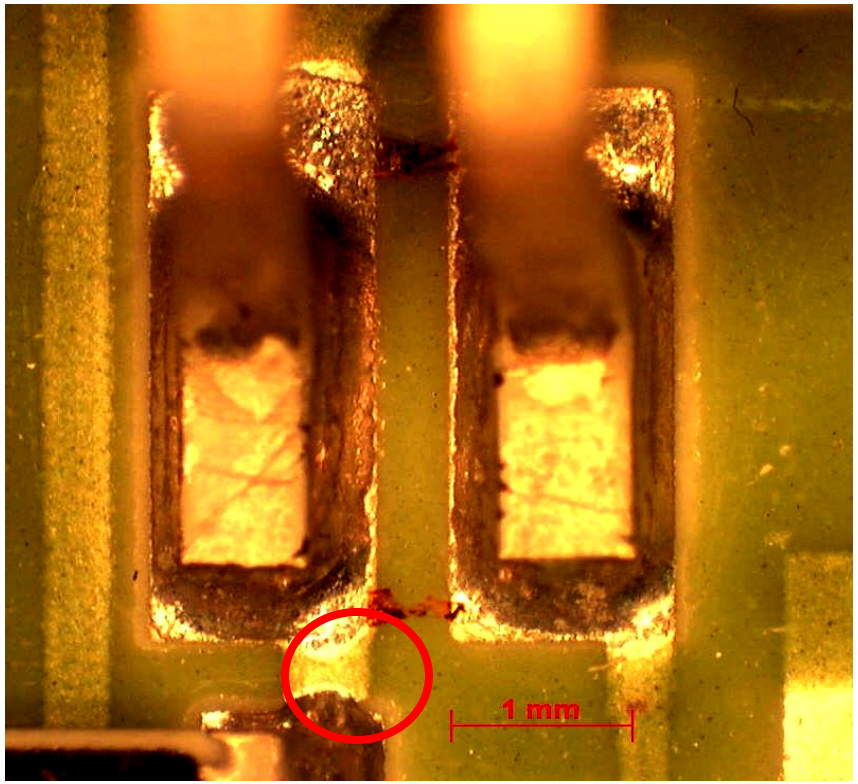
Lead-Free Effects on Cleaning

From Lead to Lead-free	Consequences
More aggressive activators	→Risk of corrosion on leads and connectors →Danger of leakage currents
Higher rosin content	→Formation of hairline cracks on coatings →Affected signal integrity with AF assemblies →Impaired testability
Containing Ag solder paste	→Tendency to form temporary dendrites

Climatic Reliability

→ Electrochemical migration

→ Through continuous SIR measurement



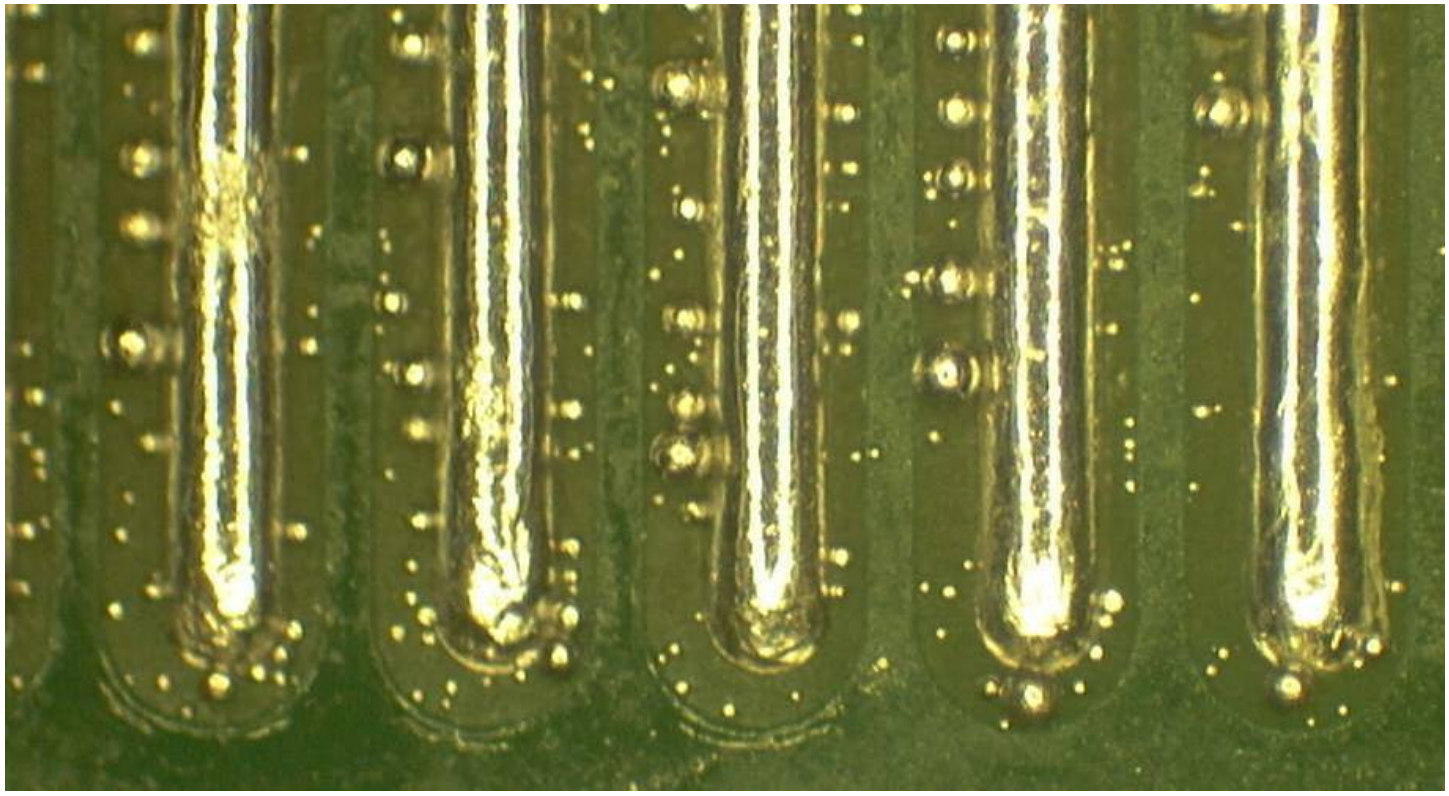
Ag lead-free solder paste tend to form temporary dendrites

Lead-Free Effects on Cleaning

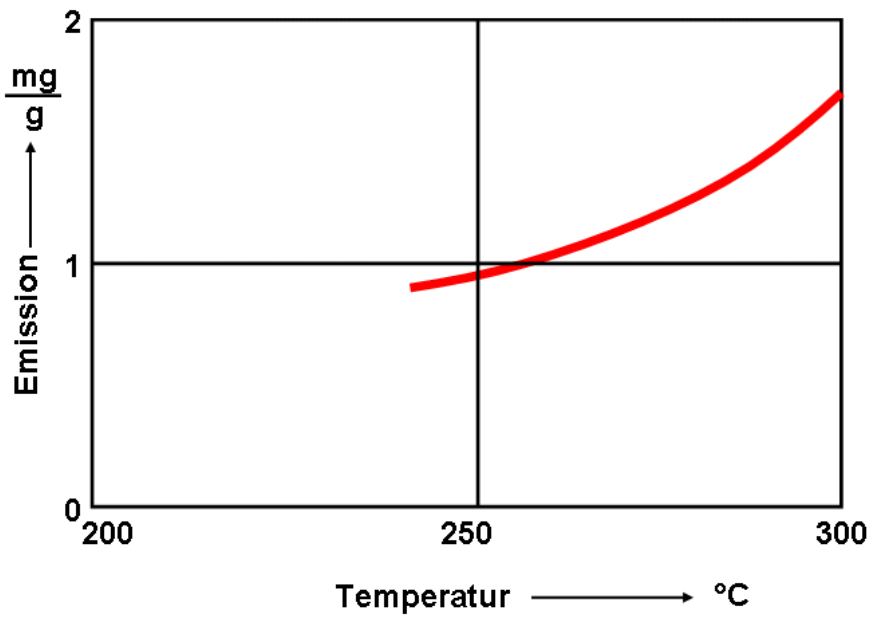
From Lead to Lead-free	Consequences
More aggressive activators	→Risk of corrosion on leads and connectors →Danger of leakage currents
Higher rosin content	→Formation of hairline cracks on coatings →Affected signal integrity with AF assemblies →Impaired testability
Containing Ag solder paste	→Tendency to form temporary dendrites
Increase in solder temperature	→Impacts the delineation of the print →Increase in residues due to degassing →Burnt in fluxes

Is the print stability guaranteed at higher temperature?

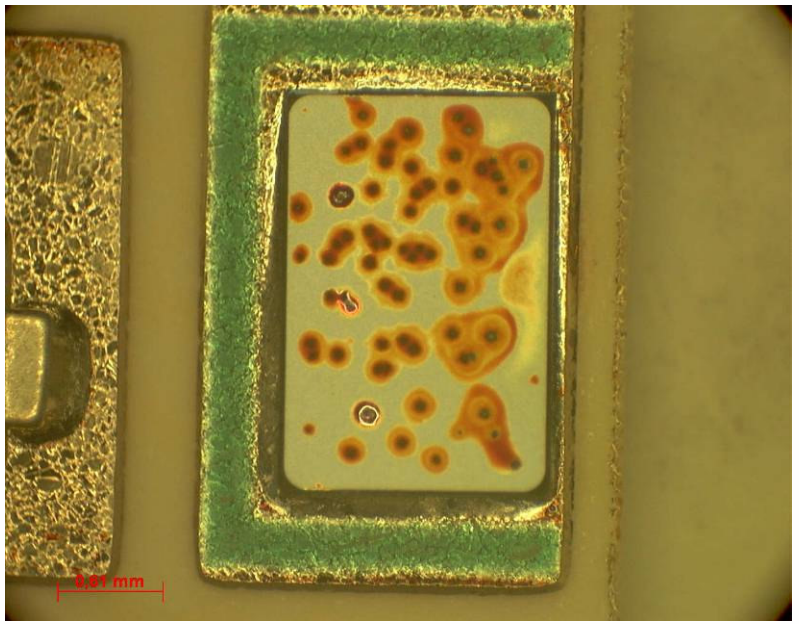
→ Danger of solder balling after reflow!



Increased Residues due to Degassing



The boost in temperature increases degassing



Residues due to degassing on chips

2. Regulation & Definitions

RoHS regulation & limitations (effective July 1st, 2006)

- Current legislation restricts the level of lead in lead-free assemblies not to exceed 0.1% by weight.

RoHS included other heavy metals:

- Cadmium (0.01%)
- Mercury (0.1%)
- Hexavalent Chromium (0.1%)

Industry users FAQs:

- How to convert a straight DI designed machine one?
- Why is it that water-soluble fluxes in conjunction with lead-free alloys are not very cleanable with DI-water anymore?
- Can I use my existing chemistry based cleaning process to clean eutectic and lead-free alloys in the same process?

3. Main Risk of Mixed Processes

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Mixed Cleaning Process Definition:

Cleaning lead-free and eutectic assemblies in a single process

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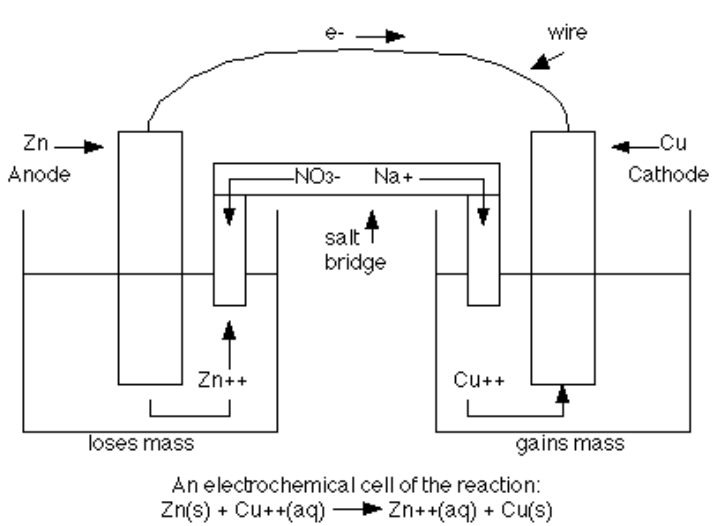
Main risks of Mixed Processes:

A. Reduction of lead salts via redox reaction

B. Lead-based ionic residues, due to insufficient rinsing

A. Reduction of lead salts via redox reaction:



An electrochemical cell of the reaction:
$Zn(s) + Cu^{++}(aq) \rightarrow Zn^{++}(aq) + Cu(s)$

A low or high pH-level respectively can affect the redox potential between different metals.

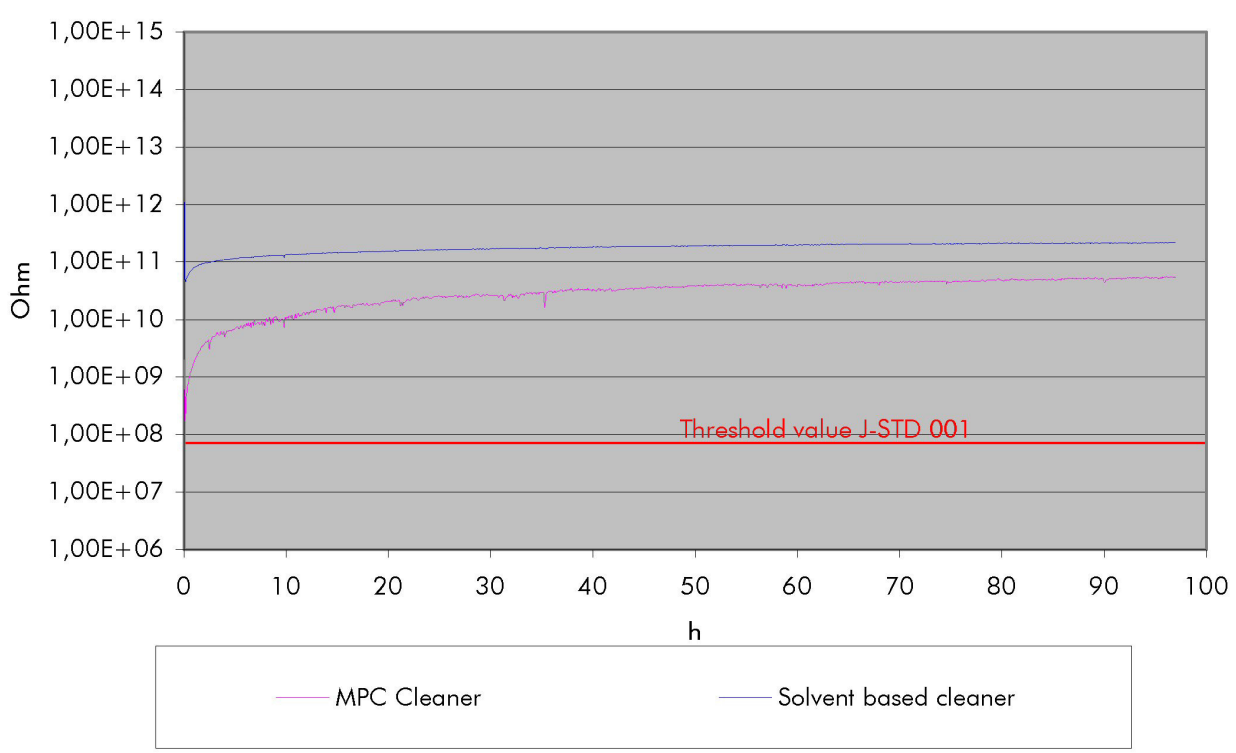
The redox potential for Lead and Tin in an alkaline aqueous solution is:

$Pb + 3\ OH^- \leftrightarrow Pb(OH)^-_3 + 2e^-$	$\varepsilon = -0.540$
$Sn + 3\ OH^- \leftrightarrow Sn(OH)^-_3 + 2e^-$	$\varepsilon = -0.909$

Impact of the redox reaction will be dependent on numerous factors such as:

- Solubility of Tin and Lead in the respective cleaning agent
- Temperature of the cleaning agent
- pH-value of the cleaning agent
- Exposure time of the cleaning agent
- Concentration of the involved species

B. Lead-based residues, due to insufficient rinsing



A common ionic contamination limit (J-STD-001-C § 8.3.6) is below 10.06 µg / sq.in.

Experimental tests confirmed the limited solubility of lead

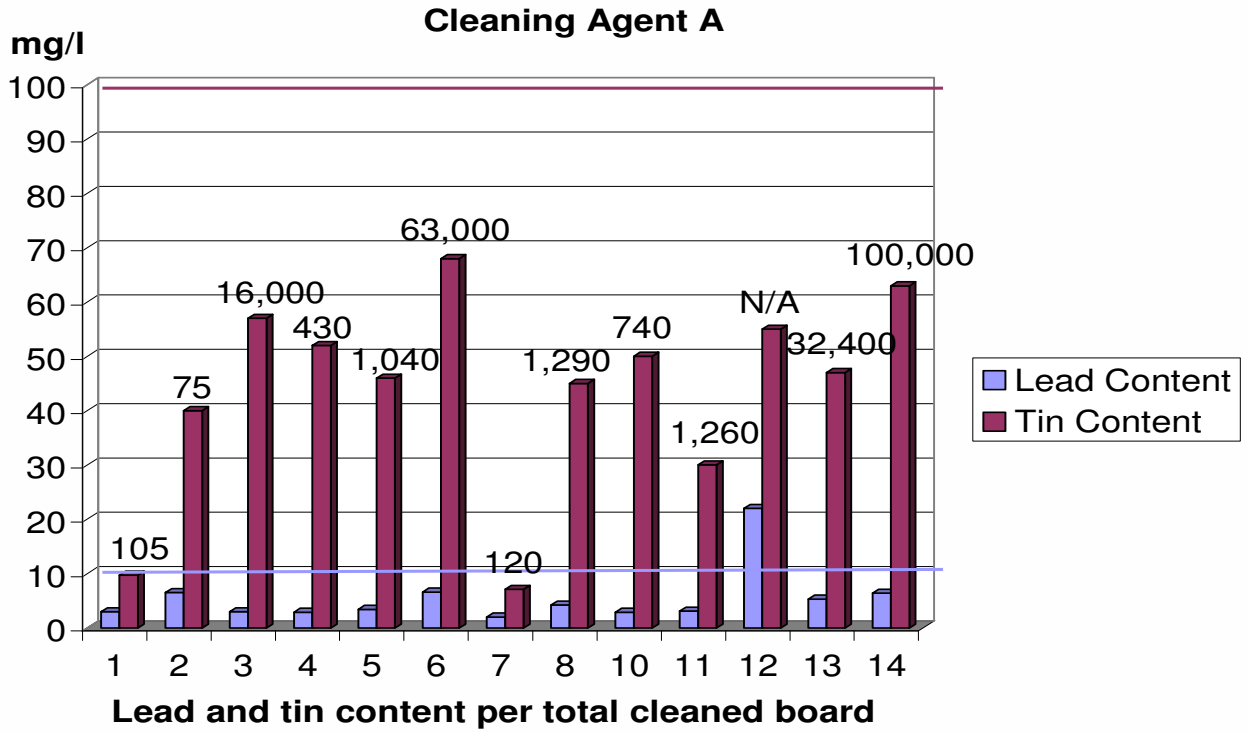
Concentration gradient and solubility of lead salts

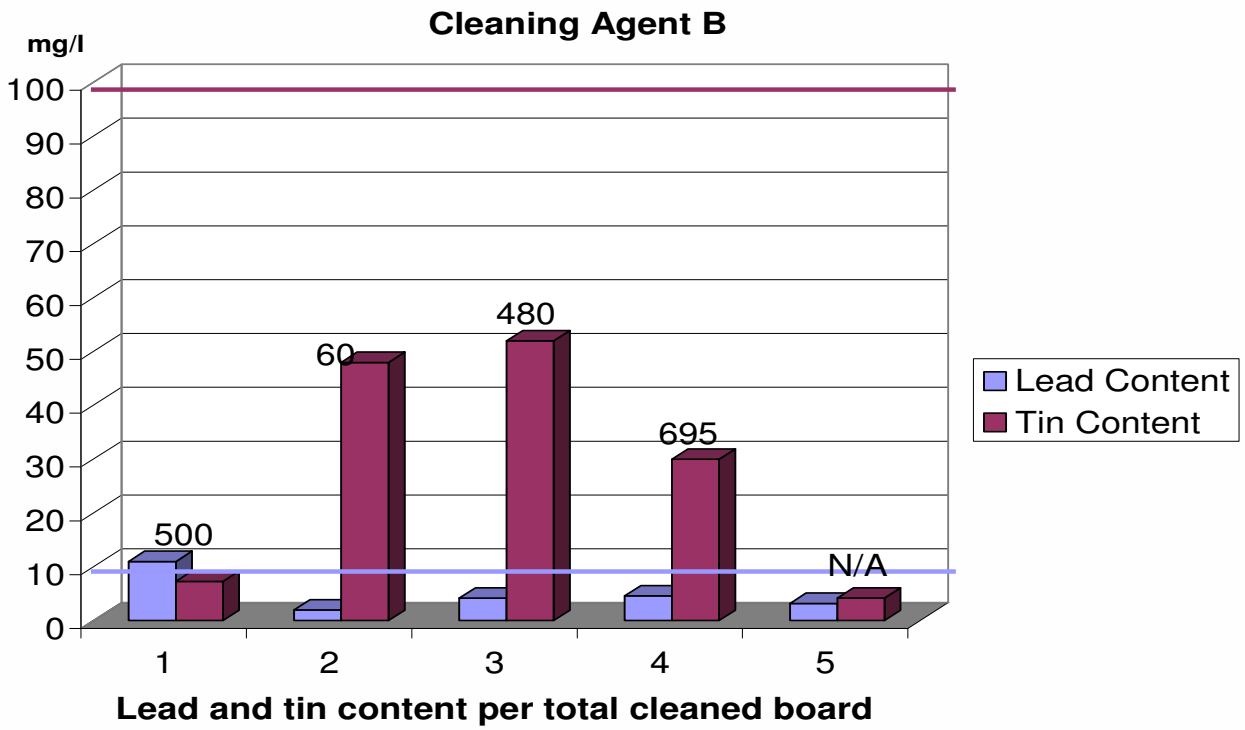
Δc

none slight heavy precipitation

⇨ Solubility of Lead and Tin can be dependent on the cleaning agent in use

To fully understand risks of a mixed cleaning process, current customer samples were collected:





⇨ The maximum level of Lead was always found to be lower than 10 mg/L

Outcome: No linear relationship between contamination and throughput due to:

- Constant precipitation
- Consistent replenishment of fresh cleaning medium in high volume applications

Determination of experimental error of lead-free boards:

- Lead-free: 0.0 to 0.3 mg/cm^2
- Eutectic: 3.0 to 5.0 mg/cm^2

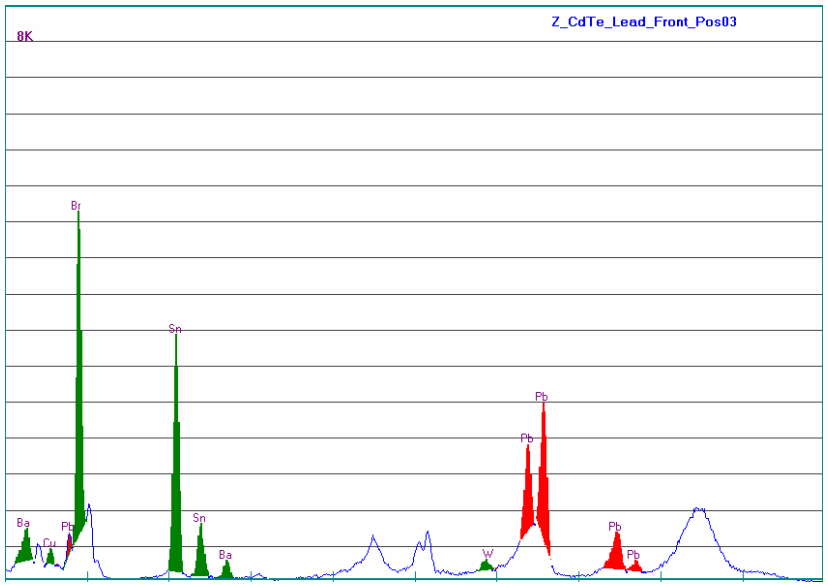
⇨ Test confirmed the 1:1000 ratio (0.1% lead limit according to RoHS) between eutectic and lead-free assemblies.

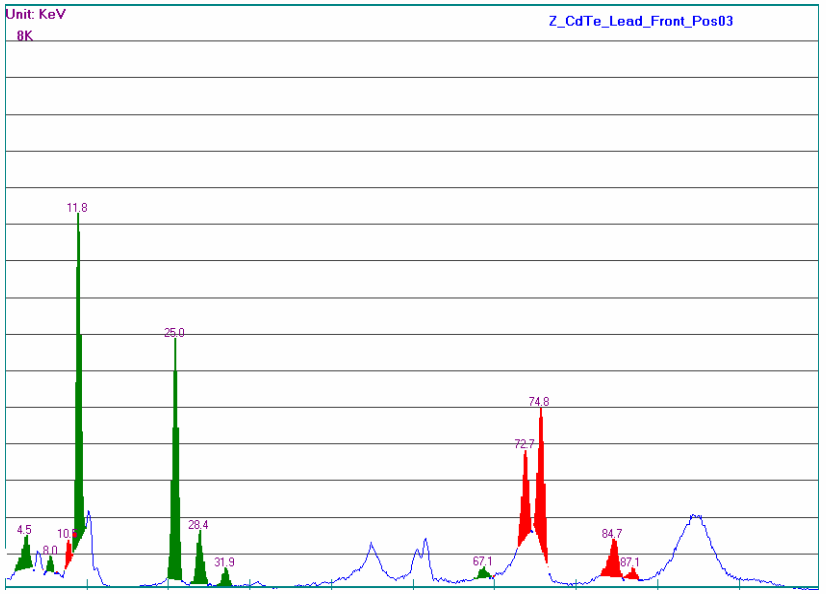
	Lead-free measurements (mg/sq cm)		
Board #	Top	Center	Bottom
1	0.0	0.0	0.0
2	0.2	0.1	0.1
3	0.2	0.0	0.0
4	0.1	0.0	0.1
5	0.0	0.0	0.1
6	0.0	0.1	0.1
7	0.2	0.3	0.1
8	0.2	0.2	0.1
9	0.1	0.1	0.1
10	0.0	0.3	0.2
11	0.1	0.2	0.3
12	0.3	0.0	0.0
13	0.1	0.2	0.2
14	0.0	0.0	0.1
15	0.2	0.1	0.2

	Lead-free measurements (mg/sq cm)		
Board #	Top	Center	Bottom
16	0.3	0.2	0.1
17	0.0	0.0	0.0
18	0.2	0.1	0.1
19	0.2	0.0	0.0
20	0.0	0.1	0.0
21	0.1	0.0	0.2
22	0.0	0.0	0.1
23	0.2	0.0	0.0
24	0.3	0.2	0.2
25	0.1	0.1	0.1
26	0.2	0.2	0.0
27	0.0	0.1	0.1
28	0.0	0.2	0.1
29	0.2	0.0	0.0
30	0.0	0.0	0.1

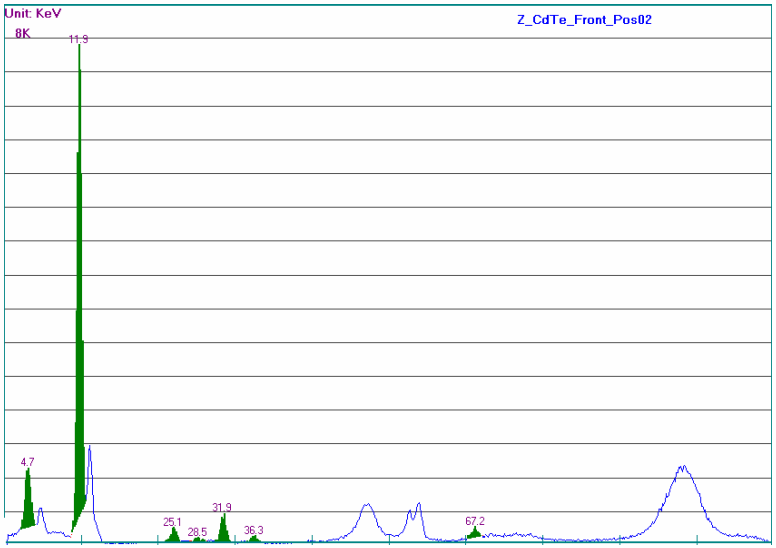
Experimental error determination on lead-free boards

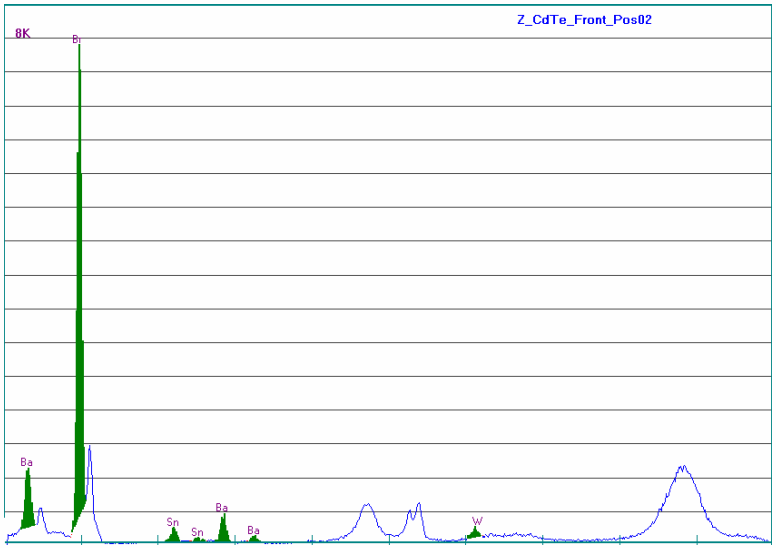
Reference Spectrum for eutectic board with element characterization:



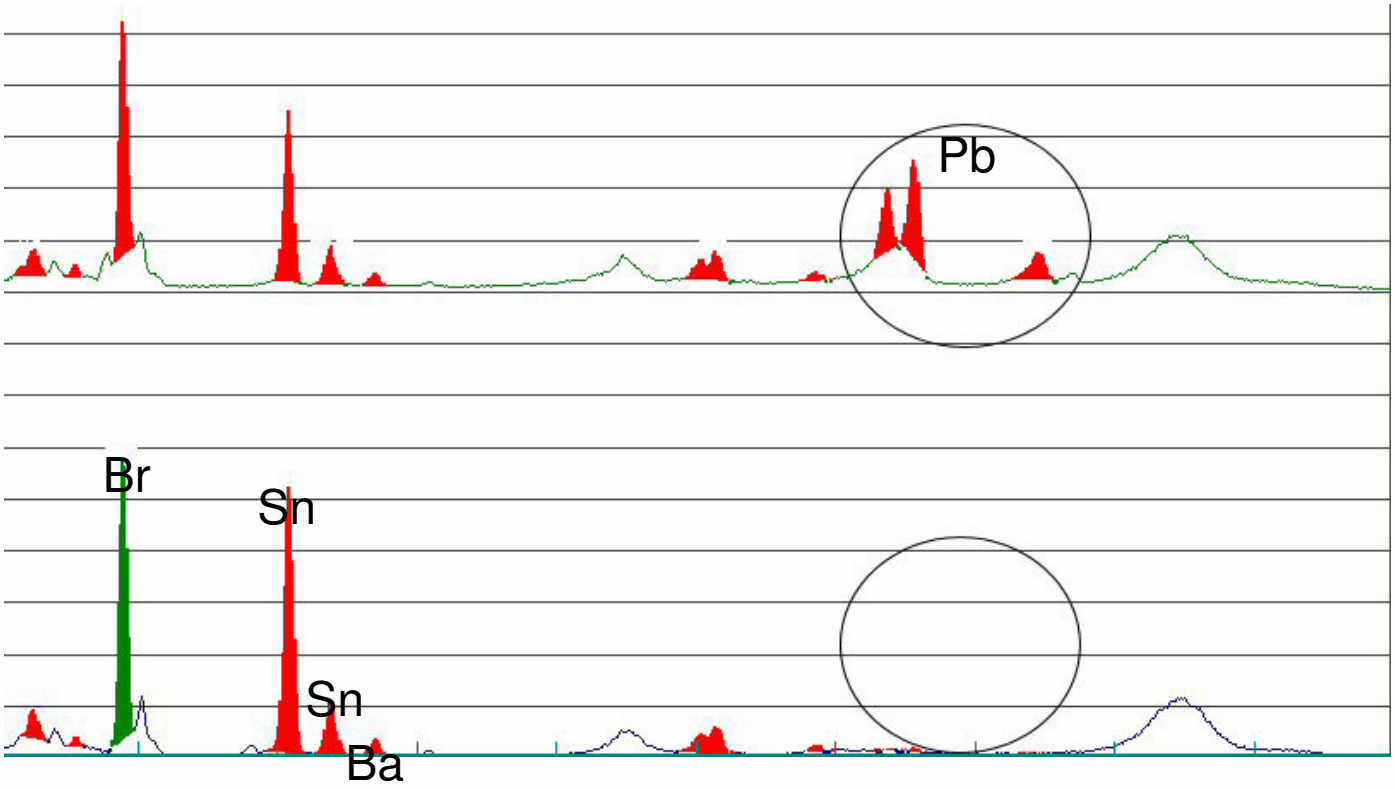


Lead-free board with element characterization:





Side-by-side lead contamination comparison of lead-based and lead-free assemblies:



Experimental laboratory analysis (WCS):

Parameters:

- Cleaning agent A
- 15% concentration
- 5 minutes exposure time
- Room temperature

50 mg/l of lead salt:*

mg/cm²	Sample board	After 1 rinse	After 2 rinse
Top	0.1	0.1	0.1
Center	0.2	0.2	0.2
Bottom	0.1	0.2	0.2

100mg/l of lead salt:*

mg/cm²	Sample board	After 1 rinse	After 2 rinse
Top	0.1	0.1	0.1
Center	0.2	0.0	0.0
Bottom	0.1	0.1	0.1

*Observed at 10 mg/l of Pb solubilized

⇨ Increase in lead salts and second rinse did not increase lead

Experimental laboratory analysis:

Parameters:

- Cleaning agent A
- 15% concentration
- 5 minutes exposure time
- 50 mg/l of lead salt

120 °F:

mg/cm²	Sample board	After 1 rinse	After 2 rinse
Top	0.1	0.1	0.0
Center	0.2	0.2	0.1
Bottom	0.1	0.3	0.0

150 °F:

mg/cm²	Sample board	After 1 rinse	After 2 rinse
Top	0.1	0.1	0.0
Center	0.1	0.1	0.0
Bottom	0.2	0.1	0.2

⇨ Increase in temperature also shows no increase in lead

Complementing trials with inline manufacturer to simulate mechanical energies:

Preparation:

- 500 eutectic boards were pre-run to establish the base values for lead and tin in the solution
- Sample taken from this solution was analyzed for heavy metals and confirm the maximum levels of tin and lead

Lead-free boards	Temp [°F]	Exposure time [sec]	Pb-content measured [mg/cm^2]		
			Top	Center	Bottom
1	125	120	0.0	0.2	0.0
2	125	260	0.1	0.0	0.0
3	140	120	0.2	0.1	0.1
4	140	260	0.0	0.2	0.1
5	160	120	0.1	0.1	0.2
6	160	260	0.2	0.1	0.0

Post Wash Spectrum
2.5 ft/minute vs. 1.2 ft/minute

Lead-free Boards	Temperature [°F]	Exposure time [sec]	Ionic Contamination [µg/sq cm)
1	125	120	0.14
2	125	260	0.21
3	140	120	0.18
4	140	260	0.02
5	160	120	0.08
6	160	260	0.11
Partial Rinse	150	88	0.38
Partial Rinse	150	180	0.23
No Rinse	N/A	N/A Air Dried	1.10

Experimental results obtained based on inline cleaning process

4. Conclusion

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Conclusion

- ✓ Among the cleaning agents tested, lead levels were less than 10 mg/liter (40 mg/gallon).
- ✓ No measurable reduction (chemical reaction) of lead was detectable.
- ✓ Optimal rinsing can provide reliable RoHS compliance by eliminating ionic (lead containing) contamination.
- ✓ A mixed process is feasible without exceeding RoHS and WEEE limitations for lead-free.
- ✓ Dependency of cleaning agent overall
  ⇨ results based on aqueous based products.